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Prefacio

La Sociedad de Ergonomistas de México A.C. (SEMAC), como parte relevante de su actividad e interés en la difusión, promoción y apoyo a la ergonomía, ha organizado desde 1999 y de forma anual, su Congreso Internacional de Ergonomía. En abril de 2009, el XI Congreso Internacional de Ergonomía tiene lugar en CD. Juárez, Chih., con la participación de ergonomistas profesionales e interesados en esta área.

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

Los editores, 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 XI 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 a nivel mundial.

Enrique de la Vega Bustillos

Presidente SEMAC 2002 – 2004

SOCIEDAD DE ERGONOMISTAS DE MÉXICO A.C.

“Trabajo para optimizar el trabajo”

Cd. Juárez, Chih. Abril de 2009

CONTENT

ANTHROPOMETRY

Page

ANTHROPOMETRIC TABLES OF INDUSTRIAL DESIGN STUDENTS OF UAEM. 1
Raúl Vicente Galindo Sosa, Marisol Navarrete Modesto, Raymundo Ocaña Delgado, Margarita Gómez Aguirre

ANALYSIS OF THE RELATIONSHIP FATIGUE - ANTHROPOMETRY-DESK DIMENSIONS IN STUDENTS OF INDUSTRIAL ENGINEERING PROGRAM Jesús Rodolfo Guzmán Hernández, Joaquín Vásquez Quiroga, Enrique de la Vega Bustillos 6

BIOMECHANICAL

MAXIMUM FORCE OF GRIP WITH DOMINANT AND NON-DOMINANT HAND. 15
Lizeth Muñoz Jashimoto, Enrique de la Vega Bustillos, Francisco Octavio Lopez Millan, Bertha Alicia Ortiz Navar

DESIGN

CAPTURING HUMAN MOVEMENTS AND HOW TO USE IT IN A 3D ANIMATION. 31
Daniel Celis Flores, Carlos Alberto Fuentes, Julio Gerardo Lorenzo Palomera, Judith del Carmen Garcés Carrillo, Hilario Manuel Radillo Llera, Juan José Cuevas Lomeli

ERGONOMICS NOTION AS QUALITY FACTOR IN DESIGN LEARNING. 40
Julio Lorenzo Palomera.

DESIGN AND WORK ANALYSIS

MODELING THE ACTIVITY, A KEY PHASE FOR THE ERGONOMICS OF THE CONCEPTION OF SYSTEMS AND PRODUCTS. 51
Carole Baudin

ERGONOMICS AND EDUCATION

ERGONOMICS AND DESIGN. INDUCTION DIDACTIC STRATEGY. 62
Julio Lorenzo Palomera, Judith Garcés Carrillo, Daniel Celis Flores, Carlos Fuentes Pérez, Manuel Radillo Llera, Juan Cuevas Lomelí

OCCUPATIONAL ERGONICS

OCCUPATIONAL ERGONOMICS: EMPHASIS ON IDENTIFICATION OR SOLUTIONS 69
Jeffrey E. Fernandez, Robert J. Marley

WORK EVALUATION

ERGONOMIC ANALYSIS IN PUBLIC MARKETS IN CORTAZAR GUANAJUATO. 79
María Teresa Medina Aboytes, Juan Luis Hernández Arellano, Jorge Luis García Alcaraz

ERGONOMIC EVALUATION IN DRIVESHAFT MANUFACTURING, TOOL ROOM AREA. 87
Ricardo Domínguez de Hita, Juan Luis Hernández Arellano,Efraín García Venegas

REDESIGN OF THE FURNITURE IN THE AREA OF MOULDING BY INJECTION OF A COMPANY OF THE ELECTRICAL BRANCH 97
Mario Ramírez Barrera, Ma. Teresa Escobedo Portillo, Carlos Amador Giner Nolasco

ERGOSOFT. 104
Nancy Ivette Arana de las Casas. David Sáenz Zamarrón, José Luis Martínez Torres, Marielena Villanueva Romero, Leticia Corral Bustamante, Jesús Salvador Cruz Núñez, Erick Hernández Moreno, *Carlos de la Pena Meraz*

ERGONOMIC EVALUATION OF WORK STATIONS RELATED WITH THE OPERATION OF ADVANCED MANUFACTURING TECHNOLOGY EQUIPMENT: TWO CASES OF STUDY. 120
Aide Maldonado Macias, Guadalupe Ramirez, Cesar Daniel Vasquez, Salvador Noriega

EVALUATION SYSTEM ERGONOMIC WORK STATIONS FOR MANUAL ASSEMBLY, IN THE PROCESSES OF PRODUCTION IN THE FACTORY INDUSTRY IN THE NORTHEASTERN STATE OF SONORA. 127
Lamberto Vázquez Veloz, José Escarcega Castellanos, Arturo Medina Borja

FATIGUE

DETERMINATION OF PHYSICAL FATIGUE IN WORKERS FROM POPULAR MARKETS AT LOS MOCHIS, SINALOA 137
José Alfredo Leyva Astorga, José Alberto Estrada Beltrán, Alberto Ramírez Leyva

OCCUPATIONAL HEALTH

ANALYSIS OF THE FACTORS THAT CAUSE INJURIES AND/OR INDUSTRIAL ACCIDENTS 148
Ma. Teresa Escobedo Portillo, Andrés Hernández Gómez, Gonzalo Palacios Valerio, Claudia Valencia Gutiérrez

CATEGORIZATION OF FACTORS CAUSING ASTHENOPIA IN RESEARCH PROFESSORS AT THE ITCJ BY READING WITH VDT: A SHARED EXPERIENCE 154
Rosa María Reyes Martínez, Rodolfo de la O Escapita, Jorge de la Riva Rodríguez, Alois Clark Fabiani Bello

Carpal tunnel and the lack of information by the user 166
Marcela Villalobos Flores, Luis Arnulfo Guerrero Chávez, Alfredo Villalba Rodríguez

ANTHROPOMETRIC TABLES OF INDUSTRIAL DESIGN STUDENTS OF UAEM

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Resumen: Dentro del proyecto de investigación titulado "Puesto de Trabajo Áulico para el Discente de Diseño Industrial" con registro ante la Secretaría de Investigación y Estudios Avanzados de la Universidad Autónoma del Estado de México (UAEM) número 2510/2007U, se requirió de obtener tablas antropométricas de los discentes de esta universidad con datos útiles para el diseño de este puesto de trabajo. El objetivo fue obtener las tablas antropométricas con los percentiles 5º, 25º, 50º, 75º, y 95º, para el diseño de un puesto de trabajo áulico ergonómicamente adecuado para el desarrollo de competencias del discente de diseño industrial. La investigación se circunscribió a una muestra de 183 discentes, representativa de los organismos pertenecientes a la UAEM donde se imparte la licenciatura en Diseño Industrial (tres Campus). El método seguido inició con un análisis para identificar las dimensiones físicas del usuario, involucradas en el mobiliario actual, determinando las dimensiones de las que se requerían nuevos datos; se realizó un levantamiento antropométrico, y se procesaron los datos recopilados para obtener los percentiles por cada dimensión y género. Como resultado se obtuvieron las tablas de los percentiles 5º, 25º, 50º, 75º, y 95º, segmentados por género y en forma mixta, de las veintiséis dimensiones requeridas para el diseño del puesto de trabajo. Una conclusión interesante del proyecto fue que la muestra estudiada mostró una tendencia diferente a una población estándar, por lo que se tuvo que analizar la información de forma semi manual para obtener los percentiles.

Palabras clave: Antropometría, Diseño Industrial, Mobiliario.

Abstract: Within the research project entitled "Aulic workstation for industrial design students" with register at the Secretaría de Investigación y Estudios Avanzados of

Universidad Autónoma del Estado de México (UAEM), registration number 2510/2007U, it was required to obtain anthropometric tables of the students of this university with useful information for the design of this workstation. The objective was to get the anthropometric tables with anthropometric percentiles 5^{th}, 25^{th}, 50^{th}, 75^{th} and 95^{th}, for the design of an aulic workstation ergonomically suitable for the development of skills of industrial design students. The investigation was limited to a sample of 183 students, representing the campus belonging to the UAEM which provides a degree in Industrial Design (three Campuses). The method began with an analysis to identify the physical dimensions of the user involved in the furniture, determining the dimensions which new data were needed. An anthropometric survey was carried out, and processed the data collected to obtain the percentiles for each dimension and gender. The result was the tables of percentiles 5^{th}, 25^{th}, 50^{th}, 75^{th} and 95^{th}, segmented by gender and one mixed, of the twenty-six dimensions required for the design of the workstation. An interesting finding of the project was that the sample studied showed a trend different from a standard population, which had to analyze information in a semi-manual way to get the percentiles.

Keywords: Anthropometrics, Industrial design, Furniture.

1. INTRODUCTION

The research reported in this paper was directed to obtain the anthropometric tables needed in the project “Aulic workstation for industrial design students” registered at the Secretaría de Investigación y Estudios Avanzados of Universidad Autónoma del Estado de México (UAEM), with registration number 2510/2007U. The research was located in the three campuses where the UAEM offers the degree in Industrial Design: Centro Universitario UAEM Valle de Chalco, at Valle de Chalco, Estado de México, Centro Universitario UAEM Zumpango, at Zumpango, Estado de México, and the School of Architecture and Design, at Toluca, Estado de México, all of them schools of UAEM.

Previous to the research, it was made an analysis to get the physical dimensions of the students involved in the actual furniture, determining in this way the twenty-six dimensions in which it’s required new data and then made an anthropometric survey at the mentioned institutions. Actually these skills are constrained by the furniture they have, because of a non ergonomic and uncomfortable design, and by a degenerative and abnormal curvature of the spine that the furniture favors, as well as by the shared facilities with other undergraduate students, with whom it does not exist the same needed furniture.

2. OBJECTIVES

The main objective was to obtain results in the form of anthropometric percentiles for the design of an aulic workstation ergonomically suitable for the development of skills of industrial design students. The percentiles needed was the anthropometric percentiles 5^{th}, 25^{th}, 50^{th}, 75^{th} and 95^{th} of the twenty-six dimensions required for the design of the aulic workstation.

The secondary objectives was: first, to do an anthropometric survey to a representative sample of the students of Industrial Design at the UAEM; second, to analyze the data of the survey to get the needed percentiles; third, to get anthropometric tables with the founded percentiles segmented by gender, and a mixed table with the two genders, all of them ordered by the sequence followed in the anthropometric survey; and fourth, to recommend anthropometric dimensions useful in the design of the aulic workstation.

3. METHODOLOGY

First, it was calculated a sample from a universe of 539 students of the three campus of the UAEM where the industrial designer degree is offered using the probabilistic sample method commented in Hernández (2003:305-306). With this method the sample was determined in 183 students. Then the sample was stratified according to the same author (Hernández:2003) by gender and school.

After this, there was designed an anthropometric form with the twenty-six required dimensions. The dimensions are shown in the table 1.

Table 1. Required dimensions.

Nº	Dimensions in sitting position (cm)	Nº	Dimensions in standing position (cm)
1	Height	1	Weight (kg)
2	Shoulder height	2	Height
3	Height of the bent elbow	3	Height of Eye to the floor
4	Height to the thigh	4	Height of shoulder to the floor
5	Popliteal Height	5	Height of elbow to the floor
6	Maximum body width	6	Femur depth
7	Width of elbow to elbow	7	Front reach of the arm
8	Width of hips		
9	Abdominal depth		
10	Distance of hip to collarbone		
11	Distance of collarbone to elbow		
12	Distance of elbow to wrist		
13	Distance of knee to femur		
14	Distance of buttock to popliteal		
15	Distance of the femur to the lower back		
16	Distance of buttock to knee		
17	Distance of ankle to the tip of the foot		
18	Distance of wrist to first phalanx		
19	Distance of wrist to the tip of middle finger		

With the anthropometric form there was conducted the anthropometric survey. In this survey was used the technique commented by Flores (2001) gathering the information in three stages: 1) Personal and institutional data recollection; 2) Measures in standing position; 3) Measures in sitting position. There was used the following measurement instruments: a bascule, 3 extensible callipers, a height anthropometer, an adjustable height bench specially designed and fabricated for this survey, and a support table for the forms.

The data analysis was made in two stages: first it was obtained the measures of central tendency, and second it was obtained the percentiles. Originally it was proposed to use the betas' procedure commented in Mondelo(2001:56-57). But the results of the analysis of the measures of central tendency showed a non-standard population trend, and the original method was changed to an interpolation method.

4. RESULTS

The objectives of the research project were covered. The anthropometric survey was made with seven people in four days at the three campus of the UAEM where there are students of Industrial Design, one day at Valle de Chalco, one day at Zumpango, and two days at Toluca.

The data was analyzed in a semi-manual way and the anthropometric percentiles 5^{th}, 25^{th}, 50^{th}, 75^{th} and 95^{th} of the twenty-six dimensions required was found. The anthropometric tables was made and ordered according to the objectives, and segmented by gender, and got one mixed table of the two genders. The three tables can be found at http://www.disenoempatico.com/tablasantropometricasproyecto.

Respecting to the forth secondary objective, the recommended anthropometric dimensions useful in the design of the aulic workstation are the shown in tables 2 and 3. The specific dimensions for the recommended percentiles can be found at the mentioned webpage.

Table 2. Sitting position.

Dimensions	Recommended percentile
Height	95
Height of the bent elbow	5
Height to the thigh	95
Popliteal Height	5
Width of elbow to elbow	95
Width of hips	95
Abdominal depth	95
Distance of knee to femur	95
Distance of buttock to popliteal	5
Distance of buttock to knee	95
Distance of ankle to the tip of the foot	95

Table 3. Standing position.

Dimensions	Recommended percentile
Weight (kg)	95
Height of Eye to the floor	50
Front reach of the arm	5

5. DISCUSSION

An interesting finding of the survey was that the sample studied showed a trend very different from a standard population. For this reason, it was required to analyze the information in a semi-manual way to get the percentiles. This is, the percentiles can not be calculated by the betas' procedure commented in Mondelo(2001:56-57) because the statistical analysis of the measures of central tendency, mean, mode, median, showed a non-standard population trend.

So it was not an obstacle because it was used the interpolation method, a mathematic procedure used to predict the value of a percentile. With this method, and the help of the spreadsheet Excel, the percentiles were calculated for all the twenty-six measured dimensions.

At this moment, the project is running, it has passed the creative phase and the workstation is in the detailed design stage, where the information obtained from this research its being very useful.

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ANALYSIS OF THE RELATIONSHIP FATIGUE - ANTHROPOMETRY-DESK DIMENSIONS IN STUDENTS OF INDUSTRIAL ENGINEERING PROGRAM

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RESUMEN
Actividades de los tutores del estudiante de Ingeniería Industrial ha puesto de manifiesto que algunos de ellos se quejan de cansancio, dolor de espalda y cuello después de clases. Mediante la aplicación de la encuesta Yoshitaka, H. (1978) a 56 estudiantes para detectar signos de fatiga al final de las clases, se encontró que 67,9% expresó sentir tensión muscular en los hombros y la espalda, y 89,3% expresó su necesidad de estirar los músculos. El objetivo de esta investigación fue estimar los parámetros antropométricos de altura poplítea, longitud nalga-poplíteo, altura de codo sentado y la anchura de la cadera de los estudiantes, así como las dimensiones de los escritorios utilizados y el cálculo de las relaciones entre ellos y comparándolos con las recomendaciones internacionales, demostrar que las mesas "tipo" utilizados por la población en estudio tiene desajustes con las medidas antropométricas de los usuarios y probablemente son causantes del cansancio y los dolores musculares citados. La muestra fue de 46 varones y 12 mujeres estudiantes de entre 19 y 23 años y se concluye que es necesario, para atender problemas de salud de estudiantes, adquirir escritorios ajustables o, al menos, mesas de diferentes dimensiones, de acuerdo con las medidas antropométricas de los usuarios, hombres y mujeres

Palabras clave: Antropometría; Mobiliario escolar; altura poplítea, posturas

ABSTRACT

Activities of tutors for students of Industrial Engineering has revealed that some them complain of fatigue, neck and back pain after classes. By applying the survey Yoshitaka, H. (1978) to 56 students to detect signs of fatigue at the end of classes it was found that 67.9% felt muscle tension on shoulders and back, and 89.3% needed to stretch their muscles . The objective of this research was to estimate the anthropometric parameters of popliteal height, buttock-popliteal length, sitting elbow height and width of the hip of students as well as the dimensions of the desks, and calculating relations between them and the comparison with international recommendations, demonstrate that the desks "type" used by the study population have mismatches with anthropometrics measures of the users and probably are the cause of fatigue and muscle aches cited. The sample was 46 males and 6 female students between 19 and 23 years and concluded that it is required, to meet student health problems, to acquire adjustable desks or, at least, desks of different dimensions, according to the anthropometric measurements of male and female users.

Keywords: Anthropometry, School furniture, Sitting posture.

1 INTRODUCTION

Illness that students in the University level frequently present on semi desert region of Sonora, are those arising from extreme temperatures. In winter, respiratory ailments ranging from colds to flu or respiratory infections are present. In the summer, dehydration and digestive disorders, which usually appear by consuming contaminated foods. Other annoyances are headaches and vision problems, caused by poor light when studying or not wearing glasses when they need them, as well as having changed the habits of sleep or long hours of exposure to the computer, let's also add the discomforts of muscle contractures of neck and back problems due to sitting a long time in inappropriate postures, resulting from bad habits or by using of furniture not consistent with their anthropometric characteristics. In relation to muscle contraction, Parcells (1999) indicates that eighty percent of the U.S. population seek medical attention for back problems at some point in their lives, and contrary to what one might guess, back problems are not confined to adults. A surprising number of children and adolescents are reported to have regular episodes of back pain and neck. Molenbroek (2003) citing Faassen (1978) Liebisch (1990), Snijders et al. (1995), states that headache, neck pain, back pain and deterioration in focusing on students, are the result of prolonged sedentary positions for educational purposes, so please pay attention to the design of school furniture. Discrepancies between anthropometric measurements of the pupils and the size of the desks in basic education schools are reported by Molenbroek (2003) quoting Parcells et al. (1999), Linton et al. (1994) and Aardoom (1987).

Activities of the mentoring program for students of Engineering have revealed that some of them complain of fatigue, back pain and neck after school. while conducting an informal investigation some pictures were taken of students sitting at a desk type attitude of being engaged in the classroom (Figure 1) and it could be seen that in some cases, the dimensions of the desks were small and in others large compared to anthropometry of students, which prevented them from taking a neutral position which minimizes the effort of the muscle tissue and enhances circulation and recovery of the body.

To quantify the incidence of muscle pain in the students we proceeded to estimate the proportion of students who felt physical discomfort after a day of classes, we took a random sample of 56 students after a day of classes, and assigned the questionnaire Yoshitaka H. (1978) "Three characteristic patterns of subjective fatigue symptoms" and found that 67.5% of

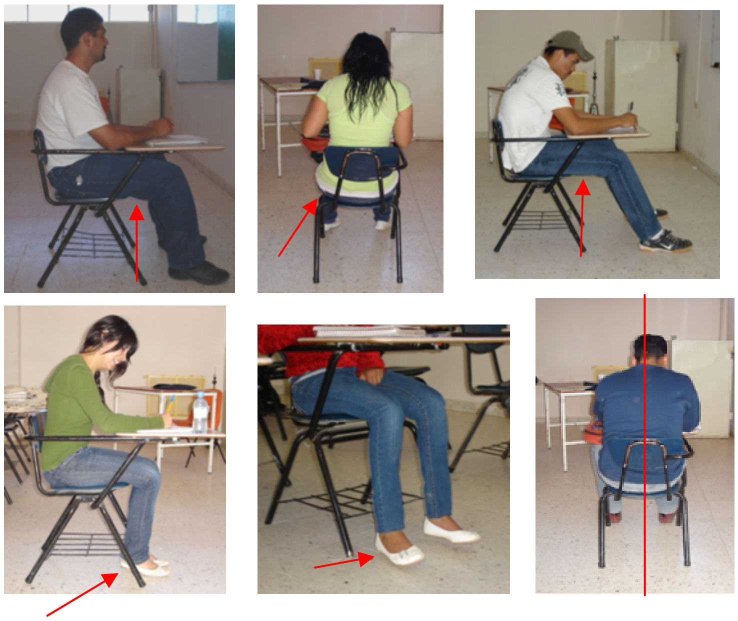

Fig. 1 Photo of students sitting at desks

them reported feeling tension in their shoulders and back pain, 89.3% showed willingness to stretch and 50% difficulty straightening their body. Moreover, most students of Engineering take between 6 and 7 subjects per semester, this means that they spend an average of 5.4 discontinuous hours to academic activities in the classroom in seated position, so the discomfort of their muscles are probably caused by the mismatch between the size of desks and anthropometric measures of the students. The intent of this work is to provide consistent evidence of the existence of factors that could negatively interfere in the academic performance of students and secondly, because there isn't a published anthropometric data of the student population at the University of Sonora, to provide information to the Anthropometric data base that is being built for the ergonomics discipline group of the University of Sonora, campus Caborca.

2 OBJECTIVES

The aim of this study was to estimate the proportion of mismatches between anthropometric measurements of students with type desks used by them, assuming that these desks and anthropometry of the students do not have a healthy relationship, according to the international recommendations. The research was conducted in the student population of Industrial Engineering at the University of Sonora, Northern Unit, Campus Caborca, and there is no reason to believe that the anthropometric data of the school population in the study population differ from other study school programs at the University of Sonora, however, there may be differences in the type and size of racks used in other curricula, so perhaps the results might or might not indicate an important problem at the institution. Furthermore this research was limited to the analysis of the relationships associated with the anthropometric height, width and depth of seat and table top, the table-length support with abdomen length, size of the table with hands or any preferential and backed up with Lordotic curvature were not examinated.

3 FRAME OF REFERENCE

3.1 Body weight and muscle activity in sitting position

Parcells (1999) citing Zacharkow D. (1988) argues that, the adverse effects of body weight and muscle activity in sitting position for inadequate school furniture have been known for a long time. He Also expresses that the dynamics of a seated position can be better understood by studying the mechanical parts of the body and the external support system involved. For example, 75% of total body weight is supported to be seated in an area of only 4 plg2 (26 cm2) of surface. This small area is under ischial tuberosities of the pelvic. The heavy burden is concentrated in this area, according to Tichauer E. (1978), causes a compression between 85-100 pounds per square inch (psi). Structurally, the tuberosities are two-point supports system that is inherently unstable, so the center of gravity of a person sitting on top of that zone can not be directly on the tuberosities and the area is insufficient to stabilize which makes it necessary to use the legs, feet, back in contact with other surfaces, as well as muscle forces to produce equilibrium P. Branton Et al (1969). Haffin (1999) states: The legs, when sitting, distribute and reduce the load on the buttocks and the back of the thighs. The legs must rest firmly on the floor or foot support, thus the weight of the lower leg is not supported by the front of the thigh resting on the seat. If pressure is applied on the thigh near the knee swelling can occur in the legs and pressure on the sciatic nerve. Winkel and Jorgensen (1986) state that in general, the legs increase their volume between 2.3 and 4% in a workday. In relation to muscle activity, Chaffin (1999) notes that electromyography has been used in some investigations to study the muscular activity of the back in sitting position. In these studies yamaguchi et. al. (1972) found that muscle activity detected by electromyography in the lumbar area decreases when armrests and seats tilted to the back are used this probably is because the load is transferred to the backrest. Likewise Åkerblom (1948) found that support in the lumbar region is more effective than a stand in the back. Bendix et. al. (1987) found no differences in muscle activity between seats slope tilted backward or forward, or adjustable tilt. Lunderbold (1951) found that the length of tables high or low relative to the leg lengths of users increases muscle activity, and so does the vertical length between the seat and the table.

3.2 Relationship popliteal height and seat height

Chaffin (1999) says that, when the seat height is very low, the knee bending angle becomes sharp, and the weight of the trunk should be transferred to the seat through the back of the thigh, it is transferred through a small area on the isquial tuberosities on the pelvis (Keegan, 1953, Floyds and Roberts, 1958, Kroemer 1971, Kroemer and Robinett 1969). When the seat height is so high that the feet do not touch the ground pressure on the back of the thigh is not very comfortable (Åkerblom 1948.1969, Schoberth 1962, Bush 1969) and the person tends to go to the front of the seat of the chair, allowing to support feet on the floor but the support is not used properly, resulting in low back pain if the position is for a long time (Burant and Grandjean 1963, Kroemer 1963.1971). Feet should rest firmly on the floor or on the foot support so the weight of the lower leg is not supported by the thighs that rest on the seat. In addition to ISO 9241-5: 2003 states: It is not acceptable to assume that people stay with the legs vertical it is convenient, therefore, that the lower leg can reach the ground in front of the knee, so that it presents a greater articulation angle of 90 º.

3.3. Buttock-knee length with a deep seat

In the ISO 9241-5: 2003 notes: seat depth is important both to ensure that the legs can be placed without compressing the back of the knees and to be able to rely fully on the back. The back of the knee is a fairly sensitive skin and tendons have little protection, so the depth of the seat should be slightly shorter than the length between the back of the knee and thigh. A big depth of the seat does not an appropriate use of back support which causes curvature of the spine (kyphosis) and may lead to no comfort.

3.4 Relationship wide hips and wide seat

In the ISO 9241-5: 2003 A.2.3 states: Besides the obvious need to ensure that a reasonable proportion of the population of potential users can easily get up and sit down, this is one of the most important way to ensure that the user lessens the burden by taking the postural position. Due to the flattening of the buttocks and the tendency to open her legs while sitting, the anthropometric measure width of the hips should be lower than what should be allowed for width of the seat. There must be added, on each side, an extra width for movement of the arms if the seat is equipped with armrests.

3.5 Relationship elbows height with work table height

Chaffin (1999) noted that the height of the table in relation to the person, is very important not only for the bottom but it affects the shoulders and torso height, depending on the position and supporting arms. A work surface, located above the elbow, causes arm abduction, resulting an increase in the stress of the shoulders, arms and necks. For prolonged work, it is recommended that the shoulder's abduction angle is between 15^0 and 20^0. Bendix (1987) recommends that the height of the desk must be between 3 and 4 cm above the elbow height of the person in sedative position.

4 PROCEDURE

In fall of 2008, to be able to realize this research and beginning from the assumption to estimate the proportion of pupils who do not have a healthy relationship between physical size and dimensions of the desks used by a confidence interval of 90% with an estimation error of ± 0.08%, we calculated a maximum sample size of 67 students of a population of 180 students of Industrial Engineering, given the proportionality of gender, a sample of 52 students was selected of whom 46 were men and 6 women between 19 and 23 years old, 15 anthropometric measurements were taken in sitting position and stand up; they were wearing common clothes, with casual shoes or tennis shoes, jeans and polo shirts. For this research measures of interest were popliteal height, buttock-knee length, width of the hip and seat-elbow height at 90^0. On the other hand the dimensions of the desk used were obtained. With this information the analysis of the corresponding relations was realized comparing them with the published recommendations and this way to demonstrate that the desk used by the population in study has mismatches with anthropometric measurements of the users and are probably the cause of fatigue and muscle pain, maybe affecting academic achievement.

5 ANALYSIS OF RESULTS

5.1 Definition of criteria

Based on anthropometric measurements of their population in different countries recommendations have been developed on the dimensions of the chairs for work done in sitting position, especially the recommendation to use adjustable chairs so that each user can regulate them and achieve comfort and possibilities of changes in posture. Two recommendations are shows in Table 1.

Table 1 Dimensions recommended for office chairs

	BIFMA 2002	ANSI/HFES 100-2007
Seat heigth	Adjustable from 39.2 to 49.75 cm	Adjustable from 39.0 to 55.0 cm
Seat width	Minimum 45 cm	Minimum 45.25 cm
Seat length (depth)	Minimum 42.25 cm	Minimum 42.25 cm
Seat slope angle	from 0^0 to 40^0 backward	from 0^0 to 10^0 backward
Backrest height	More 30.5 cm	More 44.25 cm
Backrest width	at least 35.5 cm	at least 35.6 cm
Backrest-seat angle	at least 90^0 between thigh and torso	at least 90^0 between thigh and torso
Lumbar support	Between 14.75 y 24.5 cm height of the most forward point of the support	Between 14.75 y 23.25 cm height of the most forward point of the support
Armrest height	form 17.25 to 24.5 cm	From 17.75 to 26.5 cm

source: Fernandez and Marley, Applied occupational ergonomics, International journal of Industrial Engineering Press, Cincinnati OH, 2007

In relation to the height of the working surface in seated position, there are some recommendations like the ones published by Chaffin (1999), the standards of the German rules, Switzerland and Europe, which recommend 65 to 75, 67 to 78 and 67 to 77 cm from the floor respectively, also Fernandez (2007) who, quoting Ayoub (1973) recommended for men between 72.5 to 77.5 cm and from 68.75 to 73.75 cm. for women long soil-work surface. All these recommendations were generated based on the anthropometric population of their respective countries. In the Mexican nation, according to Prado (2009), there are a few research publications of anthropometric measurements with an ergonomic approach, there is one Mexico city by Sanchez Monroy, (no year of publication), another in the United States-Mexico border by Chen et. H., (1999) and one on school children in the Metropolitan Zone of Guadalajara, Jalisco of Prado et. H., (2001), the book Anthropometric dimensions of Latin American Population was published recently by Avila, et. al.(2007) which includes anthropometric information of the population of the city of Guadalajara, Jalisco, Mexico. Since there is no anthropometric data of the Mexican population, there are no published recommendations for the dimensions of chairs and work surface heights for workstations and furniture used in the classroom, including desks. In this situation, in most sections of the analysis results, the criteria published by Parcells, et. H. (1999), because recommendations are not based on anthropometric dimensions population but are recommendations percentage ranges of anthropometric dimensions of the user.

5.2 Analysis of relationship popliteal height and seat height

Parcells et. al. (1999) defined on the basis of existing research that, a mismatch in the height and popliteal height seating is provided for any seat whose height is> 95% or <88% of popliteal height of the subject. This allows a clear knee between 5% and 12% of popliteal height. Under this criterion it was found that 78.85% of all students in the sample show a disagreement between popliteal height and seat height of the desk. The latter exceeds in 97.6% of the cases the upper limit recommended. Also the author states that in order to determine how the results are sensitive to changes in the definition, using a stricter definition of a mismatch: seat height with> 99% or <80% of popliteal height. Under this new approach it was found that 76.92% of all students in the sample, show a disagreement between popliteal height and seat height of the table because the latter exceeds in all cases the upper limit set. With both approaches can be seen that there is a disagreement between the two dimensions because the seat height is desks beyond the upper limit.

5.3 Analysis of relationship buttock-popliteal length and seat depth

Just as in the previous analysis Parcells (1999) determined that a misalignment of the buttock-knee length and depth Seat is for any seat depth that is> 95% or <80% of the buttock-knee length of the subject Under this criterion it was found that 98.07% of all students in the sample, show a disagreement between their buttock-popliteal length and seat depth of the desk as the latter is smaller in 95.3% of the cases to the lower limit established. Also according to Parcells (1999), to determine how the results are sensitive to changes in the definition, using a stricter definition of a mismatch: seat depth> 99% or <80% of the length of the buttock-popliteal subject. Under this new approach the same percentage of mismatch was found in the implementation of the above criteria.

5.4 Analysis of relationship hip width and width of seat

There is no recommendation by Parcell (1999) in relation to the gap between hip width the seat width, however, Melo (2009) states: An important element in the magnitude of the pressure under the buttocks is the form of the supporting surface, a flat surface provides less contact for the exchange of muscular load while a curved surface (anatomical) allows a greater contact area and when containing the muscle mass prevents deformation was so there is more mass (more fiber), less traumatizing to the muscle, which causes the body to rest. In the literature there were found a number of recommendations, Mondelo (2002) recommends a seat higher than 48 cm. Fernandez (2007) recommends hips wide plus 5 cm., ISO 9241-5: 2003 indicates that the seat width must be greater than the width of the hips, ANSI / HFS indicate that should be 45 cm, Molenbroek et. H. (2003) recommended a seat width equivalent to 99 percentile value plus 15%. This study found that in 69.23% of the participants has a width of the hip over the 36 cm. that is the measure of the width of the seat which is a mismatch in any of the recommendations, the seat also has a curved surface that hip length exceeds the width of seat, the side edges of the same curvature, rather than being a supporting surface to hold the muscles become edges that compress the thigh and buttock with the weight of the portion of hip width in excess of the seat. Moreover, the width of the table type seating is limited by the right side, for the support of the work table 4 cm. distant from the seat so the user, in most of the cases can not accommodate their hips as equidistant from the center of the seat.

5.5 Analysis of relationship elbow height at 90^0 and work surface height

As the analysis of the previous relationships we found that there are several recommendations in height ranges that working surfaces must have. For this investigation, and considering that there are not anthropometric measures of the population, using the recommendations made by Chaffin (1999) who notes that the table height should depend on the user's elbow height for what he recommends The height of the desk, the activity in writing, should be between 3 and 4 cm. above the elbow height of each person in a sedative position. Under this criterion the results are found in Table 2.

Table 2 Results of relationship Elbow height at 90^0-table height

	frequency	%	Table height
acceptable	12	23.08	Between the range
not acceptable	14	26.92	Very high
	4	7.69	Equal to of elbows height
	15	28.85	Slightly lower
	7	13.46	very low

6 CONCLUSIONS AND RECOMMENDATIONS

The results obtained in this investigation show that there is consistent evidence to conclude that the dimensions of the desks used by the Industrial Engineering students of the study population present a mismatch with the anthropometric characteristics of students and, considering that in some cases this mismatch is very strong, can be an important factor which influences the academic productivity of the same.

The main indicators of bad adjustment were:

- Over 60% of students had a mismatch with the seat height, the seat is too high.
- Over 98% of students had a mismatch with the depth of the seat, the seat is too short.
- The 69.23% of students had a length greater than the width of the hips of the seat, the seat is very narrow.
- In 77% of the cases the height of the table presents a mismatch, of these, 34.61% higher than what is recommended and 42.31% lower than recommended for the type of work being done.

Given the above findings and considering that this is a relatively small sample in relation to the size and diversity of environments within the University of Sonora is recommended to develop an anthropometric database of students on the basis of it, at the time of renewal of furniture, take into consideration this information either to gain adjustable furniture or possibly acquire, in size, three types of desks, large, medium and small so that students have the options and find the most suited to their anthropometry.

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Maximum force of grip with dominant and non-dominant hand

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Resumen: Para llevar a cabo un buen diseño del puesto de trabajo es imprescindible determinar los espacios necesarios para desarrollar la actividad requerida; en segundo lugar, se necesita conocer la postura adoptada que junto con la repetición de movimiento y la fuerza necesaria para ejecutar las tareas, nos indicara cual es el puesto con el menor riesgo de lesiones.

Este estudio es para determinar cuál es la máxima fuerza de agarre recomendada para una amplia variedad de actividades intensivas de manipulación manual comúnmente encontradas en los lugares de trabajo. Estas actividades han sido objeto de estudio por lo importante que es el evaluar el diseño de las estaciones de trabajo y determinar el riesgo que representan para la salud de los trabajadores.

Palabras Clave: Biomecánica, esfuerzo máximo

Abstract: To implement a good design job is essential to determine the space needed to carry out the activity required, and secondly, you need to know the position that with the repetition of movement and strength necessary to perform the tasks We outline the position with the least risk of injury.

This study is to determine the recommended maximum grip strength for a wide variety of intensive manual handling commonly found in workplaces. These activities have been examined by how important it is to assess the design of work stations and determine the risk posed to the health of workers.

Keywords: Biomechanics, maximum effort

INTRODUCTION

The need to protect workers against the causes of occupational diseases and accidents is a matter unobjectionable. Any source of work should make efforts towards the prevention of occupational risks, with consequent advantages in production and productivity, thus achieving a greater social welfare, which is reflected in the economy of the company.

Ergonomic principles that are based on product design and other work must focus on the knowledge of the skills and abilities, as well as limitations of the people designing these elements used in the light of these characteristics. Tortosa et al (1999).

The incidence of problems with injuries that are associated with ergonomic problems has increased steadily in recent years. The Administration of Occupational Safety and Health estimates that in the European Union due to overexertion injuries, poor posture and repeated trauma accounted for 20 to 25% of total accidents. OSHA (2000).

Occupational injuries in Mexico represent a significant problem for small, medium and large industries. According to information reported by the Instituto Mexicano del Seguro Social from 1999 to 2003, disorders of the synovial capsule of sinovia and tendons, and carpal tunnel disorders, are among the first eleven places higher incidence of work-related injuries, which can be reduced with the participation of ergonomics, to intervene in the assessment, design and redesign of activities and jobs. Perez (2006).

Batti'e MC et al (1989). He mentioned that currently, when the limit to be used in industrial operations using criteria established workers in Central American population, or due to be of different races and / or different anthropometric characteristics, develop muscle strength not have to match individuals from the Latin race, and if, as seems logical, this force is superior to ours, the values considered appropriate now exceed the capabilities of our compatriots and can aggravate or cause the occurrence of injuries in our population .

Because in Mexico there is no evidence confirming the use of standard grip forces that can be exercised in carrying out manual handling of materials, this research project is developed in order to know the maximum grip force workers Hermosillo, Sonora in different working conditions. Therefore, it poses the following question:

What is the acceptable maximum grip force than men and women can exercise with their dominant and non dominant hand using gloves or not, for the people of the city of Hermosillo, Sonora?

OBJECTIVE

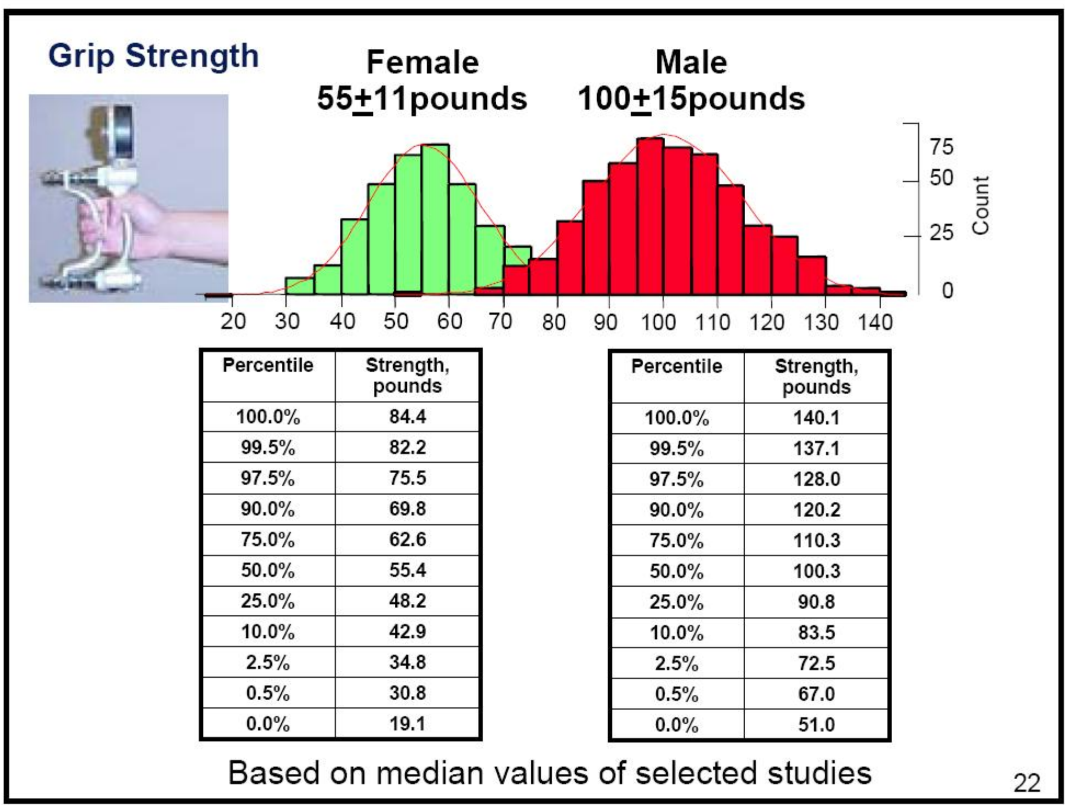
The objective of this research is to determine the maximum force of grip they can have men and women with non-dominant and dominant hand using wadding or not for the people of the city of Hermosillo, Sonora.

OTHER RESEARCH ON THE SUBJECT.

Armstrong (2002), in its investigation found that the average grip strength for women was 55 ± 11 pounds for men and 100 ± 15 pounds (average ± standard deviation), as shown in Figure 1. He mentioned that the important factors affecting the strength are: position, gender, dominant hand and non dominant age / condition, fatigue, and gloves.

Further found that the force required to load a tool can be small compared with the force required to use the tool, and also that the force required to load a part perhaps is small compared with the force required to install, are some examples Figures 2 and 3 respectively.

Armstrong (2002) also mentions that the absolute force is measured in pounds, Newton or kilograms (kg but is technically not a strength). The relative strength is a fraction of an absolute value and may be expressed as a simple fraction, eg, ½, a decimal fraction, eg, 0.5, a percentage, eg, 50%, an arbitrary number on a scale, eg, 5 to 0 to 10.



Percentile	Strength, pounds
100.0%	84.4
99.5%	82.2
97.5%	75.5
90.0%	69.8
75.0%	62.6
50.0%	55.4
25.0%	48.2
10.0%	42.9
2.5%	34.8
0.5%	30.8
0.0%	19.1

Percentile	Strength, pounds
100.0%	140.1
99.5%	137.1
97.5%	128.0
90.0%	120.2
75.0%	110.3
50.0%	100.3
25.0%	90.8
10.0%	83.5
2.5%	72.5
0.5%	67.0
0.0%	51.0

Figure 1. Average grip force.
Source: Armstrong (2002).

Figure 2a.. Grip force.

Figure 2.b. Insertion force.

Figur3 3.. Working with gloves.

Hertzberg (1955), the results of their research with 44 fighter pilots who use gloves as protection, are tabulated in Figure 4, where each subject using gloves in the appropriate tests to perform 8 and 20 minutes rest between each one, as shows the subjects exerted more force with the separation of 2 ½ inches than any other (4 separations are handling 1 ½, 2 ½, 4 and 5 inches), each subject lost almost 20 percent when using gloves. Obviously does not mean that 2 ½ inches is the best distance for all hands, big and small. Means that the distance of 2 ½ inch is close to being the optimal distance for each hand than any other tested distance. But 2 ½ inches becomes an acceptable basis for any design that should allow the application of maximum force over a wide range of sizes of hands.

The data are fundamental to the ergonomic design of safe and easy to use (Norris and Wilson, 1997), and the benefit of using this data in the early stages of the design process is widely recognized. Peebles and Norris (2003)

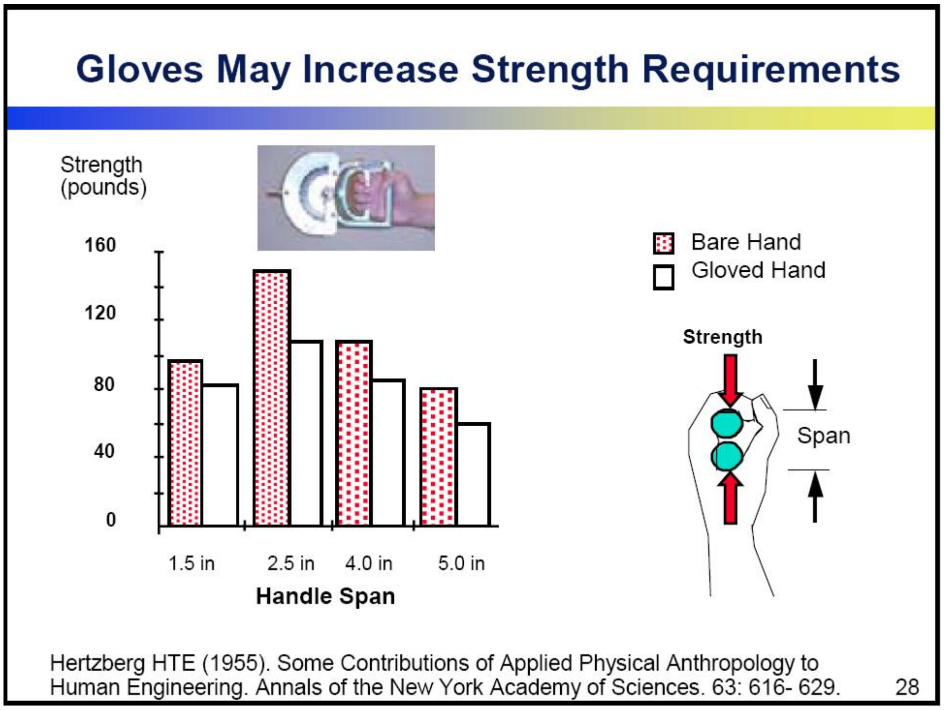


Figure 4. The use of gloves increased strength requirements**.**

It was in response to this need for ergonomic data that the University of Nottingham, in partnership with the Department of Consumer Affairs of the United Kingdom Department of Trade and Industry (DTI), recently produced a series of publications that bring together everything relating to data design in a user-friendly compendium of resources for design. The three publications on children, adults and elders ('Childata', 'Adultdata' and Older Adultdata ') (Norris and Wilson, 1995, Peebles and Norris, 1998, Smith et al., 2000) containing anthropometric data and physical strength upgraded to more countries around the world.

MATERIALS AND METHODS

To achieve the objective of this study involved healthy men and women, aged between 18 and 30 years, students and degree-level skills in industrial manual materials handling, all subjects were informed of the procedure of the study and allowed to participate .

The measurements were carried out with a hydraulic hand dynamometer Jamar brand, model

5030J1, shown in Figure 5, and offers the following features for routine evaluations and the evaluation of trauma and diseases of the hand

Figure 5. Hydraulic Dynamometer JAMAR.

We used 100% cotton gloves for the experiment, knitting special type of Japanese 45 grs. with adjustable elastic cuff at hand, fits, as shown in Figure 6
.

Figure 6. 100% Cotton gloves.

Method

The experiment research consists of two phases, first phase was a series of measurements to find out which found its highest opening grip strength most of the subjects who participated in the same, ie to find which of the five sizes the handle of the dynamometer is ideal for the second phase of the experiment,
In the first phase, involving 21 subjects, 10 men and 11 women were treated with 10 tests each hand, we used five different measures to handle with the dynamometer (1 3 / 8, 1 7 / 8, 2 3 / 8 , 2 7 / 8, 3 3 / 8 inches) with and without a glove.

In the second phase, subjects participated x, x and x men women, 2 tests were handled in each hand, using the size 1 7 / 8 inch (4.7625 cm.) The opening of the handle of the dynamometer, with a glove and the other without he.

When performing the procedure is assessed the maximum force of grip, Baker (1993), that requires a minimum of three efforts, separated from them at least 10 seconds, minimum time required for muscles to recover from the effort.

It was recorded only the maximum strength of each test, ie if the first test of grip becomes more serious in the subsequent peak force and in his case if the second or third largest is the reader and the move would be recorded. Based on this, only the maximum grip strength of men and women in each of his hands with or without a glove was recorded.

RESULTS

Table 1 is generated which specifies in general with which each subject was opening the maximum grip strength, which also shows opening with and without the use of gloves and the value in pounds. The results obtained from the accumulation each aperture is shown in Table 2.

In table 2 shows clearly that the ideal size of the aperture for phase 2 of the experiment is $1^{7/8}$ inch (4.7625 cm) and in 7 out of 10 male subjects, and 9 out of 11 female subjects obtained their maximum grip strength. No glove 5 out of 10 male subjects and 7 out of 11 female subjects and 9 of each glove 10 male subjects and 9 out of 11 female subjects obtained their maximum grip strength

We can also see which is the only size where no subject was opening its maximum grip strength, was the largest of the opening 3 3 / 8 inch (8.5725 cm). From the tests conducted in phase 1 were the 420 samples that are contained in Annex A, the samples were obtained Table 4.3 which is the statistical description of each opening with and without gloves, which shows the average standard deviation, minimum value, maximum value among other values that were used later.

Comparison of Media With and without gloves.

In Table 3 are the average of the maximum grip aperture of each are shown graphically in

Figure 1. In this figure confirms that the aperture size for Stage 2 is to 1 7 / 8 ", the highest peak in the middle and is given in glove with the opening two.

We can see clearly in the same figure using the glove increases, this result contradicts the statement in the investigation of Hertzberg (1955) which says that each person loses about 20 percent when using gloves

Table 1.- Aperture where each subject received the maximum grip strength

		sin guante		con guante		apertura
#	Gen.	fma kg.	apertura	fma kg.	apertura	en general
1	M	45	2	43	1,2,3	2
2	M	42	3	43	2	2
3	M	42	3	58	3	3
4	M	44	4	40	2	4
5	M	56	2	62	2	2
6	M	49	4	64	2,3	2,3
7	M	49	2	52	2	2
8	M	44	2	46	2	2
9	M	70	2	66	2	2
10	M	61	1	54	2	1
1	F	30	2	26	2,4	2
2	F	28	2	24	2	2
3	F	24	1	24	2	1,2
4	F	34	2,4	40	2	2
5	F	26	2	24	2	2
6	F	22	1	24	1	1
7	F	19	4	22	2	2
8	F	28	2	26	2	2
9	F	28	2	23	2	2
10	F	24	2	26	2	2
11	F	27	3	28	3	3

Tamaño de Apertura	
1	1 3/8
2	1 7/8
3	2 3/8
4	2 7/8
5	3 3/8

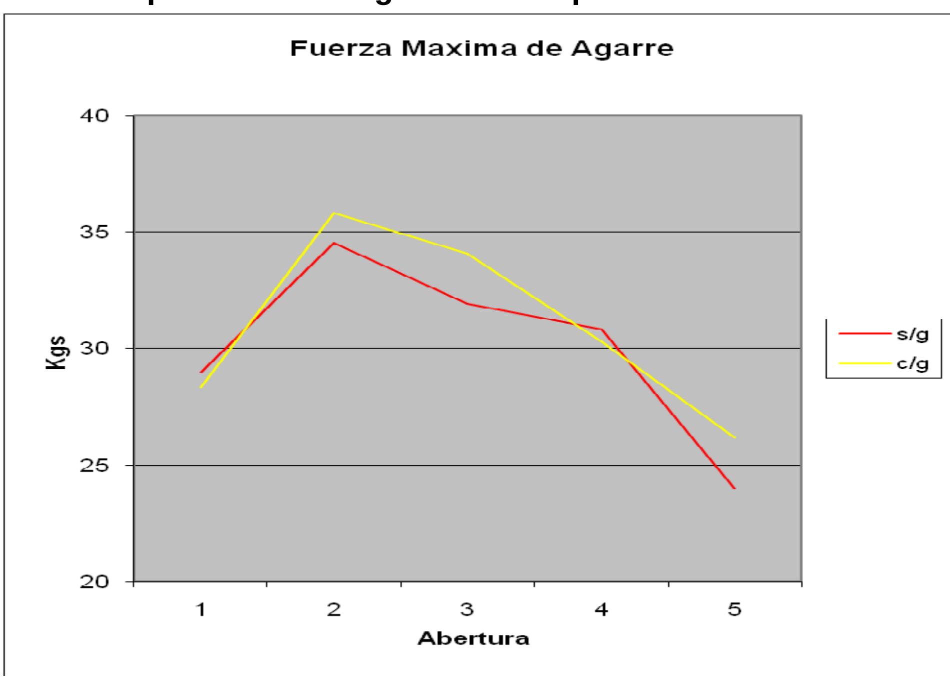
Table 2.- Aperture results.

Resultados del Genero Masculino				Resultados del Genero Femenino			
Tamaño de	Cantidad x cada 10 sujetos			Tamaño de	Cantidad x cada 11 sujetos		
apertura (")	sin guante	con guante	en general	apertura (")	sin guante	con guante	en general
1 3/8	1	1	1	1 3/8	2	1	2
1 7/8	5	9	7	1 7/8	7	9	9
2 3/8	2	3	1	2 3/8	1	1	1
2 7/8	2	0	1	2 7/8	2	1	0
3 3/8	0	0	0	3 3/8	0	0	0

Table 3.- Average of the aperture With and without glove.

aperture	wo/g	w/g
1	28.98	28.33
2	34.55	35.83
3	31.93	34.07
4	30.83	30.29
5	23.98	26.17

Figure 1.- Graph of the average for each aperture with and without gloves.



Data Tables 6 through 9 present the results of maximum grip force for both male and female populations in each condition. In Tables 6 and 7 represent data grouped by percentile in Tables 8 and 9 represent the mean and standard deviation

Table 6 Percentiles of maximum grip force for females in each condition

	KG. - FUERZA			
	Sin Guante		Con Guante	
Percentil	MD	MND	MD	MND
100%	38	41.00	40	38.00
99.5%	36	37.50	38	34.50
97.5%	34	34.00	36	31.00
90%	30	28.00	32.5	30.00
75%	28	26.00	28	25.50
50%	24	23.00	26	22.50
25%	22	20.00	22	20.00
10%	19	16.00	20	18.00
2.5%	14	16.00	16.5	16.00
0.5%	12	15.50	16	16.00
0%	10	15.00	16	16.00

Table 8 Percentiles of maximum grip forces for males in each condition.

	KG. - FUERZA			
	Sin Guante		Con Guante	
Percentil	MD	MND	MD	MND
100%	66	70.00	65	66.00
99.5%	65	66.00	64.5	65.00
97.5%	61.5	59.50	62.5	63.00
90%	54.5	54.00	54.5	53.00
75%	47	45.00	50	46.00
50%	42	40.00	44	42.00
25%	36	33.50	38	34.00
10%	32	26.00	34	30.50
2.5%	27	22.00	29	28.00
0.5%	23	21.00	26.5	28.00
0%	22	20.00	26	28.00

Table 8.- Average and standard deviation of maximum grip force obtained for the female population

PRUEBAS/KG.FUERZA	PROMEDIO	DESVIACION ESTANDAR
SIN GUANTE / MD	24.479	5.336
SIN GUANTE / MND	23.042	5.153
CON GUANTE / MD	25.417	5.156
CON GUANTE / MND	23.229	4.628

Table 9 Average and standard deviation of maximum grip force obtained for the male population

PRUEBAS/KG.FUERZA	PROMEDIO	DESVIACION ESTANDAR
SIN GUANTE / MD	42.58	9.07
SIN GUANTE / MND	39.8	10.59
CON GUANTE / MD	44.29	8.84
CON GUANTE / MND	41.53	9.14

Comparison with other investigations.

First of all, we are represented as the results of previous studies, in this case comparing the investigation of Armstrong (2002), gathering information and converting the same way. The tables 10 and 11 accommodate the information with the same percentile groups of both genders and converting the results of this study force kilograms to pounds force to compare the results more easily. The mean and standard deviation are shown in Table 12.

Table 10 Percentiles of the maximum grip force for female population.

Percentil	Kg. -Fuerza	Lb. -Fuerza
100%	41	90.39
99.5%	40	88.18
97.5%	35	77.16
90%	30	66.14
75%	27	59.52
50%	24	52.91
25%	20	44.09
10%	18	39.68
2.5%	16	35.27
0.5%	14	30.86
0%	10	22.05

Table 11 Percentiles of the maximum grip force for male population..

Percentil	Kg. -Fuerza	Lb. -Fuerza
100%	70	154.32
99.5%	66	145.50
97.5%	64	141.09
90%	55	121.25
75%	48	105.82
50%	42	92.59
25%	36	79.37
10%	30	66.14
2.5%	26	57.32
0.5%	22	48.50
0%	20	44.09

Table 12 Average and Standard Desv. for the sample.

	KG. FUERZA		LB. FUERZA	
	MEDIA	DESV. EST.	MEDIA	DESV. EST.
MUJERES	24.04	5.13	53.00	11.31
HOMBRES	42.05	9.51	92.70	20.97

The results obtained in both investigations are presented in Table 13, where you can see a similarity between the maximum grip strength obtained for the populations of the city of Hermosillo, Sonora and the United States.

In this table shows that the values of maximum force grip T. Armstrong is a little lower than the results of this investigation. In table 14 are considered the average value and standard deviation of the results of this investigation (Table 12) and the outcome of T. Armstrong (Figure 1), for comparison of the maximum grip. The values are lower at this time.

Table 13 Comparison of results obtained from the this investigation and by Armstrong in 2002

	Libras Fuerza			
	Presente investigación		Armstrong (2002)	
Percentil	Mujeres	Hombres	Mujeres	Hombres
100%	90.39	154.32	84.4	140.10
99.5%	88.18	145.50	82.2	137.10
97.5%	77.16	141.09	75.5	128.00
90%	66.14	121.25	69.8	120.20
75%	59.52	105.82	62.6	110.30
50%	52.91	92.59	55.4	100.30
25%	44.09	79.37	48.2	90.80
10%	39.68	66.14	42.9	83.50
2.5%	35.27	57.32	34.8	72.50
0.5%	30.86	48.50	30.8	67.00
0%	22.05	44.09	19.1	51.00

Table 14 Average and Standard Desv. of men and women obtained from this investigation and by Armstrong in 2002.

	Libras Fuerza			
	Presente investigación		Armstrong (2002)	
Genero	Media	Desv. Est.	Media	Desv. Est.
Mujeres	53.00	11.31	55	11
Hombres	92.70	20.97	100	15

Of the four tests of the hands of forces which were made in the study of Mathiowetz et al. (1985), we focus only on that of the present study, which is in the grip strength test, both studies used a similar mark Jamar dynamometer with adjustable handle, remaining fixed in the 2nd position for all subjects.

As in the present study the age range of the subjects who participated were 19 to 27 years, we consider only 2 of the 12 age groups in the study who managed to compare, so the characteristics of the subjects that taken into account is shown in table 15

Table 15 Characteristics of the subjects in both studies: age, sex and dominant hand.

Mathiowetz et al. (1985)								
	Hombres				Mujeres			
			Mano Dominante				Mano Dominante	
edad	N	Edad(x)	D	I	N	Edad(x)	D	I
20-24	29	21.7	26	3	26	22.4	26	0
20-29	27	27.4	21	6	27	26.6	25	2
Presente Estudio								
edad	N	Edad(x)	D	I	N	Edad(x)	D	I
19-24	108	21.1	100	8	96	21.1	90	6
25-29	2	27	2	0	0			

As mentioned earlier, unlike the present study all subjects using a standard dynamometer was loaded slightly by the examiner. The present study used an open stance and to prevent the fall of dynamometer, it contains a loop which is placed around the wrist for each measurement.

Accommodate the results of grip strength in the same order used by Mathiowetz to have an easier way of comparison, results are also handled in pounds and are shown in Table 16.

Table 16.- Result of the grip strength of both studies

Mathiowetz (1985)		hombres					mujeres				
edad	mano	media	s/d	se	low	high	media	s/d	se	low	high
20-24	derecha	121	20.6	3.8	91	167	70.4	14.5	2.8	46	95
	izquierda	104.5	21.8	4	71	150	61	13.1	2.6	33	88
25-29	derecha	120.8	23	4.4	78	158	74.5	13.9	2.7	48	97
	izquierda	110.5	16.2	3.1	77	139	63.5	12.2	2.4	48	97
Presente Estudio		hombres					mujeres				
edad	mano	media	s/d	se	low	high	media	s/d	se	low	high
19-24	derecha	97.06	21.35	2.05	48.5	154.32	55.34	11.37	1.16	22.05	88.18
	izquierda	88.74	20.06	1.93	44.09	136.69	50.66	10.79	1.1	33.07	90.39
25-29	derecha	87.09	10.91	7.71	79.37	94.8					
	izquierda	77.16	9.35	6.61	70.55	83.77					

CONCLUSIONS

As seen, if we think the information they had read and from other populations could be applied to our population. When looking for an ergonomic standard is necessary to consider the reference population in order to know whether it applies to our situation.

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CAPTURING HUMAN MOVEMENTS AND HOW TO USE IT IN A 3D ANIMATION

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Resumen: este estudio se enfoca a ver como es posible capturar la escala humana con un sistema económico de captura eliminando los altos costos de los sistemas comerciales, este sistema captura el movimiento humano en 3D, utilizando para ello cámaras caseras, pintura fluorescente y un algoritmo de seguimiento. Extrayendo las coordenadas X, Y y Z de los marcadores para ser utilizados en un carácter en 3D dentro de un ambiente arquitectónico. Este estudio trata de acercar crear un sistema barato para poder estudiar los movimientos reales de una persona.

Palabras clave: Luz ultravioleta, luz negra, tintes fluorescentes, captura de mocimiento, animación en 3D

Abstract: This study aims to show how it is possible to replace some elements in a commercial motion capture system; capturing an actor's movements, getting clean data and applying it to 3D character to create full computer animation. This approach captures 3D movement using two video streams obtained with Ultraviolet light fixtures and low glow in the dark markers. Extracting the markers X, Y and Z coordinates with a tracking algorithm designed for the purpose and importing this 3D data into 3D software. After a series of video tests it is noticeable that only the fluorescent markers are visible and nothing else. This study will try a new approach within this area of research. Applying some techniques and ideas from other fields, the author will bring new evidence into the motion capture field.

Keyword: Ultraviolet light, black light, fluorescent dyes, motion capture, 3d animation.

1. INTRODUCTION

Most motion capture systems are cumbersome, expensive, time consuming and intrusive. These drawbacks may not only prevent MoCap data from being easy to use but they might make it impractical for other potential applications (Liu, Zhang et al. 2006). The creation of a new practical, cheap, fast and intuitive motion capture is a must. Our goal is to establish a

new technique and equipment capable of capturing movements in a dim room and reduce the cost of motion capture developing. In addition a new image processing tracking algorithm which will be used to improve the quality of motion capture data making it accessible to a wider audience including those with minimum knowledge of the field.
This Ultraviolet system proves to be practical, fast and straightforward, its only takes few minutes from capturing the video to create the 3D animation.
G. Johansson's experiments show (Johansson 1973), that with only a few white dots against a dark background the idea of movement can be shown.
Generally a passive MoCap system consists in a group of infrared cameras, ultra highly reflective markers, Infrared LEDs lights, 3D Data, 3D software, a Data Station and a powerful computer. The cameras this research uses are off the shelf cameras and can be purchased in any electronic store. This study is trying some of the most common cameras in use, a Panasonic Mini DV, a Sony HDV camera video recorder, a Mini DV Digital8, a DVD Sony Handy cam, and even a Kodak EasyShare photo camera (digital photo cameras are not used very often in motion capture).
After checking the different colour dyes and their correlation with the UV-A lights this study needed to check on each colour dye to determine which was the most appropriate for the capture; this depended upon the luminance value of the markers in the video test and the kind of camera used.
Using point-light alike is one of the main points of this study in such display there may be no motionless form information yet complex forms will be seen when the point-lights alike move. The markers used were table tennis balls painted with fluorescent dye in different colours these can be found almost anywhere at a very low cost. These markers were video recorded and then their coordinates segmented from each frame using a multi object-tracking algorithm, into an editable ASCII file to be imported into 3D software.

1.1 Motion Capture System

There has been much research done on motion capture systems but limited research has explored the use of Black Light, fluorescent markers and low cost cameras in the animation area. To have effective results in capturing 2D coordinates only one camera is needed to get 3D coordinates at least two cameras are needed these cameras can be identical or heterogeneous as long as the frames per second are the same in both. A system based on the presented concepts has been implemented and experimental results obtained which show the effectiveness of the proposed system in creating an easier way to obtain 2D and 3D data. This research used two cameras labeling one camera X and the other Z, Z being the depth coordinates using the Y axis as the height for both, so X becomes the front view Z becomes the side view.

An actor with fluorescent markers is illuminated with three black light fixtures and video taped with two perpendicular cameras after that a tracking algorithm is used to extract the markers' coordinates and imprinting these in an ASCII file to be fed into Architectural Maya 8.5.

Suggesting a new way to explore this field, Margaret S. Geroch (Geroch 2004) illustrated how to focus studies on MoCap systems from a general view into a more specific view maybe trying to get clean data only or standardizing some equipment. Kim Jong (Jong Hyeong, Ryu et al. 2004) states that almost all high-end human motion capture systems in commercial market are expensive and complicated. Therefore, they proposed a practical and fast motion capturing system consisting of optical sensors linking the data with 3-D characters in real time. In another study carried out by Castro and Galisteo (Castro and Galisteo 2006) shows how a low-cost a motion capture and analysis system can be developed. The first incentive for this study was to try to help independent 3D animators and small animation companies by providing an alternative less expensive practical system capable to capture a human movement a system utilizing off the shelf equipment enabling the creation of a “homemade” system. In order to accomplish this; first, one must create recording conditions such that nothing is visible in the video stream other than the markers positioned on the main joints of the performer, two cameras capable of taking shots in a dim room, a computer with the video capture port, software capable of importing the video stream is also required; along with a tracking algorithm to extract the markers coordinates, also camera calibration image processing software is required to scale the image sequence. Significant time was spend finding the level of ambient or environmental light required without overexposing the performer or other objects in the room. This was to define how many lamps are considered optimum and how many lamps are the maximum required to catch the glow in the dark markers. Moreover this can identify the camera which works best with this UV-A “Black Light”.

2. DESIGN OF THE INVESTIGATION

This methodology followed very simple steps; two cameras are placed at 90 degrees to each other. Three Ultraviolet fixtures as “Black lights” are place one on top of each camera and another in between them facing the actor. It was very important to test/experiment with a different fluorescent dyes (red, blue, yellow, green and white as a control colour), to compare pixels of typical background characteristics (Demos 1991), with all the pixels in the given image so the difference between markers brightness was measured with RGB values to find the brightest one. In order to find out the minimum and maximums number of Ultraviolet lights and lumens per watt needed, a photo-measuring device was use, the research used a photometer (Spectroline 2006), to measure brightness in the experimental room. Finally the data from the test was applied to a 3D character in order to have a full computer animation from this Ultraviolet system. The performer to be track is supposed to move inside a confined volume. The scene is monitored from two synchronized cameras at 90 degrees from each other. The performer faces a UV-A light fixture in an equal space between the cameras, at 45-degree angle.

2.1 Black Light

We used “Black light” as a light source; this kind of light makes some items bright in the dim environment. This study does not use any data station or special video cards all it needs is video capture software like Movie Maker from Microsoft and depending the camera used either an IEEE 1394 connection for the cameras, a memory reader or a DVD Reader. The tracking algorithm; the image segmentation and the video capture have a low computational expense.

A thousand frames can be tracked in less than one minute the segmentation takes less than two minutes and the video capture depends entirely on the recorder time.

2.2 Motion Capture Data

Optical motion capture data is maybe the most important part of all the capture process. Without clean data there is no way to have a good 2D or 3D animation most of the time the data needs to go through a cleaning process; before this data can be used in a 3D animation character. Sometimes the data has to be altered this data is very easy to edit. The data this research is trying to get will be usable in most 3D software. The 3D data extracted from this system will come in an ASCII format; a simple TXT file. All the information in this file is fed into the 3D software script editor and executed to create a series of locators for every X, Y and Z coordinate extracted from the markers' reflections for 3D animation frame by frame without going through a cleaning process or adjusting it in any other software. The data shows the marker label (locator), the locator name, the number of frame in the animation (currentTime), and 3D coordinate (X Y Z). Using locators gives the animator more freedom to works with; vertex, faces, cameras, lights, objects or joints can be constrained to a locator.

In some cases the marker were not visible this problem can be avoided by wrapping retro reflective material around the areas to be marked (Johansson 1973), when video taped with contrast set high and brightness low the performer is not visible only the reflective patches. However, even this solution has its problems such a marker will change size and orientation as the performer moves as M. Dekeyser (Dekeyser, Verfaillie et al. 2002), shows in their study. A solution to these problems is to identify the location of each joint in a frame. To map this optical data to a skeleton in AutoDesk Maya this system treats all markers with equal weight; no weight is apply to any of these markers.

2.3 Scene Setup

To the author's surprise, very little evidence has been found, concerning researcher involving the use of UV-A (Black light) and exploiting fluorescent dye in markers within this field of the human motion capture.

The tripod-mounted cameras are pointed towards the centre of the volume; the whole room was painted black the performer is dressed in black. Fluorescent markers are attached to the wrist, elbow, shoulder, chest and head of the actor, who performs facing a UV-A light located between both cameras. As a result, his / her left, right and front sides are cover by the two cameras. Black Light illuminates the fluorescent markers attached to the actor; the reflection from these markers is pickup by the cameras (X and Z). The video streams are segmented into an ASCII file, this file can create locators, spheres or joints, and this file is copied and pasted into 3D software. These locators are constrained into a 3D character's joints, to produce a full 3D animation.

3. SOLUTION

Very little information about the use of fluorescent markers in the MoCap area has been found. In case of a occlusion happening this research will try to follow Liu Guodong's (Liu and McMillan 2006) study, used which for missing marker estimation by finding the least squares solutions based on the available marker positions and the principal components of the associated model.

After an exhaustive search of how to design a different MoCap system this study chose to try low cost cameras and find out which one works better in a dim environment. By attaching small point lights to the main joints of a person's body and filming the scene such that only the lights were visible in front of an otherwise homogeneously dark background this research was able to obtain usable data.

Video from both cameras were download to a computer segmented into frames using the calibration images (the first image from both videos) to check the distance between the lowest and highest markers and after finding the distance all the remaining frames were scale to the real measurements.

The main goal for this study was to capture on video the markers' reflection in a visually dim environment and then apply image-processing algorithms to every single frame to determine the markers' X-Y-Z coordinates and export them into a 3D animation program making motion capture easier than ever.

4. MAIN CONTRIBUTION

Combining some ideas from others researchers and applying some new techniques this research is creating a new way to capture motion to be used by anyone with the equipment mentioned earlier. This simple idea of placing fluorescent table tennis balls or any other glow-in-the-dark sphere as "point lights" on the actor's main joints will open several new ways to use "Black Light" in the animation area. Moreover, no special room is needed with this system; easy setup system. The main contribution of this research will be for the majority of the character animators, giving them the possibility of building a "homemade" practical and reliable Ultraviolet motion capture system.

5. RESULTS

Very little evidence of research into the use of Ultraviolet Black light and fluorescent dyes has been found particularly for the motion capture application. Motion capture is mainly accomplished by optical magnetic and sonic technologies and although each technology has its strengths. The success of our approach would enable the creation of new generation of affordable motion capture devices and would open a new ground for many related applications in the animation industries. By using these types of camera and the tracking algorithm the price reduction can be a reality. An optical MoCap system with two of these cameras and lights is a maximum of £3,000 or as lower as £300 (without including a computer). The less complicated a system is the more end users will be able to access and purchase one. This work will demonstrate that UV-A "black light" and a tracking algorithm are not only the appropriate method to accurately track the fluorescent markers but also deliver very useful 3D data. The best result was obtained using three UV-A lights and HDV cameras. Using less light was acceptable however, using more than three lights made the performer visible in the video. The output was an animation of acceptable quality. In an early stage of this research a 20 seconds video experiment, took less than 30 minutes to have a full reconstruction of a 3D animation on screen. Including the frame segmentation from the video streams, combining the data from the X camera and the Z camera, loading the script to Maya key-framing, applying the skin bind to a 3D character's joints and reconstruct the joint orientation. From the viewpoint of motion analysis, this approach poses a little restriction on human motion; at the same time it is so cheap and easy that any person can use it. Several tests were performed video test with one two and three UV-A lights positioning the camera at different distance the minimum distance for capturing the upper body was 2.50 metres and the maximum distance allowed by our Photo studio Room was five metres for a two cameras setup and seven metres for one camera setup.

6. DISCUSSION AND CONCLUSIONS

There are a couple pro points in this study; first it is possible to capture the fluorescent markers in a dim environment with low cost cameras. Secondly, using two cameras at 90 degrees to each other to obtain X-Y-Z coordinates is a practical solution. In addition, it is possible to extract coordinates from these the markers in a series of images. Using free software to process the images will increase the number of end users for this system. Having editable 3D Data is a plus. With this system no special equipment is require to calibrate the cameras or process the images.

On the other hand, there are still problems with the system. The main problem for this system is marker occlusion with only two cameras covering threes of the performer's sides; the tracking algorithm loses some markers. Three cameras increase the area of capture but increasing the performance volume area causing problems with the number of UV-A lights used additionally increases the setup time the capture. The transition from two-camera configuration to a three-camera configuration will not require additional technical effort and will often be self-evident for reasons of reliability and robustness.

One drawback of the method as it currently stands is that is does not directly incorporate a straight forward respond to avoid markers occlusion.

This study finds the tracking performance will be weakened if there a too much self-occlusion on the markers. There need to be try others tracking algorithms that include an estimation position for the hidden markers. Future tests will show how many auxiliary lights (lux), are need it as it might help to increase the quantity of the lights; however, it is probable they may disturb the equipment.

This research hopes that this study will help other researchers in this field opening new ways to capture movement. Many 3D animators will benefits from this new system. This system can be build as a homemade optical motion capture system. Overall, this research has yielded very positive results about using Ultraviolet and fluorescent dyes to replace some of the most expensive elements in an optical motion capture system.

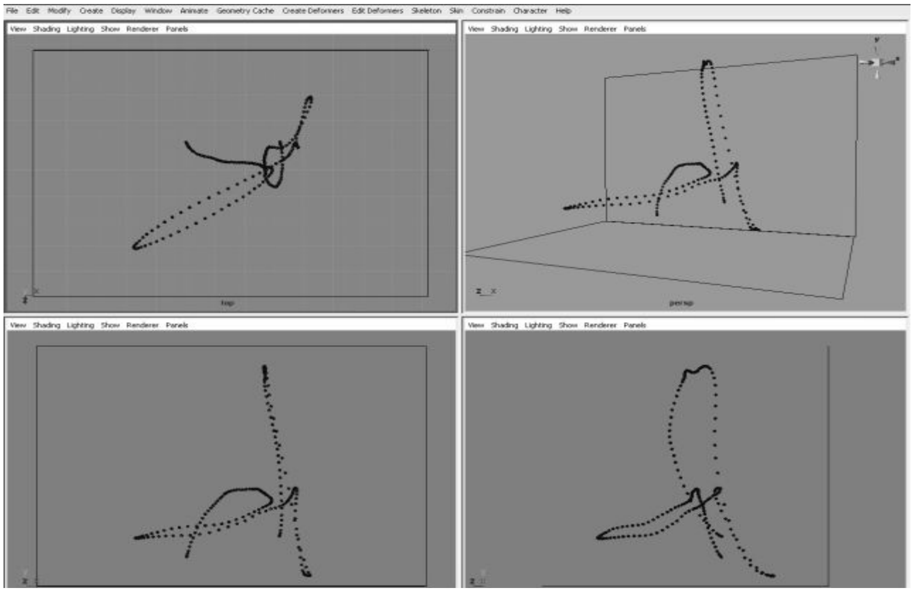

Figure 1 Tracking of the left hand marker only, during 200 frames, in the top left of the image, the TOP view can be found, in the upper right the PERSP view can be seen in the lower left corner the FRONT view and in the lower right the SIDE view is located.

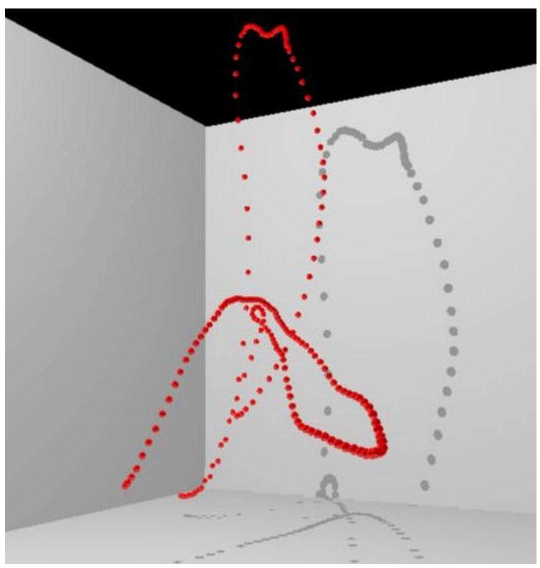

Figure 2 The image shows only 200 frames from a 3D animation, but it is enough to show that both cameras have picked up the distances in the X, Y and Z coordinates.

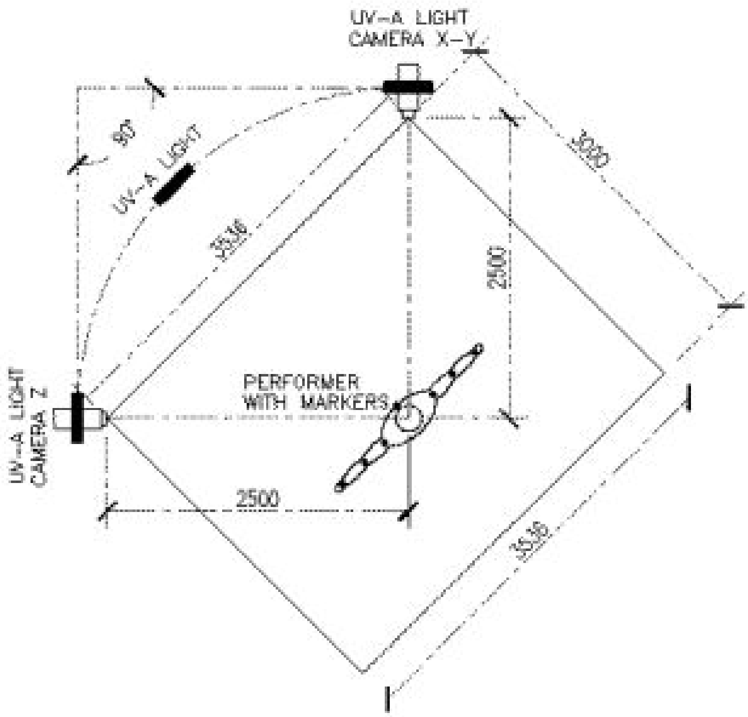

Figure 3 Typical camera setup, the performer faces the cameras at 45 degrees, facing one UV-A Black light instead of the camera, his / her left, right and front side are covered by these cameras.

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ERGONOMICS NOTION AS QUALITY FACTOR IN DESIGN LEARNING.

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Abstract: Processes of Quality and Ergonomics are complemented in overlaps of activities. The client satisfaction, human factor and adapted environment for thuman activities, would have to comprise of the cultural and instrumental heap of the designers. If it is tried to stay and to improve the professional performance continuously, through service life of design products we needed to incorporate the value of the appropriate participation of the people in the processes.
On the other hand, the organization is documenting to the processes according to norm ISO 9001:2000, nevertheless, is not evident some characteristic that in the organizational culture the ergonomics comprises. Oriented towards the philosophy of Quality, a diagnosis of the conceptual frame of ergonomics in the scope of the Faculty of Architecture, Design and Urbanism of the Independent University of Tamaulipas settles down. A sounding by means of surveys is applied.
With three races, three masters and a doctorate, are appellant noticing that the ergonomics notion, or is nothing else in the unconscious mind of the involved ones in this educative organization, or of conscious way is ignored the importance of applying it in the processes and products of design. Even from an important stage in the service life of the design, as the one of professional formation.

Keywords: Notion. Ergonomics. Quality. Learning. Design.

Resumen: Procesos de Calidad y Ergonomía se complementan en un traslape de actividades. La satisfacción del cliente, el factor humano y la adecuación del ambiente para las actividades humanas, en la actualidad deberían formar parte del acervo cultural e instrumental de los diseñadores. Si se pretende mantenerse y mejorar continuamente el desempeño profesional, a través del ciclo de vida de los productos de diseño necesitamos incorporar el valor de la apropiada participación de las personas en los procesos
Por otro lado, la organización se encuentra documentando los procesos de acuerdo a la norma ISO 9001:2000, sin embargo, no es evidente algún rasgo de que en la cultura organizacional la ergonomía forme parte. Orientado hacia la filosofía de Calidad, se establece un diagnóstico del marco conceptual de ergonomía en el ámbito de la Facultad de Arquitectura, Diseño y Urbanismo de la Universidad Autónoma de Tamaulipas. Se aplica un sondeo mediante encuestas.
Con tres carreras, tres maestrías y un doctorado, es recurrente el percatarse de que la noción de ergonomía, o está nada más en el inconsciente colectivo de los involucrados en esta organización educativa, o bien de manera consciente se ignora la importancia de

aplicarla en los procesos y productos de diseño. Incluso desde una etapa importante en el ciclo de vida del diseño, como lo es el de formación profesional.

Palabras Clave: Noción. Ergonomía. Calidad. Aprendizaje. Diseño.

1.INTRODUCTION.

1.1. Design and Quality.

A design is the result of a series of processes that are executed to satisfy requirements for a better persons life. Still like foreshadowing of a solution, regularly a design is materialized in a product.

The design has like primary target the satisfaction of needs through aesthetic and functional projects. In agreement with Juan Acha, at the moment we have as manifestations of design to the industrialist, graph, architectonic, urban, audio-visual and iconic-verbal. These designs are task of the designers. How we assured the production designs of high quality level? The appreciation of an final item, for example, a house, regularly is determined by the author or supplier. Who creates it says that he is functional, beautiful and resistant. The user of a house accepts the product without protesting. On the other hand, a product of industrial design us can extremely seem aesthetic and functional. Nevertheless, through Life Cycle Analysis the perspective is another one.

As it happens to other products, the elaboration comprises of life cycle through what people take part. On each stage of the cycle a series of activities carries out in an environment with characteristics and specific conditions. The involved people play the roll of suppliers at the time and clients, since consumptions are processed and products or services are given. In the life cycle of a design product, or from the point of view of trade or within the framework of ecoeficiencia, the quality is a frame of fundamental reference.

The Quality can be defined of several ways. The quality talks about for example, to the fact to fulfill the requirements. To the characteristics of the product that respond to the needs of the client. To meet the requirements that the client demands. The quality of a product can be defined as its capacity to satisfy the needs and expectations with the consumer. Set of properties and characteristics of a product or service that confer the aptitude to him to satisfy established the explicit or implicit needs. The quality is not something subjective or intangible, its characteristics are perfectly objective and quantifiable, even in the industry of services. The quality is not an isolated event, is responsibility of a person either or of a department, the quality is integral, total, and therefore it is responsibility of every one within the organization.

Quality is the satisfaction degree of the clients´ expectations and needs, then in a system of processes it is required to satisfy a great amount of clients, as much internal like external. In an ample perspective, from its gestation to its deposition on the environment, a product exists in a life cycle. Raw materials are extracted, make, are distributed, used, re-used, recycle. In all these stages the human presence is essential, and the satisfaction of its needs is required.

The human factor is quality essence. In the terms of lean production, considers waste the nonsatisfaction of clients needs. “This concept focuses in the added value of resources from the point of view of the client: What they need, When they need it, Where they need it, At what competitive price, In amounts and variety that they require, but always with respect to the awaited quality” (Alukal- Hands, 2006). The ergonomics must be present in all process, like factor of client satisfaction. And in all organization where it is tried to assume a philosophy of continuous improvement or Kaizen.

In the design activities, as it practices directed to satisfy human needs and to try a better life quality, ergonomics must be essential part. A nonergonomic design, would generate product nonconformities, when not satisfying the requirements related to the adjustment with productive processes and its results. Without counting on the environmental impact of the wastes generated in the life cycle.

Within the design products life cycle, the educative processes are key factor. In them they train the design professionals, whom they try to give an excellent service to the society. But, in the educative organizations it is taught and it learned to produce with quality? Even though it seems absurd to ask it, it is taught and it learned to generate ergonomic designs?

1.2. The Faculty of Architecture, Design and Urbanism (FADU). Mission and Vision.

The FADU until now, counts on three supplied degrees Architecture, Graphical Design and Design of Interiors, counting on pupils enrolled in the curriculum Milenium III, approximately of 1047 students, them 42% are of the Lic. in Architecture, 48% of Graphical Design and 10% of Design of Interiors, the majority in a rank of 17 to 25 years of age. On 1971, one is based the Faculty of Architecture, Design and Urbanism of the Autonomous University of Tamaulipas, campus Tampico - Madero. The first supplied race was the Degree in Architecture, 24 years later, Graphical Design is born, and recently in the 2006, supply Design of Interiors.

The FADU has as mission to train professionals in the different scopes of the design, able to face successfully and I devise the different changes and challenges that impose the times and norms at the time, conformed a vigorous institution, united, with a high academic spirit, honest and prepared to face estusiasmo the constant changes that the present technological rate entails.

The FADU has like Vision, structured for the different groups from interest. That is to say:

The students own an integral preparation and of quality that allows them to face and to adapt to new labor challenges of its surroundings; with capacity to analyze, to organize and to process the information, they have analysis and reflective. They can communicate of graphical, verbal and written way; they solve problems in creative and functional form. They are entrepreneurs who count on the facility to develop work in equipment.

The professors besides preparing themselves and updating themselves constantly in their field of study, count on pedagogical formation, use the technological tools to invigorate the preparation of their students and the investigation. They work reunited in seminaries and academic bodies where they fortify and they update the contemplated curricula the educative innovation like a factor of relevance in the education.

All the programs take care of the needs of the surroundings, are updated and have adopted didactic, pedagogical and curricular innovations. For its operation sufficient infrastructure exists that it allows to satisfy the new academic requirements and that takes care of the needs of the social surroundings of the region.

The entailment that owns the Faculty widely is recognized by the society and the productive sector of all the organization and the country, as well as the supply of specialized services that have great demand by their quality.

The directive body develops work integrated for the continuous improvement of the Faculty and the support to its educational students and, with innovating vision and attitude on watch, knows the needs and the situation the Faculty. It has the technology in his activities and participates with its academic in the creation and use of the knowledge.

In the Faculty of Architecture, Design and Urbanism (FADU), of the Autonomous University of Tamaulipas, work to certify under the of norms ISO 9000:2001 criteria. That is to say, contact with the terms of quality through seminaries of induction to the subject has already been had offered to the personnel of the organization. On the other hand, within the curriculum of the race of Design of Interiors, of recent creation the matter of Ergonomics is offered.

2. OBJETIVE.

is tried with this work to showing if in the institution exists an ergonomics notion within the conceptual formative framework of the people. And if it exists, that is to say assuming that we know ergonomics, in what degree are considered the ergonomic requirements as quality factor in the design.

3. METHOD.

Se realizó un sondeo simple con base en un cuestionario estructurado en tres secciones. En la primera se refiere a datos generales en cuanto a rol en la organización, y en qué área de diseño se aplica. Véase la tabla 1.

A simple sounding was realised based in a structured questionnaire in three sections. In first one talks about to general performances as far as roll in the organization, and in what design area is applied. See Table 1.

Table 1. Questionnaire Section A. General Data.

A. General Data.
Mark with "X", in the column Leith and down, your roll within the institution. If you have two or more activities, by example, professor y administrative, answer as your more significative activityIn the right and down columna, mark with"X", the designa rea where you have more influence.

	Administrative		Architectonic Design	
	Student		Grafic Design	
	Intendance		Interior Design	
	Professor		Urban Design	

In second section, 6 definitions of Ergonomics are enlisted, which is requested are related to 6 different concepts. The displayed definitions were obtained from:
The Association the International of Ergonomics.
The Society of Ergonomists of Mexico, A.C.
Manual of Ergonomics. Mapfre foundation. (See Table 2)

Table 2. Questionnaire Section b.1: definitions.

B. Please answer the questions.
b.1. Write at the left space of each phrase, the related concept number.
1. Psycology. **2.** Industrial Design. **3.** Ecology. **4.** Ergonomics. **5.** Medicine. **6.** Management.

	Set of scientific knowledge regarding the man and necessary to conceive the equipment, machines and devices that can be used with the maximum comfort and effectiveness
	Technology that takes care of the relations between the man and the work.
	Interaction between the man and environmental conditions.
	It is the scientific discipline related to the knowledge of the interaction between the human being and other elements of a system.
	Work conditions analysis that concern the physical space of the work, wears away power, mental load, nervous fatigue, service load and everything what it can put in danger the health of the worker and its psychological and nervous balance.
	Set of techniques put to the service of the companies to increase productive capacity and the degree of integration in the work of the direct producers.

In third section it is asked on the requirements of ergonomics like quality factors. Fifteen aspects of different areas from ergonomics were chosen: physical load (CF), biomechanics (B), physical and mental load (CFM), organizational ergonomics (EO), mental ergonomics (EC), anthropometry (a), ergonomic method (M), physical environment (AF). See Table 3.

Table 3. Questionnaire section b.2: ergonomics requirements.

b.2. As you know, following the intention, in the processes it is needed to fulfill with some requirements and do not for another ones. In the Design processes and during its life cycle, to obtain a product of high quality level, please indicate as they are essential and in what degree (%). If you consider each one nonnecessary, please mark in the 0% column.

	0 %	25%	50%	75%	100 %
The people power metabolism.(CF)					
The psychosomatic vulnerability. (B)					
A classification of the handled tools . (B)					
Analysis of the operative behavior variations . (CFM)					
The organization of the work and the tasks enrichment. (EO)					
Perceptive taking of information and processes. (EO)					
Positions assumed in the handling of tools. (B)					
Characteristics of biomechanic models. (B)					
Static and dynamic efforts. (CF)					
Physical anthropology. (A)					
The tasks analysis method . (M)					
Comfort (acoustic, visual, thermal, sensorial).(AF)					
Environmental proxemics. (A)					
Positions, movements and visibility in the work space . (A)					
Functional volumes. (A)					

In the FADU there is an approximated population of 120 professors and a little more than 1500 students. Due to the time pressure the study is only a sounding pilot type. Diverse events that are the attention of the population generally like holidays and the eve of the vacacional period, determined that the instrument application could be carried out during the second fifteenth of March. The questionnaires were distributed at a random way, 60 to professors and/or office staff, and 230 to students. They were not answered or were not given back 15 of professors and 13 of students.

4. RESULTS.

Reluctance on the part of the professors was observed to respond the questionnaire. Several mentioned to have stress by the type of questions. They took up to fifteen minutes in responding. The attitude of the students was different, since they responded with fluidity and tranquillity.

In the section of Ergonomics definitions (b.1) there was no consistency in the answers. All the definitions corresponded to Ergonomics, nevertheless as in the instruction it were requested to relate the phrase to the concept, were forced the answers to accommodate each one of the six concepts to each one of the definitions, even though in fact is not the suitable definition. This indicates that there was probably certain confusion by the type of instruction, but also that is not known clearly of what the Ergonomics consists. See Tables 4 and 5.

Table 4. Ergonomics definition with more marks. Teachers Group:

41%	**Set of scientific knowledge regarding the man and necessary to conceive the equipment, machines and devices that can be used with the maximum comfort and effectiveness**
20%	Technology that takes care of the relations between the man and the work.
4.3%	Interaction between the man and environmental conditions.
8.6%	It is the scientific discipline related to the knowledge of the interaction between the human being and other elements of a system.
20%	Work conditions analysis that concern the physical space of the work, wears away power, mental load, nervous fatigue, service load and everything what it can put in danger the health of the worker and its psychological and nervous balance.
2.1%	Set of techniques put to the service of the companies to increase productive capacity and the degree of integration in the work of the direct producers.

With no answer (4%, 3)

Table 5. Ergonomics definition with more marks. Students group:

31.8%	**Set of scientific knowledge regarding the man and necessary to conceive the equipment, machines and devices that can be used with the maximum comfort and effectiveness**
26.1%	Technology that takes care of the relations between the man and the work.
3.6%	Interaction between the man and environmental conditions.
22.5%	It is the scientific discipline related to the knowledge of the interaction between the human being and other elements of a system.

10%	Work conditions analysis that concern the physical space of the work, wears away power, mental load, nervous fatigue, service load and everything what it can put in danger the health of the worker and its psychological and nervous balance.
4.6%	Set of techniques put to the service of the companies to increase productive capacity and the degree of integration in the work of the direct producers.

With no answer (1.4%,3)

It is observed that in both groups, they agree mainly in choosing the same definition.

In the section of Ergonomics requirements like quality factor (b.2), in the group of teachers only one person responded that all are requisite of quality. In the group of students, one person responded that 14 are requisite of quality. Mainly one settles down that the ergonomic requirements are dispensable to obtain a high quality level design. See Table 6.

Table 6. Quality ergonomics requisites answers.

Teachers		Students	
15	**1**	15	0
14	0	**14**	**1**
13	0	**13**	**1**
12	0	12	0
11	0	11	1
10	0	10	2
9	1	9	6
8	3	8	4
7	1	7	4
6	4	6	17
5	4	5	14
4	6	4	20
3	4	3	41
2	2	2	29
1	10	1	36
0	9	0	41
	45		217

5. DISCUSION.

An organization with quality culture has like pounding in all program the satisfaction of the clients. Part of the value wished and hoped by the client to define them process that will be created, and later giving that value. According to Cantú (2001), "the value chain can be described like a set of links that represent the diverse processes that are carried out in an organization to provide to the consumer a product and a service of quality."

The quality management systems objective is to satisfy the clients necessities. Quality is what the client is prepared to pay based on which obtains or values. According to Pola (1999), "we will only obtain products or services of quality when we pruned to define a set of quality characteristics that guarantee a total adjustment to the use on the part of the client. It will be observed that this is impossible to define without taking into account to the client or user like interested part".

This adjustment implies the intervention of the Ergonomics like quality factor. Diverse studies exist to demonstrate it (Eklund, 2001). Nevertheless, the relation of the Ergonomics with the Quality, through interventions of continuous improvement in the productivity of the organizations, is a subject that has still not integrated in some educative institutions like the FADU. The design, like discipline to satisfy needs with the society, obligatorily would have to be ergonomic. It is not thus in the products that we generated in the institution. We consider that as well as in the Medicine degree, the Anatomy is essential for the practice of that profession, the Ergonomics would have to be fundamental in the degrees of Design.

In the results obtained in the sounding, the affinity with a definition of Ergonomics is detected: "Joint of scientific knowledge regarding the man and necessary to conceive the equipment, machines and devices that can be used with the maximum comfort and effectiveness". (Wisner, A., in Mapfre, 2003). This can be used for the concept guides of an induction campaign the Ergonomics in the FADU. Thus also, it would agree to establish like cross-sectional strategy, to propose Ergonomics like obligatory matter for all the degrees that are offered in the FADU. At the moment exclusively in 3er period of the degree of Design of Interiors is offered.

On the other hand, in the short and long term institutional strategies are not aligned with the attention and clients satisfaction strategies, as much internal like external. This demonstrates because it is not common that the personnel that we toiled in the FADU handle and act within the framework of the quality philosophy. This also leaves to shine in the sounding. How can be conscious the designer of his participation in a chain of value with impact of quality in the society, if he does not learn it in the formative period, nor of existential way in the daily thing?

Who have the Management responsibility in the organizations must try to go ahead to the future environmental changes and to design flexible plans and structures that allow the adaptation, the innovation and to face any nonpredicted situation. The strategic Course is the set of concrete references (mission, vision, values and directives) that indicates the direction that must follow an organization in the long term, of form so, that it focuses the efforts of all components.

The educative institutions of design, certified or not, have formulated the mission, the vision and the objectives. The fact to have these ideals and documented by norm, is not guarantee of which the withdrawn ones are effective, that is to say, efficient when using of optimal way their effective resources and, obtaining its objectives. We ask the withdrawn ones by these statements. It is not bad that they do not remember them, is serious that does not put them in practice. It happens that those organizational declarations for the short and long term are not aligned with the expectations and needs of the clients.

That's why it is recommendable to review the strategic directives of the FADU, which does not contemplate to the ergonomics explicitly as quality factor in the design. To give by understood it will continue causing discrepancies in the strategic alignment of quality. We consider that the problematic one must to a series of discrepancies nonsolved in the educative institutions. That is to say, differences between the expectations of the clients exist and that what the administrators think there are the expectations of the clients. Between which the administrators think that they are the expectations of the clients and the service specifications. Between the service specifications form and the way in which really the service occurs. Between which we do in the educative organizations and what we say we have. We need to change or we will continue producing nonergonomic designs.

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MODELING THE ACTIVITY, A KEY PHASE FOR THE ERGONOMICS OF THE CONCEPTION OF SYSTEMS AND PRODUCTS

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RESUMEN:
La ergonomía como disciplina tiene un objetivo esencialmente aplicativo e intervensionista. De hecho, las maneras de intervenir del ergónomo forman parte del debate epistemológico de la disciplina que se define como investigación-acción. Muchos autores de la corriente francófona, centrada en la actividad – diferente al enfoque normativo del Human Engineering -, consideran que la praxis ergonómica sigue el paradigma del proceso de concepción (o diseño). Vale decir que los problemas que deben solucionar los ergónomos se asimilan a los problemas de concepción de sistemas y productos porque son problemas complejos y mal definidos, aceptando varias soluciones, y cuyas soluciones son oportunistas y no óptimas, etc. Asimismo, varios autores (Daniellou, Falzon, Béguin, entre otros) han identificado que los procesos de intervención de la ergonomía son similares a los procesos de diseño, y han desarrollado modelos metodológicos así como métodos de observación y simulación ergonómica para optimizarlos. Si bien, estos modelos han permitido racionalizar la acción ergonómica y generar instrumentos para que el ergónomo pueda apoyar la definición de diseño de sistemas y/o productos, algunas fases quedan todavía sin resolver.

Asimismo, los métodos ergonómicos normalmente impartidos en las formaciones de la ergonomía y utilizados en las intervenciones profesionales enfatizan, por lo general, sobre las fases de análisis y diagnóstico ergonómico, apoyándose sobre la experticia y habilidad del propio ergónomo para poder integrar el enfoque humano en el proceso de diseño. No obstante, la experiencia tanto académica como profesional del autor ha permitido identificar una fase crucial para la integración óptima del punto de vista ergonómico en la concepción de sistemas que consiste en la modelización de la(s) actividad(es) intervenida(s) por el sistema de concebir. Modelizar la actividad estudiada permite entender una actividad e intervenirla. Asimismo, orienta la fase analítica para generar informaciones directamente aplicables a la definición del diseño de realizar. También permite fomentar una cultura interdisciplinaria o inter-oficio, al generar modelos que son instrumentos de comunicación dando cuenta de las dimensiones ergonómicas y pudiendo acoger las dimensiones técnicas necesarias al diseño de sistemas y/o productos. Por fin, permite a los distintos actores del proceso encontrar soluciones integrales apoyándose en proceso heurístico.

De este modo, después de una breve introducción sobre los alcances actuales de la ergonomía de concepción, este artículo presentará la problemática identificada y demostrará como el modelizar la actividad permite optimizar la praxis ergonómica a través de distintos casos de estudio. Finalmente, se debatirá el alcance teórico y metodológico de esta propuesta.

Palabras Clave: Diseño ergonómico, modelado, actividad

Abstract: Ergonomics as a discipline has an essentially aplied and interventionist objective. In fact, the ergonomist's ways of intervening are part of the epistemological debate of the discipline, which is defined as research-action. Many authors of the French speaking current centered on activity consider that ergonomic praxis follows the paradigm of the conception (or design) process. Although this approach has made it possible to rationalize ergonomic action and generate instruments for the ergonomist to support the systems and/or product design definition, some phases still remain unsolved.
Also, the ergonomic methods normally in the training of ergonomics and used in professional interventions usually emphasize the ergonomic analysis and diagnosis phases, supported on the expertise and skill of the ergonomist himself to be able to integrate the human approach into the design process.
This article proposes an approach centered on modeling activities intervened by the conceiving system. Modeling the studied activity allows understanding an activity and intervening in it. It makes it possible to orient the analytical phase to generate information directly applicable to the definition of the design to be made. It is also an instrument that allows efficient communication of the different actors of the conception and generates heuristic conditions needed to be able to participate in the generation of integral solutions.
In that way, after a brief introduction on the present scope of conception ergonomics, the article presents the identified problems and shows how modeling the activity allows optimizing ergonomic praxis through a brief description of two case studies. Finally, the theoretical scope and the methodology of this proposal are discussed.

Keywords: Design ergonomics, modeling, activity

1. INTRODUCTION: THE ERGONOMICS OF SYSTEMS CONCEPTION

Ergonomics as a discipline has an essentially applicative and interventionist objective. In fact, the ways of intervening of the ergonomist are part of the discipline's epistemological debate that is defined as research-action. In particular, this debate takes place in the so-called French speaking community of ergonomics, and it arose with the problem of integrating ergonomic intervention with the processes of conception, design, or development of industrial systems.

That is how this current of ergonomics, also known as conception ergonomics or design ergonomics (Daniellou, 1987), has generated intervention methodologies of the ergonomist in this kind of project, thereby setting up ergonomics as a preventive transformation of systems.

1.1 Conception Ergonomics in the face of an "Ergonomics without ergonomists"

Ergonomics got close to the world of industrial conception since its birth, but the urgency and need to get the ergonomists to enter the industrial conception projects appeared after several industrial incidents (and catastrophes) in the 1980s that put in evidence the problems of conception and representation of the users' activity in the conceived industrial systems. These events showed in particular that "ergonomics without ergonomists" (Daniellou, 1998), based on the insertion of regulations related to individuals generated by the Human Engineering current, as it used to be done and is often still done in many projects, does not allow correcting the gap that exists between the logic of systems conceivers or developers and the logic of the users. French language ergonomics (FLE) therefore maintain that this gap, which is a source of gap and disfunction, can only be reduced by understanding the real activity from the standpoint of the users.

Also, an ergonomics called conception ergonomics emerged that not only tries to find the insertion point of the discipline in engineering processes, but also ponders on ergonomic action, since the viewpoint of FLE shows that there are different logics of ergonomic action (Nikolopulo, 1998) or different ergonomic intervention cultures (Hubault, 1997), understanding that all intervention implies certain vision of the individual in the intervened organization or system.

1.2 Ergonomic activity

From this perspective, a reflection was carried out on the intervening ways of ergonomics. Falzon (2004), from the cognitive standpoint, proposes an interesting analysis that identifies three types of ergonomic intervention. He states that the practice of ergonomics can be approached as a *diagnosis and intervention* activity, as an activity for *solving ill-defined problems* -i.e., a conception or design activity-, or as a *collaborative resolution* activity –i.e., a service activity-.

The diagnosis-intervention approach is the one most widely applied, and yet Falzon considers that ergonomics is not a sufficiently mature science to apply an expertise similar to medicine, according to which symptoms correspond to pathologies that have a treatment. Ergonomic knowledge does not allow having an established diagnosis by kinds of symptoms. This type of intervention also makes it possible to apply a rather corrective intervention because the diagnosis can not always lead to a prediction.

As to the service approach, it appears in very few projects. It corresponds to an ideal of ergonomic activity, where there is a close, collaborative and cooperative relation between the ergonomist and his client.

That is why numerous ergonomists chose to understand their activity as a process of conception, not only because of placing ergonomics in an area of prevention rather than correction, but also to optimize their action by means of some rationalization of the intervention.

Falzon (Baudin, 2005) held that "conception is the new paradigm of ergonomics", because the ergonomist has, the same as the conceiver, to find solutions to complex, ill-defined problems of a collective type, etc. He also points out that the activities observed by ergonomists are also conception processes, because writing a text, building a house, processing a product, etc., are all conception activities.

This new paradigm of ergonomics establishes the necessary presence of the ergonomist as cobuilder of design solutions.

2. PROBLEMS OF CONCEPTION ERGONOMICS

2.1 Problems of ergonomists in conception processes

There is consensus at the world level among the ergonomic community to consider ergonomic intervention multidisciplinary and participative. Within this framework, methods, albeit few, have been generated to facilitate these conditions.

Conception ergonomics projects are and/or should be multidisciplinary within ergonomic dimensions, but also multiactors as to the different specialties required by the conceiving system, increasing the level of complexity, cultural conflicts, and therefore increasing the risk of straying from an activity model as representative as possible of reality. As "representative of the user/worker", the ergonomist must be a mediator of those processes and contribute to materialize a system that must be adapted to the actual future activity, also in the models.

That is why the authors of conception ergonomics often highlight two levels of intervention of ergonomists in industrial conception processes. According to Daniellou (2004), the intervention of ergonomics in conception projects assumes two constructions by the ergonomist: a *social construction*, because the ergonomist must take position in front of the actors of the conception to carry out pertinent interactions, and a *technical construction*, because the ergonomist must know how to gather information, contributing a prescriptive viewpoint for the conceivers.

Therefore, the ergonomics involved in conception processes has two great challenges that must be dealt with interdependently: how to cooperate with the other actors of the conception, and how to deliver knowledge for systems conception.

2.2 Methodology of conception ergonomics

The approach centered on the activity needs to define the principles of design solutions starting from the study of existing or future activities. Although there are variables (Garrigou et al., 2001), it is possible to rescue a very generic scheme of the methodology that is commonly used: reformulation of the demand, exploratory observation, and formulation of hypotheses, fine analysis of reference activities, experimentation and simulation, validation and follow-up.

From this generic methodology, the authors of conception ergonomics pondered in particular on methods and instruments of the reference situation analysis phase, such as the work of Daniellou on the identification and treatment of the characteristic action situation (Daniellou, 2004), by means of the identification of the determinants of the studied activity. Many studies have also been generated on the simulation and experimentation phases (Daniellou, 2007; Béguin, 2004; Maline, 1994), allowing the validation of the proposed activity from ergonomics, i.e., tasks constructed by the new conceived system. However, there are few papers that specify the crucial step that consists in translating the analyses of the reference situations to generate ergonomic preconizations for the design of the future system (Roussel, 1997).

2.3 From analysis to ergonomic preconization: a crucial step

Although some of the most prevalent discussions of ergonomics are concerned with this process that allows going from a field research to an intervention, few papers actually approach the fundamental stage of this process: participation in the generation of solutions. In fact, few describe the way of going from the analysis of observations in the field to ad hoc preconizations, i.e., ergonomics knowledge of the activities studied that allows the design of a new system. As already stated, the authors and ergonomists who ponder over conception ergonomics processes and over ergonomic action, usually center their studies on the analysis phases -diagnosis and experimentation- simulations that take place once the solution has been found, without specifying the crucial stage of going from the analysis made in the field and the promotions for the system's conception or design solutions.

That is why one of the central problems of the research-action approach to ergonomics is not used much, because many times it is argued that the action depends on the ergonomist, i.e., his expertise and his way of taking positions in the projects (Lamonde, 2004).

2.4 Conception Ergonomics in practice

The conception ergonomics methodology described above is not exclusive of French ergonomists who intervene explicitly in design processes, but it is a scheme followed by many ergonomists without formalizing it and without always carrying it out completely, many times because the ergonomists are not recognized or legitimized as valid spokespersons in a conception project. However, the hypothesis presented in this article has to do with the inadequacy of these instruments used by ergonomists at the time of entering these projects, which may precisely represent an obstacle to the recognition of ergonomic contribution.

In most cases, the ergonomic intervention is a virtual intervention (Nikolopoulo, 1998) that ends with the issuing of recommendations for the design. These recommendations are given in normative terms, many times coming from the Human Factors, i.e., from a "set of data extracted from experimental studies made in laboratories by researchers in psychology, physiology, biomechanics, and others" (Lamonde, 2004). Although these data report on the normative límits of ergonomics, they are not sufficient to ensure an ergonomically pertinent solution. In this way, even though it may be possible to generate an approach centered on the activity in the analytical phase, at the time of contributing to the transformation of reality indications appear whose feasibility and viability are arguable. Making recommendations does not allow the generation of design-adapted specifications and puts in evidence the risk of a merely technical development of the design parameters which does not solve the ergonomic problems.

The experience gathered from various incursions into the approach of conception ergonomics at both the professional and the academic level in Chilean reality allowed the identification of a very important process to foster a preventive ergonomic intervention. It is the activity modeling process. The hypothesis stated here is that modeling is a crucial phase that makes it possible not only to understand the observed activities, but also facilitates communication between the different actors in the process of conception of the new system and drives the generation of co-constructed solutions adapted to the use.

3. MODELING THE ACTIVITY

Modeling the activity is not an innovation in ergonomics practice, because ergonomics, like every scientific discipline, is supported by models to understand reality.

In fact, model generation was one of the first problems that ergonomics had to solve from its beginnings. In 1967 De Montmollin stressed that a good model for the analysis of the activity and for experimentation is that "which allows one to work on reality in all its complexity" and in which "the elements of which it is composed are chosen in such a way that a transformation of its image in the model can correspond to an isomorphic transformation in reality" (De Montmollin, 1967).

That is why a large part of the development of cognitive ergonomics considers pondering on the models of interaction of man with his surroundings, and in particular with specific devices. However, and excluding the work that allowed the development of models adapted to the concept of informatics systems, few are centered on finding models that not only allow understanding and analyzing reality, but contribute to change it, communicating and relating it to instruments for the conception of productive systems.

3.1 Modeling in conception ergonomics

Modeling is the action of translating in a model a phenomenon of reality. A model is a symbolic representation of a situation, and as established by Chapanis (1961), it operates by analogy with reality, without covering all the elements of that reality.

Conception ergonomics must respond to a problem which, even if poorly defined, corresponds to an enunciated model in order to reach a model of solution. The difficulty arises because the construction of the enunciated model is many times unconscious, since it comes from particular (culture, language) or implicit representation systems. That is why usually these initial models provide functional, operational, and therefore reduced representations of human beings. Within this framework the ergonomist must not only be able to propose enunciated models pertinent and adapted to the user's models, but he must also propose solution models, representing a reality of the activity observed under a preconization perspective, i.e., of definition for the design.

The descriptive approach of the FLE consists in making an analysis of the activities (existing or future) of the users of the system to be conceived. It is the deep knowledge of the activity that represents the preconization of the activity (Lamonde, 2004). Ergonomists using this approach often stress the interactions between the determinants of an activity, and the activity itself and its effects. However, this kind of model, even though it may serve as guide in the analysis, can rarely generate models of solutions.

The other models that are used already in the simulation and experimentation phases are often, as established by Daniellou (2007), human models (anthropometric or biomechanical), models of the work system, and models of the work. In fact, Daniellou warns on the risk of these models and proposes an optimized participative simulation phase. However, this approach and these models intervene once a first material or virtual representation of the system to be conceived has been conceptualizada and developed, working after the heuristic stage proposed on the basis of the models of solutions.

3.2 Modeling the human

Ergonomics uses human beings interacting with socio-productive systems as study subjects. Establishing models to account for the complexity of human reality is not an easy objective. The development of anthropo-sociological science as well as of neuroscience has shown no model by itself can encompass human phenomena. Understanding human phenomena implies adopting an outlook that can capture them. That outlook must in turn be focused on both global and particular issues, it must be systemic, dynamic and reflexive, the same as the phenomena that are being studied. Some authors (Honeyman, 2004; De Rosnay, 1971) refer to the need for a *macroscope* (a neologism to describe an illusory instrument that allows observation of phenomena at the macro and micro scales at the same time*)* to observe human phenomena.

This macroscope is even more useful in conception processes in which the systems that must be conceived present a crucial interdependence of the whole and its parts. That is why, to encompass the complexity of what is real and allow the delivery of a response that serves the whole and its parts, some ergonomists adopt an operational systematic approach (Honeyman, 2004) that allows them to have the macroscopic and microscopic vision of industrial situations. Therefore, they use flow diagrams and act diagrams, for example, that allow them to see the functional and operational dimensions of the activity, or more sophisticated modeling of the activity that comes from systems engineering, such as S.A.D.T. (Structured Analysis and Design Technique) or F.A.S.T. (Functional Analysis System Technique).

These modelings offer the advantage of presenting a configuration of data readable by many of the actors of the conception and allow a rationalization that offers support for the process of generating solutions.

In this way, over the last ten years many models have been generated copied from this approach, and they are showing their validity in particular in the intervention in work systems. However, these models allow part of the activity to be understood, particularly its operations, but they do not allow solving by themselves problems of a bio-psycho-social order related to the use (and no use) of the conceiving system and to the development of the project. Obviously, as already stated, no human activity can be described by a single model. However, there is little pondering on the ways of generating models that can also account for these more subjective dimensions of the activity.

3.3 Implementing ad-hoc modeling

H.A.Simon (1969), considered the father of artificialism, and therefore of the science of design, said that the design or conception solutions are “satisfacing” solutions. Decades later, Falzon (Baudin, 2005) specified that “conception solutions are opportunistic, not optimal.” That is why in systems conception projects, decision making conditions the materiality of the conceived systems. Also, each project considers different realities, every conceiving system considers understanding and intervening different activities in different contexts. Ad hoc modeling of the activity must also be considered.

This assertion is validated, among others, by the work of Lamonde (2004), who without talking about modeling, but doing so about the ergonomist's preconizations, states that they are evolutionary along the conception process, conditioned by the project's circular and recursive rhythms in its particular context, and by its actors. It also identifies that the dimensions that constitute the context or challenges of the conception project, such as the work teams, the resources made available, the time requirements, etc., constitute a fundamental factor of the ergonomist's preconizations, because they determine the choices that finally govern the materiality of the conceiving system.

This approach applied to the problems of modeling the activity was put to the test in various projects, professional as well as academic. The study of these cases tends to confirm the initial hypothesis, which consists in aiming the modelization of the activity as a key process of conception ergonomics. However, a larger number of projects are needed to generate a deeper and more systemic study required for developing an expertise whose objective is to generate methods for supporting this process.

4. MODELING THE ACTIVITY IN PRAXIS

The implementation of an approach centered on the modeling of the activity has been experimented in some projects as well as in formative processes.

4.1 Diagnosis and Modeling

A project is presented below that can stand out because it shows a possible way of developing the modeling of the ad hoc activity.

It is a project whose objective was to carry out an evaluation of 21 administrative work positions at a public institution, to "identify risk factors and generate recommendations for solutions." This request is characteristic of a corrective intervention. However, the response given to the request can appear to be successful on various points: because it delivered an analysis that goes beyond the diagnosis, and it intended to contribute oportunistic solutions because it proposed a preconization instrument for transforming those positions adapted to the institution's resources, and directly understandable and "intervenable" by the actors of the institutional counterpart.

The job positions evaluated were identified because their holders presented symptoms of osteomuscular and mental pathologies. Preliminary exploratory observations allowed the initial diagnosis to be validated and generated flow diagrams, posture evaluation, and interviews that allowed the realities of each job position to be tackled. Then the hypothesis was issued that a transversal study could be generated, considering not the job position in itself, but the overall work space. This hypothesis was strongly conditioned by the fact of having available the expertise of an architect in the work team, coinciding with the architectural renewal period of the institution. Therefore, an analysis was made of the work spaces, using various models to represent the work activity in those spaces.

In this way a modeling of the activity based on the architectural description of the space was generated, articulated with a proxemic reading of the organization of the work positions (inspired by the work of anthropologist E. T. Hall, 1966), compared with sociograms describing the interpersonal relations, and indications obtained from interviews on the substance of the job activity (see Fig.1). This articulation of various models made it possible to point out that most of the work stations were not adapted in their spatial organization to the nature of the identified jobs nor to the operation of the jobs. For example, the work stations that in their disposition and proxemics with the other stations corresponded to an interactive type, were assigned to people whose work required concentration. It was also found that usually these spaces did not correspond either to an operational description of the job. That is why in many cases the people had to go up and down stairs or cross buildings in order to carry out the cooperative relations required by their job, either with other devices or other people.

This articulation of models centered on the simultaneous reading of the spaces under various dimensions corresponding to the job allowed a homogeneous modeling to be achieved for optimizing the evaluated work spaces.

Also, although this project was not labeled as a conception project, the approach centered on the modeling of the activity made it possible not only to deliver a deep diagnosis result of the work situations under a transverse modeling, but also to propose models that allow the generation of feasible and pertinent solutions in the project's context.

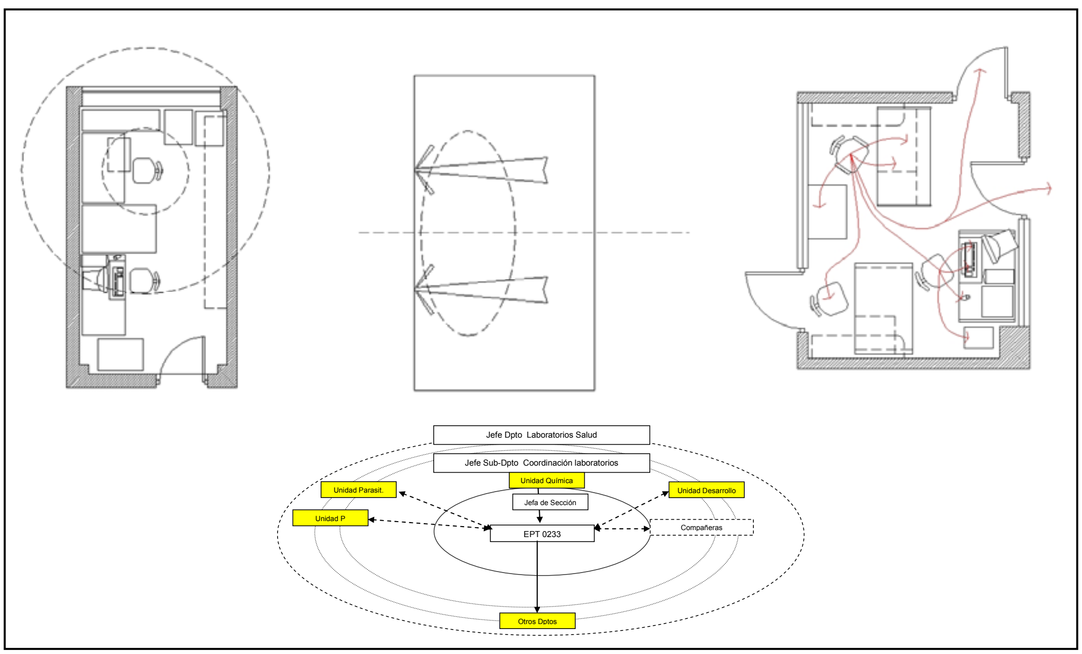

Figure 1. Modeling of administrative work spaces

4.2 Modeling and generation of solutions

In the academic context, at the level of the practical course in the career of industrial design, the validity of a methodology based on the modeling of the activity is being evaluated. The experiments that have been made within this framework are based on the methodology developed by Roussel (1996), a conception ergonomist. Roussel's methodology, oriented at

the conception of industrial products, also delivers its own methods and instruments inspired in the work of the FLE. In particular, Roussel (1996) proposes an instrument, the Common Use Reference, to contribute to the generation of solutions from ergonomics, which is composed of different modelings of the activity, in particular where the activity's operational models are articulated with use models based on psychological theory, but also with reproductions of reality, such as, for example, sketches and video recordings that are considered as valid instruments for efficient communication between actors and for supporting the solution searching heuristic processes.
What has been verified by the implementation of this methodology in various courses for about two years tends to confirm that modeling the activity is a pertinent source for the process of product design and communication with the actors of the conception, in this case the industrial designers.

3. DISCUSSION AND SCOPE

This paper proposes a reflection on a stage that has been little considered in the literature and in ergonomic practice: the generation of solutions. Making use of an interpretation of existing theories and of the proposed methods, it is identified that this phase can be treated through a process of modeling of the activity. Considering that this modeling may in turn allow an analysis of the activities and be an instrument for efficient communication to generate a solution model, i.e., to participate in the generation of conception alternatives. Obviously, validating this proposal requires a systemic and deep analysis of case studies.

This paper can also be considered as a contribution to an international as well as a national development of conception ergonomics, understood as a branch of the discipline and not as a theoretical current built by some. Ergonomics, as underscored by the definitions of an Anglo-Saxon ergonomics as well as of a French language one, is essentially the generation of knowledge, methods, instruments, that allow the conception of optimum systems of activity from a productive as well as a human standpoint. Also, this contribution is aimed, above all, to provoke a reflection from the essence of the role of ergonomics and ergonomists on the tools that allow to resolutely register ergonomics in the field of conception and not only in that of correction.

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ERGONOMICS AND DESIGN. INDUCTION DIDACTIC STRATEGY.

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Abstract:

To recognize that they exist areas of opportunity for the Ergonomics in the scope of the design, is not sufficient. It is needed to act. In the scene of the Faculty of Architecture, Design and Urbanism, are introduced in one of the Basic Design programs of, an elementary strategy to induce the participants to know and to apply concepts of Ergonomics. Although simple, it is tried with this strategy to hit significantly in the future professional of the design. In order to obtain more than a theoretical approach, existential experiences in the learning of subjects of the source program are used: Color, Forms, Structure, Proportion, Space. The learning exercises go to the body of the students, and then, they project to the space. With this process it is tried to undergo the necessity to generate design possibilities related to the physical characteristics of the person, and in spaces with better ergonomic quality.

Keyword: Ergonomics. Design. Induction. Didactics

Resumen:

Reconocer que existen áreas de oportunidad para la Ergonomía en el ámbito del diseño, no es suficiente. Se necesita actuar. En el escenario de la Facultad de Arquitectura, Diseño y Urbanismo, se introduce en uno de los programas de Diseño Básico, una estrategia elemental para inducir a los participantes a conocer y aplicar conceptos de Ergonomía. Aunque sencilla, se pretende con esta estrategia impactar significativamente en el futuro profesional del diseño. Para conseguir más que una aproximación teórica, se emplean experiencias vivenciales en el aprendizaje de temas del programa original: Color, Forma, Estructura, Proporción, Espacio. Los ejercicios de aprendizaje van al cuerpo de los alumnos, y desde el mismo se proyectan al espacio. Con este proceso se pretende experimentar la necesidad de generar posibilidades de diseño relacionadas a las características físicas de la persona, y en espacios con mejor calidad ergonómica.

Palabras clave: Ergonomía. Diseño. Inducción Didáctica.

1. INTRODUCTION.

The Faculty of Architecture, Design and Urbanism (FADU) until now, counts on three supplied degrees Architecture, Graphical Design and Interior Design, counting on pupils enrolled in the curriculum Milenium III, approximately of 1047 students, them 439 are in Architecture, 499 of Graphical Design and 109 of Interiors Design, the majority in a rank of 17 to 25 years of age. On 1971, one is based the Faculty of Architecture, Design and Urbanism of the Autonomous University of Tamaulipas, Tampico – Madero campus, the first supplied degreee was Architecture, 24 years later, Graphical Design is born, and recently in the 2006, supply Interiors Design.

In the FADU, until for 2 years the curriculum of the race of Design of Interiors has been gotten up, through what the matter of Ergonomics is offered. Exclusive right of the interiorismo, the other areas of the design are incomplete. Graphical architects and Designers do not completely consider the adjustment of the atmosphere to the people. See on Table 1. One occurs by fact. The necessity to learn the design with an ergonomic approach is urgent. We need to consider that the design products, will be used by human beings and not by dummies. The objective of all the variants of the design, is to project thinking about the human being like the final consumer. The Ergonomics is present when an activity is a human being in front of an object in a space when realising (Flores, 2001).

Like an emergent effort, one looks for to promote an approach to the ergonomics from the present curricular schemes. An experiment is introduced to incorporate basic concepts of ergonomics as didactic tools of basic design. The chosen course is the denominated Tridimensional Design Workshop. On this course it takes to the three-dimensional practice concepts learned in the preceding course named “Design Processes Workshop”, in which aspects, like color, forms, structure, proportion and volume, is learned in a bidimensional perspective. The approach is of visual design and the elements with which to realise a plastic composition. Regularly abstract objects are generated, sometimes representations concerning supposed solutions of the reality.

Table 1. Location of the courses.

Architecture. 2nd period Suggested courses.	
Environment and Sustainable Development. Informatics Technologies Introduction. **Tridimensional Design Workshop.** Architectural Construction Systems Statics Bidimensional Geometry	Optionals courses: Art and Design Fundamentals Representation Techniques. Impression Techniques Stadistics.
Interior Design. 3rd period Suggested courses.	
Introduction for a scientific mind Accessibility Art history. Representations for Interior Design. **Ergonomics.**	Optionals courses: Minimum Housing Workshop Interiors Design History. Object Vectorial Drawing. Tridimensional Geometry Management Fundamentals. Actual Contents for Representation.

The Tridimensional Design Workshop course program, consists basically of the subjects: Color, Forms, Structure (Texture), Composition and Proportion. It is developed during 14 weeks in every school semester. The reaches of the program limit the imagination of the professor and the disposition of the group. Initially the exercises are realised in factory, with a frame of reference of 40 x 50 cms. Nevertheless, some exercises take to the outside, to handle different scales. The handling of the color, the form and structure had been materialized previously in attractive and funny exercises. Experimenting in body the formal relations of a design through a fantastic figure of 5 meters of height or length, for example. See Figure 1

Figure 1. Tridimensional Design practices..

The efforts to update an academic program become presents with works that of intuitive way, consider the physical characteristics of the people for the form adjustment, color and materials. Nevertheless, the use of Ergonomics concepts are not explicited. Not necessarily the professors promote works outside the Workshops classes. Rather the majority develops the program realising excellent exercises of visual design, although it does not get up itself either to the Ergonomics in the scale representations. The practices executed in the patio are not a complete solution. The fact is that it is needed with urgency to integrate explicited Ergonomics in curricula.

2. OBJECTIVE.

It is tried to demonstrate that from basic level of design, and with a program oriented to plastic composition practices, elementary concepts of Ergonomics can be applied.

3. METHOD.

With base in the source program of Tridimensional Design Workshop, the use of basic concepts of Ergonomics has been introduced as a didactic tool, and in particular applied Anthropometry. An alternative guide under the following headings is structured:

		HAND PHALANGES			
19cm-7cm	**LARGE**	**PROXIMAL**	**MEDIA**	**DISTAL**	**WIDTH**
THUMB	9cm	4cm	3cm	2cm	2cm
INDEX	8cm	3cm	3cm	2cm	2cm
MEDIUM	8cm	3cm	2.5cm	1.5cm	1.5cm
ANNULAR	7cm	2.5cm	2.5cm	2.5cm	1.5cm
LITTLE	6cm	2cm	2cm	2cm	1cm
		FOOT PHALANGES			
25cm-9cm	**LARGE**	**PROXIMAL**	**MEDIA**	**DISTAL**	**WIDTH**
1º	6cm	1cm	2cm	3cm	3cm
2º	5cm	2cm	2cm	1cm	1.5cm
3º	4cm	2cm	1cm	1cm	1.5cm
4º	4cm	2cm	1cm	1cm	1cm
5º	3cm	1cm	1cm	1cm	1.5cm
1º	6cm	1cm	2cm	3cm	3cm
		ARM			
ARM	**LARGE**	**HUMERUS**	**RADIUS**	**HAND**	**WIDTH**
	72cm	29cm	24cm	19cm	8cm
		LEG			
LEG	**LARGE**	**FEMUR**	**TIBIA**	**CALCANEUM**	**WIDTH**
	87cm	40cm	40cm	7cm	15cm
		TRUNK			
TRUNK	**LARGE**	**WIDTH**	**DEPTH**	**SPINAL C**	**HIP**
	30CM	32CM	13CM	56CM	40CM
		HEAD			
HEAD	**LARGE**	**WIDTH**	**BOTTOM**	**NECK**	**NECK-HEAD**
	20cm	14cm	19cm	6cm	26cm

Table 2. Body measurements table. Elaborated by: Vanessa Márquez Zumaya. Tridimensional Design Workshop pupil (2009)

1. General Ergonomics concepts; relation of Ergonomics with the design variants (graphical, inner, architectonic, urban).
2. Anthropometric measurements.
3. Proportion. To find the proportional relations in the body with base to the denominated "gold number" with its two values 0,618 and 1,618.
4. Ergonomic space design. To make anthropometric space modules in real scale (1: 1).
5. Ergonomic structure design. To make selflifted structure in a real space.
6. Ergonomic object design. To relate objet forms to a human necessity.

4. RESULTS.

1. General Ergonomics concepts. In this exercise it was requested to investigate documentarily, and to illustrate with graphs.

2. Anthropometric measurements. One was in charge in equipment to measure with flexible tape, the bodies of the major and minor people stature. Drawings of the body, extremities superiors and inferiors were elaborated, and of the head and face; with measures. Besides a table they summarize main data.

3. Proportion. The structure of the human body was physically demonstrated locating the points articulate that it. The lengths of the body were moderate; then multiplyed by the value phi=0.618; it was located the position of the navel, joints of arms and legs, verifying itself the possibility of relating harmonically the designs to the human body, from simple numerical factors.

4. Ergonomic space design. Firstly they were realised space compositions with anthropometric modules on scale 1:10. The formula was used to multiply the stature by the factor phi=1.618. See Figure 2.

Figures 2. Space compositions with anthropometric modules.

Later anthropometric real scale space modules were elaborated (1: 1). It being constructed space units derived from the personal stature multiplied by the value phi=1.618. See figures 3 and 4.

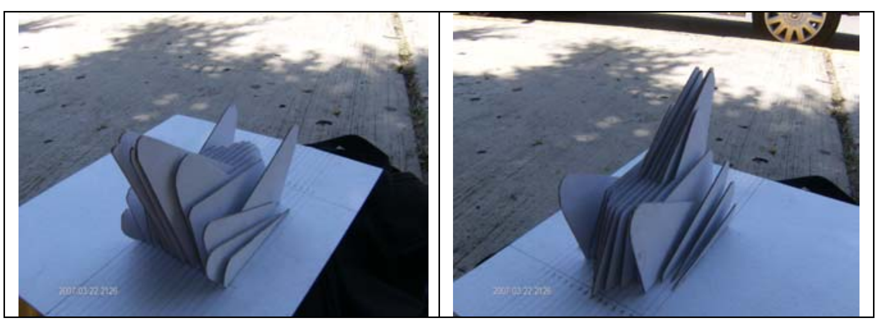
Figures 3 and 4. Real scale (1:1) anthropometric modules.

5. Ergonomic structure design. To make selflifted structure in a real space. There were designed and constructed anthropometrical and proportional structures in a small garden of the FADU, considering pupils measurements factors. It was well-known that the motivation surpass to the deficiency of referring Materials Resistance and Statics practices. See Figure 5.

Figure 5. Ergonomic Structure Design.

6. Ergonomic object design. To relate corporal form to a human necessity. The rest necessity settled down to design an object, starting off of the concept of continuous serial planes. This subject of serial planes learned from the preceding course Design Processes Workshop. Now, in this course of Tridimensional Design Workshop it is asked for that these planes change their size and forms according to ergonomics adaptation. This work is in process, reviewing prototype models 1:10 scale. Real scale prototypes (1:1) was in development procedures. See Figure 6.

Figure 6. Ergonomic object design.



5. DISCUSION.

We recognize that we lived a series of nonsolved discrepancies in the educative institution. There exists differences between the clients expectances(students) and what the administrators think that they are the clients expectations. Between which the administrators think that they are the clients expectances and the specifications for the service (currícula).

Between the service specifications form the and the form in which really the service occurs. Between which we do in the educative organizations and those what we said to have.

This is reinforced with the fundamental design deceits, apparently ours design process ideology:

1. The design is satisfactory for me, therefore it is satisfactory for all.
2. The design is satisfactory for the person average, therefore it is satisfactory for all.
3. The variability of the human being is so great that it is not possible to please to all; but as people are wonderfully adaptable, of all ways does not matter.
4. Ergonomics is very expensive, and as we buy the products at the moment by their appearance and style, ergonomics considerations can be ignored to convenience.
5. Ergonomics is extremely important. I always design the things with the Ergonomics in mind, I do but it of intuitive way and I trust my common sense. So that I do not need tables of data nor empirical studies. (Prado-Avila, 2006)

Although the results obtained in this experiment do not move away much of the works carried out normally without the ergonomic application, the students use now the terms anthropometry and ergonomics and identify them in the designs processes. Its benefit has been specified,also the necessity to work with this discipline to assure high quality designs.

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Occupational Ergonomics: Emphasis on Identification or Solutions

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Abstract: This paper provides an overview of the major techniques (or tools) for conducting workstation analyses for the purpose of assessing risk for musculoskeletal disorders. No attempt is made to discuss the superiority of one identification tool over another but, rather, to provide information about the relevancy of each in different workstation design scenarios. In addition, the overall process for conducting workstation analyses is discussed with an emphasis on prioritization, solution development, implementation and follow-up strategies. The "trade-off" between extensive evaluations and solution implementation is also discussed.

1. Introduction

The role of the occupational ergonomist to identify workstations for evaluation by analyzing available information, recommends a workstation evaluation system that helps to identify the severity of ergonomic related risk factors through the use of ergonomics evaluation models, reviews methods for developing recommendations to reduce the risk factors present in a task or operation, and proposes ways to validate the effectiveness of implemented recommendations. In this paper, the terms solutions, recommendations, abatement methods, and controls are used interchangeably to mean actions that reduce the exposure and/or presence of risk factors.

2. Ergonomic Evaluation Process

The problem solving structure with for the ergonomics evaluation process is a presented in graphical form in Figure 1.

2.A. Preliminary Data Analysis

The first step in accurately defining the problem is to take a broad look at information for the department or area to be analyzed. The preliminary analysis should consist of a determination of the workstation, tasks, or operations present, a review of injury records, an analysis of the current discomfort level of the workers, a discussion of important relevant non-ergonomic factors such as hours worked (including overtime), age of workers, years of work experience, and worker turnover. When the information in the preliminary data analysis is as accurate and complete as possible, it is easier to determine the areas of the greatest impact of change. At the end of the preliminary analysis, the evaluator will have enough information to prioritize the order of evaluation for workstations or tasks.

2.A.1. Workstation Flow Diagram
When presented with a group of workstations that should be assessed, it is often helpful to develop a flow diagram. The diagram should be a pictorial representation of the approximate location of workstations in the appropriate order. The flow diagram can include information such as workstation name, key workstation operations or tasks, processing time, material inputs (types and locations of bins or holders), machine process information (including machine time).

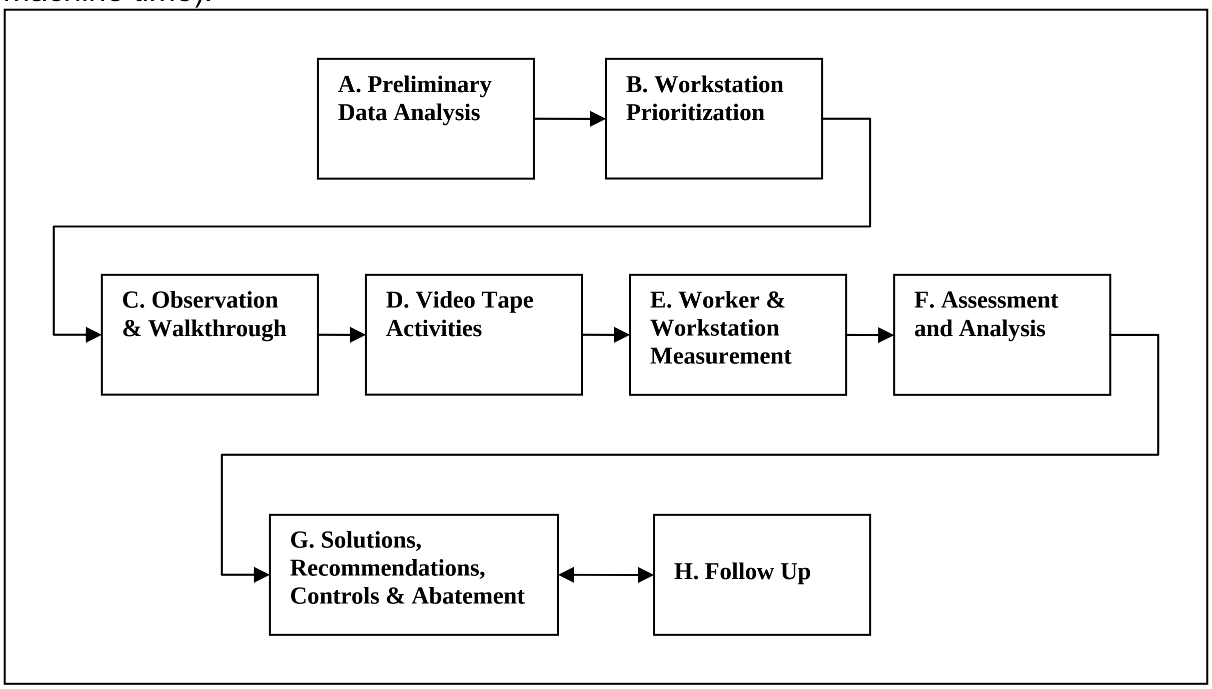

Figure1. Ergonomic Evaluation Process

This workstation flow diagram will assist in showing the relationship between workstations and can be used later to show the impact of changes in layout. Additional information regarding the order of operations within each workstation will be helpful in the detailed analysis discussed later in the chapter. Special attention should be paid to workstations that involve lifting of heavy parts, workstations with short cycle times (less than 30 seconds), and workstations that require a large travel distance.

2.A.2. Injury Records Review

After the workstation flow diagram has been completed, an injury records review can assist in determining which workstations may have risk factors that are causing injuries. A thorough injury records review includes all of the injury records for the facility or department for the previous three to five years. The easiest and most common form of injury records are the OSHA 300 logs and injury investigation forms. This will provide a general idea of the types of injuries that have occurred. Many companies have additional information that includes the workstation or operation that was being performed when the injury happened in the injury investigation report that is often completed by the supervisor or safety personnel.

The injuries should be separated and counted by department. Departments with higher injury frequencies may include jobs or tasks that have a number of significant injury risk factors. Additional analysis can be done to determine how many of the injuries within each department occurred at the same workstation or while performing the same task.

2.A.3. Pareto Analysis
Pareto analysis can be used in the preliminary analysis as well as during recommendation development. Pareto analysis includes sorting the data by a given criteria (e.g., workstations with injuries, cost of recommendation implementation, number of awkward postures decreased). Conceptually, the ergonomist uses Pareto analyses to concentrate greatest effort on the few jobs that produce most of the concern (such as cost, frequency, severity, etc.).

During the preliminary data analysis, Pareto analysis will identify where the majority of analysis effort should be spent to gain the greatest benefit. Pareto analysis during recommendation development provides the company with specific recommendations that may decrease more than one awkward posture or improve productivity in addition to decreasing injury risk.

2.A.4. Pie Chart
Pie charts are used to show subgroups that make up a whole. All of the data is represented in the shape of a pie. Each subgroup is represented by a slice of the pie. Each slice is sized to appropriately represent the proportion of the subgroup to the whole either by a fraction or by a percentage. During an ergonomic evaluation a pie chart may be used to show the number of injuries attributed to a particular workstation, operation or task as compared to all of the injuries that occurred during a given time period. A pie chart may also be used to depict the percentage of budget that will be used to implement specific recommendations.

2.A.5. Trend Analysis
Trend analysis looks at the pattern created by a specific data set. The data should be collected and depicted in a bar graph with the categories positioned from largest number of occurrences to smallest number of occurrences. Some useful trends to analyze include discomfort or injuries by body part, by task, by shift, by time of the day, by gender, by years of experience, by age, or by worker turnover.

2.B. Prioritization of Workstations

In order to determine where analysis efforts are best invested, the preliminary data discussed above should be used. Several individual or a combination of prioritization schemes may be used to identify the priority of workstation evaluations. One scheme that may be used is the severity of injuries that have occurred at a given workstation. When utilizing this scheme, the workstation with the most severe injury case type (usually days away from work) will be evaluated before a workstation that has not caused an injury or has caused a first aid injury. Along with severity, one may also look at the frequency of workstation injuries. In this case, the workstations that caused the most injuries will be evaluated before other workstations that have caused fewer injuries. Another prioritization scheme that is often used is to determine the number of employees that could be affected by changes to a particular workstation or work area. In this case, the areas or workstations that affect the most people would be analyzed first. Finally, workstations can be prioritized by the estimated cost of controls. In this case, workstations may be ordered in a variety of ways depending on the amount of money available. Most often, a workstation that requires a low to moderate amount of money to significantly decrease the risk factors is evaluated before a workstation that requires a larger amount of money for the same amount of risk decrease. Occasionally, the way budgets are structured requires the analysis of high capital or high cost of control items before the analysis of lower cost of control items.

2.C. Observation and Walkthrough

Observation is the first key to workstation evaluation. Conduct a general walkthrough of the area noting anything that may be of concern. Spend a few minutes observing the worker at the workstation to get an overview of the area and work. The goal of this observational period is to get a general feel for the types of work being conducted, the layout of the workstation, and the risk factors that are present. Pay special attention to the tasks being performed and the body postures and forces associated with completion of the workstation tasks. When there is more than one shift or more than one worker, it is recommended to observe and collect data on a cross section of workers that are representative of the shifts and worker population. At the end of the observation period, a brief interview should be conducted with the worker to discuss the specific order of operations for the workstation being analyzed, the duration of the shift, breaks, and overtime.

2.D. Video Tape Activities

The next step in evaluation is to videotape the worker. The worker should be taped for at least 3-5 cycles, or 10 minutes, whichever is longer. It is important to get at least 2-3 cycles in each camera view. If the cycle time is short, getting as many as 10-20 cycles is optimal. In addition to documenting the cycle time, photographs or video should be taken of the general work area and layout. This will serve as documentation of the types and sizes of materials handling bins, carts, workstation location, activation lever locations, hand tools, and other key components to successfully completing the operation.

2.E. Worker and Workstation Measurement

Measurements should be taken of both the worker and the workstation. Important worker measurements include standing knuckle height, standing (or seated) elbow height, standing (or seated) eye height, popliteal height (if seated), and thigh height (if seated). When reviewing more than one worker, these measurements should be taken for each affected worker (if available). All measurements of the workstation should be taken including the workstation height, reach distances to objects on workstation, height and reach of activation buttons, and height and reach of product jigs and fixtures. All measurements should reference the floor and worker position as appropriate.

When materials handling is performed as a part of the workstation activities, all relevant materials handling inputs should be collected including starting height, ending height, horizontal distance, distance carried, angle of trunk rotation during the lift, frequency of task, whether the lift is performed with one or two hands, weight of object(s) being lifted, and total duration.

When hand tools are used at the workstation, it should also be documented. Important attributes for hand tools include handle length, handle shape, handle orientation (inline, pistol grip, or other), handle material, handle diameter, approximate activation force (easy, medium, or hard), weight of tool, presence of vibration, and presence of counter balance.

Estimates of force applications such as push force, pinch force, and grip force should be made. When possible, the direct measurement should be taken with a force meter. When this is not possible, the forces applied should be estimated with respect to the maximum effort applied in that particular position (e.g., a pinch force application should be compared to a maximum pinch force). The forces should be classified as low (less than 30% maximum force), medium (30%-50% maximum force), or high (50% - 100% maximum force).

2.E.1. Worker and Management Input

Worker input can be one of the most helpful data collection tools. During the course of data collection, the evaluator should ask the worker to identify the most difficult task, the task that they least like to perform, the task that causes them the most discomfort, and whether they have anything they would change about their work environment. The answers to these questions can provide the evaluator with key clues to the tasks that may have the highest risk factors and ways that they could be easily remedied. A body part discomfort survey can yield more information when trying to identify high risk workstations or tasks. The body part discomfort survey can be used as a general screening tool and a specific workstation evaluation tool.

2.F. Assessment and Analysis

After the observation, video, measurements, and worker data have been recorded, these data should be analyzed in order to identify the risk factors present using a variety of methods including both traditional industrial engineering and specific ergonomic methodologies.

2.F.1. Video Analysis

Traditional ergonomic video analysis is a method of analyzing a task through video tape so that it may be viewed a number of times at different speeds (frame-by-frame and regular) and classifying the awkward postures and number of repetitive forces. The best method of this type of analysis is to watch the available video more than once, each time concentrating on documenting the number, direction, and extent of the awkward postures. For example, one time through the video the concentration could be on the neck and back. During this viewing, the evaluator will document the frequency of awkward postures per minute or per cycle. This should be done throughout the tape so as to ensure a representative sample. This value can then be converted into a value that represents the number of motions per hour and compared to published standards.

2.F.2. Strain Index

The Strain Index (SI) is a semi-quantitative job analysis methodology that results in a numerical score that correlates with the risk of developing distal upper extremity disorders (mainly hand, wrist, and elbow). The SI is the product of six multipliers including intensity of exertion, duration of exertion, exertions per minute, hand/wrist posture, speed of work, and duration of task per day. An SI score greater than five indicates an increased risk for distal upper extremity disorders (Moore and Garg, 1995).

2.F.3. Rapid Upper Limb Assessment (RULA)

Rapid upper limb assessment (RULA) was developed to generally assess the loads sustained by the musculoskeletal system due to work posture, muscle use and force exerted and to calculate the exposure to risk factors associated with upper extremity MSDs (McAtamney and Corlett, 1993). It is a good tool to use when trying to identify or prioritize a number of tasks for further investigation. RULA creates a grand score that represents the musculoskeletal loading. A score of 5 or 6 requires prompt investigation and change, and a score of 7 requires immediate investigation and change (Massaccesi et al., 2003).

2.F.3. Rapid Entire Body Assessment (REBA)

Rapid Entire Body Assessment (REBA) was developed to generally assess whole body loads. Like its counterpart, RULA, REBA is appropriate for prioritizing a series of tasks for further evaluation. REBA uses scores A and B to determine a Score C, and Score C is used to determine the final REBA score. Score A includes postures for the neck, trunk, and legs and is augmented by a load/force score. Score B includes postures for the upper arms, lower arms, and wrists and is augmented by a coupling score. Scores A and B are combined to determine Score C. Score C is augmented with an Activity Score to identify the REBA score. A REBA score of 1-3 is considered acceptable, scores of 4-7 indicate a medium risk with necessary action. A score of 8-10 indicates high risk with action soon, and a score of 11-15 indicates very high risk with immediate action (Hignett and McAtamney, 2000).

2.F.4. Ovako Working Posture Analyzing System (OWAS)

The Ovako Working Posture Analyzing System (OWAS) consists of two parts. The first part contains an observational technique for evaluating working postures. The second part contains a set of criteria for redesign of working methods and places (Karhu et al., 1977). The method was created by collecting information on all possible working postures and then standardizing them with regard to trunk, arm, and legs

2.F.5. Lumbar Motion Monitoring (LMM)

Lumbar Motion Monitoring (LMM) assesses the instantaneous position of the lumbar spine in three dimensions. The LMM is an exoskeleton of the spine that is attached to the subject at the thorax and the pelvis with a semi-rigid material. The LMM replicates the motion of the T section in the Lumbar spine created by the spinous processes and the transverse processes in the posterior aspect of each spinal vertebrae. The exoskeleton is worn on the back, moves along with the subject, and is connected to potentiometers via wires. As the exoskeleton moves the wires change voltage within the potentiometers documenting forwards, backwards, lateral, or twisting motion. These voltage changes can then be analyzed to determine position, velocity, or acceleration of the trunk (Marras et al., 1992).

2.F.6. Michigan 3D Static Strength Prediction Program (3DSSPP)

The Michigan 3D static strength prediction program (3DSSPP) was developed to assist in the analysis of biomechanical forces during manual handling activities. 3D SSPP software predicts static strength requirements for tasks such as lifts, presses, pushes, and pulls. The program provides an approximate job simulation that includes posture data, force parameters and male/ female anthropometry. Output includes the percentage of men and women who have the strength to perform the described job, spinal compression forces, and data comparisons to NIOSH guidelines. The user can analyze torso twists and bends and make complex hand force entries. Analysis is aided by an automatic posture generation feature and three dimensional human graphic illustrations (Chaffin et al., 2006).

2.F.7. NIOSH Lifting Equation

The National Institute for Occupational Safety and Health (NIOSH) initially developed a lifting guideline in 1981 (NIOSH, 1981) that was later updated in 1991 (Putz-Anderson and Waters, 1991). The NIOSH guideline remains unique in that it is based upon a more comprehensive set of criteria and task factors than other models. According to NIOSH (1997) “The review provided evidence for a positive relationship between back disorder and heavy physical work, although risk estimates were more moderate than for lifting/forceful movements, awkward postures, and WBV. This was perhaps due to subjective and imprecise characterization of exposures. Evidence for dose-response was equivocal for this risk factor.”

2.F.8. Psychophysical Models

Psychophysical data has been used to develop the NIOSH lifting guide as well as the Liberty Mutual models for manual material handling tasks. In both of these cases, the data were generated using whole body exertion. It has been widely used in establishing acceptable weights of lift (e.g., Mital, A., Nicholson, A.S., Ayoub, M.M., 1997, Snook, S.H. and Ciriello, V.M., 1991). Still other design data have been generated for other body segments, particularly the upper-extremities in studies conducted at Wichita State University (Fernandez et al., 1995).

2.G. Solutions, Recommendations, Controls, and Abatement

After the risk factors have been identified and prioritized, controls or recommendations should be developed to reduce each risk. Controls may be classified in one of three categories:

engineering, administrative, or personal protective equipment. In all situations, engineering changes should be the preferred method of change. Engineering changes are superior to administrative changes and personal protective equipment because engineering modifications permanently change the workstation or process to reduce or eliminate the presence of the hazard. Some examples of engineering controls include workstation design and redesign, hand tool selection and implementation, workstation layout, and process redesign.

Administrative changes work to reduce exposure to the hazard through the development of rules, policies and regulations (however, the presence of the hazard remains). Some examples of administrative changes include worker training, worker selection, task sequencing, and modifications to the work pace or frequency.

Personal protective equipment (PPE) are aids that reduce the exposure through creating a barrier. Some examples of PPE include gloves, safety boots, hearing protection, and safety goggles. It should be noted that wrist splints and back belts are not effective PPE and should be worn only in cases where they have been recommended by a qualified medical professional for rehabilitation purposes.

Besides type of control (as mentioned earlier), controls can be classified as short term, long term, or ideal. Short term controls are lower in cost and can be implemented rather quickly. One example is to use a phonebook as a monitor riser until an appropriately designed riser can be purchased. Long term controls tend to be higher in cost and may take a longer time to implement. Ideal controls are the modifications that should be made if cost and time were not constraining factors.

2.G.1. Implementation of Controls

After the controls have been recommended, there may be some decision processes to determine the order in which controls are implemented. Often this includes a cost benefit analysis to determine what controls will provide the largest decrease in risk for the dollars that are being spent. When the modifications are implemented, it is important that all of the workers receive training on the proper use of the new equipment, handtools, or processes. Without this training, workers may experience increased risk instead of decreased risk.

2.H. Follow Up

Follow-up evaluations should be conducted to ensure the effectiveness of any modifications. The goal of the follow-up is to ensure that additional risks have not been inadvertently created and to document the decreases in risks as compared to the previous evaluation. The process for the follow-up evaluation will be a somewhat abbreviated version of the initial evaluation process outlined in this chapter. It should include additional preliminary data collection (e.g., additional injuries or other significant events), videotaping, recording of measurements, analysis of data, and identification of risks. These quantified risks can be compared to those of the original evaluation and improvements in risk factors, productivity, and quality can be noted.

3. Discussion

The proliferation of tools used in the risk assessment of workstations is due in part upon the virtually limitless iterations of design configurations, materials, and many other work parameters that are seen in modern business and industry. No single tool is equally useful across a wide range of workstations. It is up to the ergonomic analyst to determine the most appropriate technique under the given circumstances they encounter.

There are certainly instances when the analyst understands through observational evidence or other compelling data from initial assessment that risk for injury is present. Examples may come from a worker exposed to regular lifting of heavy items, or regular motions requiring substantial postural deviations, or very frequent motions in repetitive tasks, or other task profiles in which the ergonomic analyst's experience will dictate that risk assessment, by any technique, will result in a high level. In such situations, the analyst should weigh the cost to further document risk and the identification of specific agents, against the time reduced to determine feasible solutions. When the risk of injury is clearly evident, development of solutions should be pursued as soon as feasibly possible.

The advantages of early development of solutions in the Ergonomic Evaluation Process could include higher productivity, lower severity and cost of injury, increased work quality, lower absenteeism, lower worker turnover, lower lost work time, and increased morale. Other benefits are sometimes more difficult to measure, for example, when workers see a relatively quick turn-around in terms of assessment, followed shortly by workstation modification, workers will be more receptive to the solutions being proposed. This can lead to even more dramatic and positive impacts resulting from the solutions implemented.

4. Concluding Remarks

This paper provides an overview of the process by which ergonomic evaluation is conducted as well as provided a summary of major evaluation techniques (or tools) by which an ergonomic expert may utilize in the assessment of musculoskeletal risk due to poor workstation design. Each technique has its strengths and weaknesses and it is incumbent upon the ergonomic analyst to understand these differences and where each may be best utilized. We have also implored the expert to not succumb to the temptation to over-analyze certain situations wherein the risk factor(s) is/are readily apparent. It is our contention that engineering and/or administrative improvements in workstation design should not be delayed for the sake of a slightly higher degree of confidence in the risk assessment. This may be even more imperative during difficult economic conditions wherein workers may already be emotionally (perhaps physically) stressed due to changing work conditions.

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Ergonomic analysis in public markets in Cortazar Guanajuato.

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Abstract: the study was realized in a public market in the city of Cortazar, Guanajuato. A typical work day is more than 12 hrs, the realized activities cause that the workers adopt positions that can damage the physical integrity. With method LEST a general diagnosis of the work areas was obtained, the activities evaluated with method REBA were: to load structures, to load merchandise, joint of, to accommodate merchandise, and with equation NIOSH evaluated the rises of structures and bags with merchandise. The method LEST shows the dynamic load, illumination, thermal environment and social status like factors that can cause fatigue. The method REBA shows the activities accommodate merchandise and to assemble structures, with a final score of 5 and an action level of 2, the activity to load merchandise, obtained a final score of 8 and an action level of 3, and the activity to load structures a final score of 4 and an action level of 2. The activities of to lift structures and to lift merchandise, obtained a lifting index 1.16 and 2.26 respectively. With the risk levels obtained, is necessary to use devices to diminish the risk levels, as well as, to reduce the time or work.

Keywords: public market, dynamic load, back pain.

Resumen: el estudio fue realizado en un mercado ambulante (tianguis) en la ciudad de Cortázar, Guanajuato. La duración típica de las jornadas de trabajo es de más de 12 hrs; en el desarrollo de las actividades se adoptan posturas que pueden dañar la integridad física de los trabajadores. Con el método LEST se obtuvo un diagnostico general de las áreas de trabajo, las actividades evaluadas con el método REBA fueron: cargar estructuras, cargar mercancía, ensamblar estructuras, acomodar mercancía, y con la ecuación NIOSH se evaluaron los levantamientos de estructuras y de bolsas de mercancía. EL método LEST, nos da como resultado que los factores que generan fatiga a los trabajadores son la carga dinámica, la iluminación, el ambiente térmico y el status social. Del método REBA se obtuvo para las actividades de acomodar mercancía y armar estructuras, puntuaciones finales de 5 y un nivel de actuación de 2, para la actividad de cargar mercancía, una puntuación final de 8 y un nivel de actuación de 3, y para la actividad de cargar estructuras una puntuación final de 4 y un nivel de actuación de 2. Con la ecuación NIOSH se obtuvo un índice de levantamiento de 1.16 y 2.26 para las de cargar estructuras y cargar mercancías, respectivamente. Con los niveles obtenidos por los métodos aplicados, resulta necesaria la utilización de dispositivos para disminuir los niveles de riesgo, así como también, disminuir el tiempo de las jornadas de trabajo.

Palabras clave: mercado ambulante, carga dinámica, dolor de espalda.

1. INTRODUCTION

The traveling commerce in Mexico has had a considerable increase in the last years, this due to the difficult economic situation and the difficulties to establish a business. In this investigation the ergonomic evaluation of the activities that the workers doing in the traveling markets was realized, some of these are the joint and assembly of the structures of the position, the arrangement of merchandise until the load of the bags and boxes at the end of the labor day.

The markets public appear in all the Mexican territory, sometimes are established in fixed places with floors and solid ceilings and the work place never changes, nevertheless in other occasions the markets are mounted in the streets of the cities.

The majority of the establishments are making by detachable metallic structures on which tables are placed to show products. Nevertheless, also the products can be placed directly on folding tables or directly on the floor.

2. MATERIAL AND METHOD

2.1 Activities and workers.

The activities evaluated were: to load structures, to load bags with merchandise, to assemble structures and arrangement of merchandise. The following chart show pictures relating with the activities.

To load structures

To load bags with merchandise

To joint structures

To accommodate merchandise

Figure 1. Activities evaluated

A total of 60 workers was interviewed, all of them while they were realized their activities in the public market. The rank of ages was of 15 to 35 years, and all the interviewed were men.

2.1LEST method

The method Lest was developed by F. Guélaud, M.N. Beauchesne, J. Gautrat and G. Roustang, members of the Laboratoire d'Economie et Sociologie du Travail (L.E.S.T.), of the C.N.R.S., in Aix-in-Provence in 1978 and it carries out the evaluation of the conditions of work in the possible more objective and more global way, a final diagnosis that indicates if each one of the situations considered in the position is satisfactory, bothersome or noxious.

The method is of global character considering each aspect of the position of work in a general way. It is not deepened in each one of those aspects, a first valuation is only obtained to determine if a deeper analysis is required with specific methods. The objective is, according to Guelaud (1977), to evaluate the group of relative factors to the content of the work that it can have repercussion so much about the health as envelope the personal life of the workers. Before the application of the method they should have been considered and resolved the relating labor risks to the Security and Hygiene in the Work because they are not contemplated by the method.

The information that is necessary to pick up to apply the method has a double objective-subjective character. On one hand quantitative variables they are used as the temperature or the sound level, and for other, it is necessary to pick up the worker's opinion regarding the work that he/she carries out in the position to value the mental load or the aspects psychosocial. Guelaud, 1997

The valuation given and dimensions and factors considered by the method LEST is shown in the following charts.

Table 1. Valuation and Meaning in LEST method

Color and punctuation	Meaning
0, 1, 2	Satisfactory situation
3, 4, 5	Weak annoyances
6, 7	Average annoyances. Risk of fatigue exists.
8, 9	Strong nuisances. Fatigue exists
10	Harmfulness

Table 2. Dimensions and factors in LEST method

	DIMENSIONS				
	PHYSICAL LOAD	PHYSICAL ENVIRONMENT	MENTAL DEMANDS	PSYCOSOCIAL DEMANDS	TIME DEMANDS
FACTORS	Static load	Thermal environment	Time pressure	Iniatitive	Time demands
	Dynamic load	Noise	Complexity	Social Status	
		Ilumination	Attention	Communication	
		Vibrations		Relation with the head	

2.2 REBA method

The method REBA (Rapid Entire Body Assessment) it was proposed by Sue Hignett and Lynn McAtamney and published by the specialized magazine Applied Ergonomics in the year 2000. The method is the result of the combined work of an ergonomists team, physiotherapists, occupational therapists and nurses that identified around 600 postures for its elaboration.

The method allows the combined analysis of the positions adopted by the superior members of the body (arm, forearm and wrist), trunk, neck and the legs. Also, it defines other factors that it considers determinant for the final valuation of the posture, as the load or managed force, the type of coupling or the type of muscular activity developed by the worker. It allows to evaluate static as dynamic postures, and it incorporates as novelty the possibility to point out the existence of abrupt changes of posture or unstable postures.

The method REBA is a tool of specially sensitive analysis of postures with the tasks that bear unexpected changes of position, as consequence usually of the manipulation of unstable loads.

Their application prevents the analyst about the risk of lesions associated to a posture, mainly of muscle-skeletal type, indicating in each case the urgency with which correction actions should be applied. It is, therefore, of an useful tool for the prevention of risks able to alert on inadequate work conditions.

Table 3. REBA Method Punctuation

Final puntuation	Action level	Risk level	Situation
1	0	No risk	Changes are not necessary
2, 3	1	Low	Changes are possible
4, 5, 6, 7	2	Half	Changes are necessary
8, 9, 10	3	Nigh	Changes are necessary and quickly
11, 12, 13, 14, 15	4	Very High	Changes are urgent

2.3 Equation of NIOSH

Equation of NIOSH allows to evaluate tasks in which lifts are realized, being offered as result the Recommended Weight Limit (RWL) that is possible to lift in better conditions to avoid problems of back (Niosh, 1981).

In 1981 the Institute for the Occupational Security and Health of the Department of Health and Human Services published one first version of equation NIOSH; later, in 1991 one second version in that was made public the new advances in the matter took shelter, having allowed evaluate asymmetric rises, with you take hold of the load non optimal and with a greater rank of times and frequencies of rise. In addition, in that year the lifting Index was introduced (LI), an indicator that allows to identify dangerous rises (Niosh, 1981).

The reviewed equation of NIOSH (REN) considers 6 factors, which are the following: • Factor of horizontal range (HM) • Factor of vertical range (VM) • Factor of displacement (DM) • Factor of asymmetry (A.M.) • Factor of frequency (FM) • Factor of takes hold (CM) These multiplied factors to the being to each other and by a constant of load (K=23 kg), provide as result the weight limits recommended that the worker must handle in the evaluated activity, according to is indicated in Equation. Niosh, 1994.

REN=AH*VM*DM*AM*FM*CM*K (1)

3. RESULTS

3.1 Application of LEST method

The following chart shows the general diagnosis in the public market, this results was obtained after apply the LEST Method.

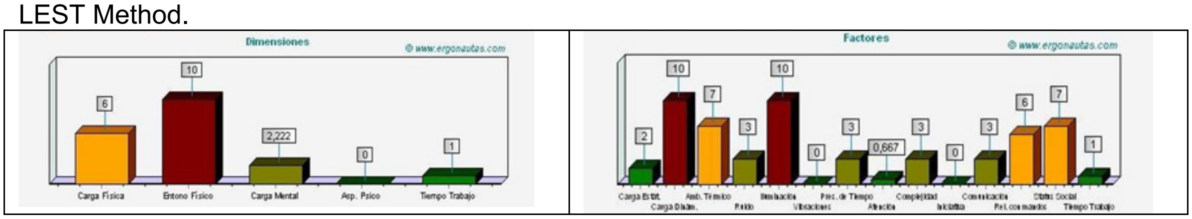


Figure 1. Result LEST Method

3.2 Application of REBA method

With the REBA method was evaluated the activities of to load structures, to load merchandise, to assemble structures, to accommodate merchandise.

3.2.1 Load structures activity.

After to apply REBA method in this activity, it was obtained a final punctuation of 4 and actuation level of 2, therefore the risk level is medium and it`s necessary the changes in the activity.

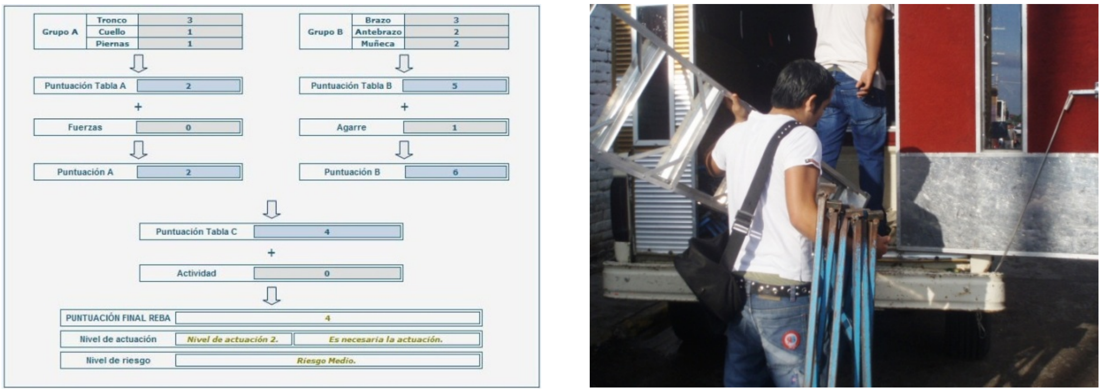


Figure 2. To load structures. Picture and Method REBA punctuation.

3.2.2 Load bags activity.

In this activity, REBA method shows a final punctuation of 8 and actuation level of 3, therefore, the changes are necessary as soon as possible because the risk level is high.

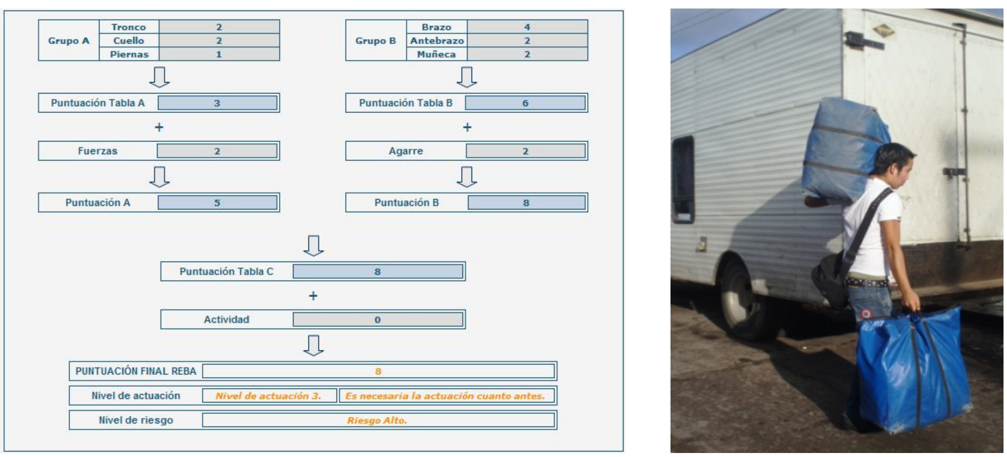


Figure 3. To load bags. Picture and Method REBA punctuation.

3.2.3 Joint of structures.

After apply REBA method in this activity, it was obtained a final punctuation of 5 and actuation level of 2, therefore the risk level is medium and it`s necessary the changes in the activity.

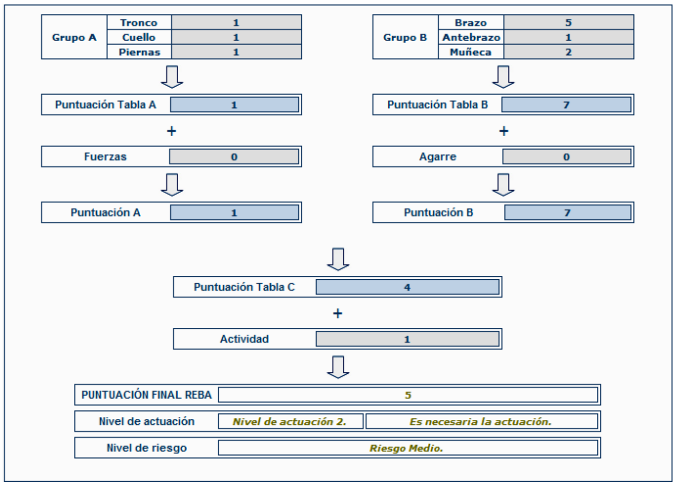


Figure 4. To joint structures. Picture and Method REBA punctuation.

3.2.4 To accommodate merchandise

In this activity, the result of REBA method was a final punctuation of 5 and actuation level of 2, therefore, changes are necessary and the risk level is medium.

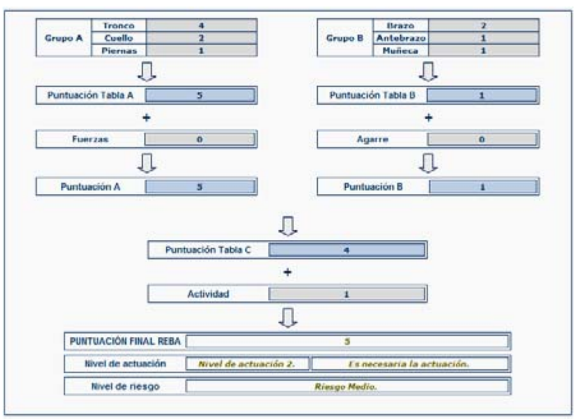
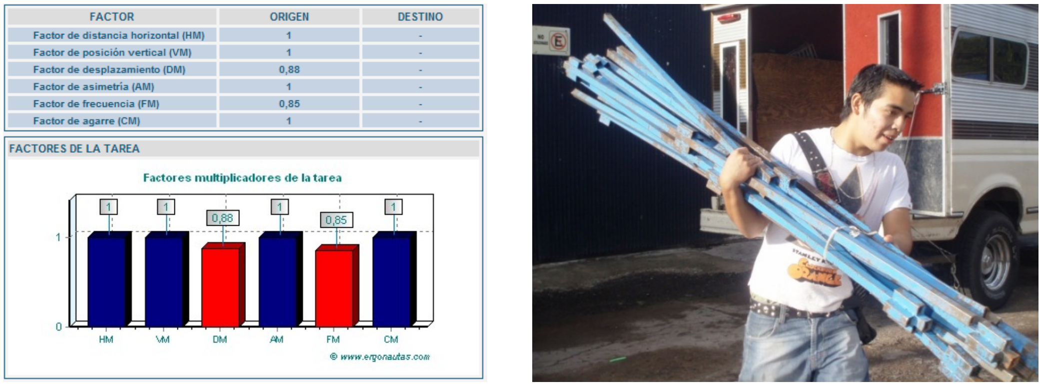


Figure 4. To accommodate merchandise. Picture and Method REBA punctuation.

3.3 Application of Equation NIOSH

3.3.1 Lifting structures

In this activity, the Recommended Weight Limit (RWL) was 17.2 kg, and lifting index of 1.16.

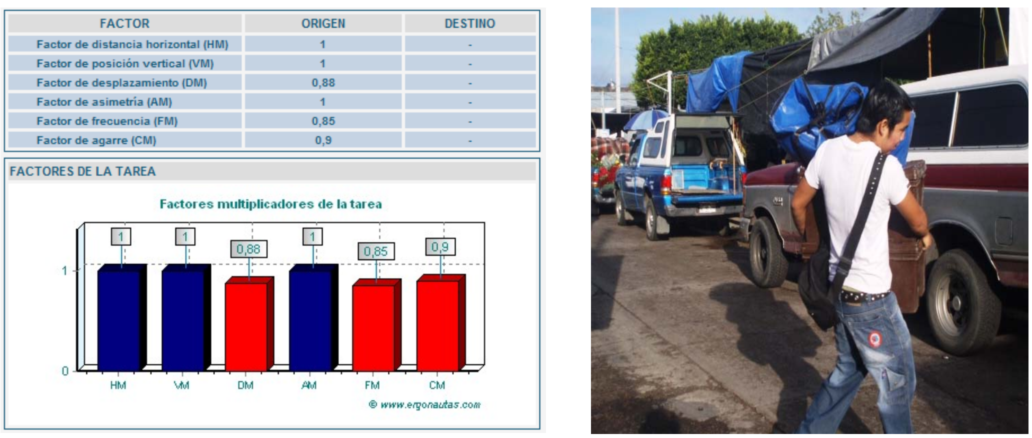


FACTOR	ORIGEN	DESTINO
Factor de distancia horizontal (HM)	1	-
Factor de posición vertical (VM)	1	-
Factor de desplazamiento (DM)	0,88	-
Factor de asimetría (AM)	1	-
Factor de frecuencia (FM)	0,85	-
Factor de agarre (CM)	1	-

Figure 5. Lifting structures. Picture and Eq. NIOSH punctuation

3.3.2 Lifting bags with merchandise

In this activity, the Recommended Weight Limit (RWL) was 15.48 kg, and lifting index of 2.26.



FACTOR	ORIGEN	DESTINO
Factor de distancia horizontal (HM)	1	-
Factor de posición vertical (VM)	1	-
Factor de desplazamiento (DM)	0,88	-
Factor de asimetría (AM)	1	-
Factor de frecuencia (FM)	0,85	-
Factor de agarre (CM)	0,9	-

Figure 6. Lifting bags with merchandise. Picture and Eq. NIOSH punctuation

4. DISCUSION AND CONCLUSIONS

After the application of Method LEST, the factors with higher risk level were dynamic load, illumination, thermal environment and social status. The obtained level of dynamic load (10), is because the workers must walk and at the same time, they must to load structures, bags and/or boxes with merchandise with weights about 15 kg. The static load was with a low level, because the weight of the individual products is little significant, nevertheless we do not have to forget the positions in which they realize the joint of the structures.

The illumination obtained a level of 10 and the thermal environment of 7, this must to that the workers outdoors realize their activities and without but protection that a cap. Finally the social status obtained a level of 7, which is considered like upper middle risk, this because the level of studies and the time that a person requires to realize those activities are very little and with a simple instruction can begin to work.

All these activities showed at least average points in the REBA method scale, this meaning that changes are necessary in the activities done by the workers and to consider the use of tools in order to diminish the ergonomics risk.

Activities analyzed by NIOSH equation, they got lifting index up to 1, this meaning that the weight lifted is higher than RWL and there is risk that the workers suffer musculoskeletal disords due to the weight of each lifting.

With the levels of risk obtained, it´s necessary to modify the activities, to consider the use of carts to move merchandise, and probably the simple solution to do the activities with two persons.

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Ergonomic evaluation in driveshaft manufacturing, tool room area.

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Abstract

In GKN Inc. Celaya, exists the tool room, there the equipment that is used by the maintenance is reviewed and fixed; the ergonomics evaluation was directed to this area. The activities more commons are the milling and lathing, these activities show the highest incidence of muscle-skeletal injuries, such as low back pain, neck and shoulder. In order to realize the ergonomics diagnosis in the tool room, it was applied the LEST method; to get the ergonomic physics evaluation in the activities of milling and lathing it was applied the RULA method considering the significant postural changes of the activity progress. The results of LEST method shown that static load, dynamic load and noise had 10 points, time demands 8.5 points, lighting and relation with the head 7 points and the thermal environment with 6 points. The RULA method show final punctuations of 6 and actuation level of 3, for both activities evaluated. According with the results, it was determinate in both activities has a poor design and show a lack of process document, and both are generating muscle-skeletal injuries to the workers.

Keywords: work place, muscle-skeletal injuries, lathing, milling.

Resumen

En la empresa GNK Celaya, existe el área de maquinas-herramientas, ahí el equipo que es usado por las cuadrillas de mantenimiento es revisado y reparado; la evaluación ergonómica fue centrada en esta área de la empresa. Las actividades más comunes son el torneado y el fresado, estas actividades presentan la más alta incidencia de lesiones musculo-esquelética, tales como dolor de espalda, cuello y hombros. Para realizar el diagnostico ergonómico en el área de maquinas-herramientas fue aplicado el método LEST, y para realizar la evaluación física de las actividades fue aplicado el método RULA considerando los cambios importantes de posturas durante el desarrollo de las actividades de fresado y torneado. Los resultados del método LEST mostraron que la carga estática, carga dinámica y el rudo obtuvieron puntuación de 10, el tiempo de trabajo obtuvo 8.5, la iluminación y la relación con el mando obtuvieron valores de 7, y el ambiente térmico obtuvo 6 puntos. El método RULA obtuvo puntuaciones finales de 6 y niveles de actuación de 3 para ambas actividades evaluadas. De acuerdo con los resultados, se puede concluir que en ambas actividades no se diseñó la estación de trabajo, muestran falta de documentación en sus procesos y ambas actividades están generando molestias musculo-esqueléticas en los trabajadores.

Palabras clave: estación de trabajo, lesiones musculo-esqueléticas, torneado, fresado.

1. INTRODUCTION

Company GKN Driveline is a factory of the area metallurgical industry/, automotive branch, which makes driveshafts, the facrory is located in Pan-American highway km 284, in Celaya, Gto. It is supplier of the following cars manufactures: Toyota, Honda, Wolkswagen, GM, Ford, Chrysler, Renault, among others. At the moment it has 1.700 employees and it includes an approximated area of 30 hectares.
This investigation concentrates in the area of forge, specifically in the area of machine-tools, where punches and matrixes are elaborated.

The evaluated activities were turned and milled. The aims were directed towards the obtaining risk index in the positions that the workers adopt when they doing the mentioned activities. The description of the positions that the workers realize shows in the following images:

Figure 1. Lathing operation

The piece that handles in the turning and the milled is a punches and its weight oscillates between 10 and 15 kg. The punch is showed the following image.

Figure 2. Punches

The methods of ergonomic evaluation LEST and RULA were applied. The obtained results were considered for the improvement of the work methods and the design of devices that help the diminution of the ergonomic risk index, such as: aids for load and unloading of tools and modification of height of work tables and machines.

2. MATERIAL AND METHODS

2.1 Activities evaluated

In the tool room there are 10 workers, all of them male, the rank of ages is 22 to 38 years, the rank of statures of 1,60 to 1,74 meters, the average of antiquity is 15 years in the factory, where 5 of them realize the turning and the other 5 milling.

Some of the positions realized during the operations are the following.

Figure 3. Lathing and milling activities.

2.2 LEST method

The method Lest was developed by F. Guélaud, M.N. Beauchesne, J. Gautrat and G. Roustang, members of the Laboratoire d'Economie et Sociologie du Travail (L.E.S.T.), of the C.N.R.S., in Aix-in-Provence in 1978 and it carries out the evaluation of the conditions of work in the possible more objective and more global way, a final diagnosis that indicates if each one of the situations considered in the position is satisfactory, bothersome or noxious.

The method is of global character considering each aspect of the position of work in a general way. It is not deepened in each one of those aspects, a first valuation is only obtained to determine if a deeper analysis is required with specific methods. The objective is, according to Guelaud (1977), to evaluate the group of relative factors to the content of the work that it can have repercussion so much about the health as envelope the personal life of the workers. Before the application of the method they should have been considered and resolved the relating labor risks to the Security and Hygiene in the Work because they are not contemplated by the method.

The information that is necessary to pick up to apply the method has a double objective-subjective character. On one hand quantitative variables they are used as the temperature or the sound level, and for other, it is necessary to pick up the worker's opinion regarding the work that he/she carries out in the position to value the mental load or the aspects psychosocial. Guelaud, 1997.

The valuation given and dimensions and factors considered by the method LEST is shown in the following charts.

Table 1. Valuation and Meaning in LEST method

Color and punctuation	Meaning
0, 1, 2	Satisfactory situation
3, 4, 5	Weak annoyances
6, 7	Average annoyances. Risk of fatigue exists.
8, 9	Strong nuisances. Fatigue exists
10	Harmfulness

Table 2. Dimensions and factors in LEST method

	DIMENSIONS				
	PHYSICAL LOAD	PHYSICAL ENVIRONMENT	MENTAL DEMANDS	PSYCOSOCIAL DEMANDS	TIME DEMANDS
FACTORS	Static load	Thermal environment	Time pressure	Iniatitive	Time demands
	Dynamic load	Noise	Complexity	Social Status	
		Ilumination	Attention	Communication	
		Vibrations		Relation with the head	

2.3 RULA method

To get the evaluation of the positions adopted by the workers when they doing its work, it was decided to apply the method of ergonomic evaluation RULA, because this one allows to evaluate the exhibition of the workers to risk factors that can cause muscle-skeletal injuries in the members superiors of the body.

Some of the factors analyzed within this method were the positions, the repetitively in the movements, the applied forces, the static activity of the system skeletal muscle, among others (Corlett, 1993).

Method RULA divides the body in two groups, the group A that it includes the members superiors (arms, forearms and wrists) and the group B, that includes the legs, the trunk and the neck. By means of the tables associated to the method, a score is assigned to each corporal zone (legs, wrists, arms, trunk…) for, based on these scores, to assign global values to each one of the groups A and to B.

The key for the allocation of scores to the members is the measurement of the angles that include different from the body of the worker. The method determines for each member the form of measurement of the angle. Later, the global scores of the groups A and B are modified based on the type of developed muscular activity, as well as of the force applied during the accomplishment of the task. Finally, the final score from these modified global values is obtained.

The final value provided by method RULA is proportional to the risk that entails the accomplishment of the task, so that high values indicate a greater risk of appearance of muscle-skeletal injuries. The method organizes the final scores in action levels that orient the analyst one on the decisions to take after the analysis. The proposed levels of action start of the level 1, this meaning that the evaluated position is acceptable, the highest level is 4, which indicates the urgent necessity of changes in the activity.

The possible results offered by RULA are divided in four levels, which depend directly on the risks reached about the developed activity. The following chart shows the different levels and the action need for each level.

Table 3. Levels and meaning in RULA method

Level	Meaning
1	When the final score is 1 or 2, the posture is acceptable
2	When the final score is 3 or 4, changes in the task are necessaries; is convenient to do a deeper analysis.
3	The final score is 5 or 6. A redesign in the task or method work is necessary.
4	The final score is 7. Changes in the task or work station are urgent.

Fuente: http://www.ergonautas.upv.es/metodos/rula/rula-ayuda.php

The obtained data was processed by means of web page developed by the Polytechnic University of Valencia, Spain; it can be consulted in Internet web page www.ergonautas.com for RULA and LEST methods.

3. RESULTS

Next, the graphics of the application of LEST and RULA methods in tool room are showed is separated sections.

3.1 LEST method application

With respect to the analysis of the workstation by means of the diagnosis conducted by method LEST the following graph was obtained, considering the operations of turning and milling is in the same work area, reason why this diagnosis is applicable for both operations:

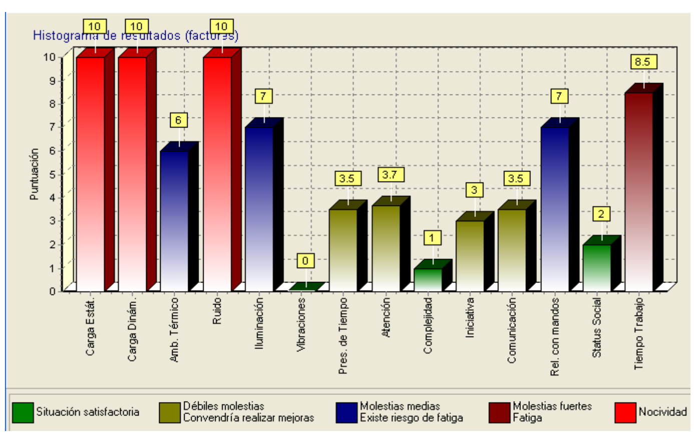

Figure 4. LEST method results. Factors.

It is possible to observe that the static and dynamic load are factors considered with high risk, due to the workers must to maintain a weight approximated of 15 kg., between load and unloading, which represents that at the end of the labor day, the operator has loaded an accumulated gross weight of 1200 kg.

Also, the noise got the highest score (10 points), this due to the level of noise oscillates between 85 and 95 dB among the labor day, this can be equivalent to the noise generated by a dryer of hair in her maximum scale or by the alarm-clock in a continuous time of 8 to 12 hours.

The time demands is a risk factor, obtained a score of 8.5 points which is considered like fatigue, a typical duration is almost 12 hours in a common labor day, obviously this situation can cause a chronic fatigue in the workers.

The following chart, show results of the dimensions considered by the LEST method.

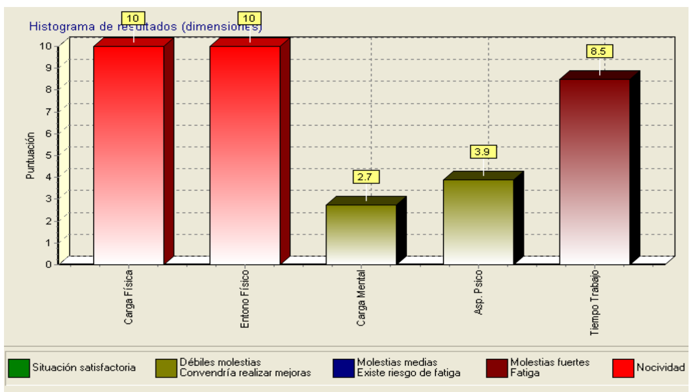

Figure 5. LEST method results. Dimensions

3.2 RULA method application

The following chart shows the results for milling operation in the RULA method application.

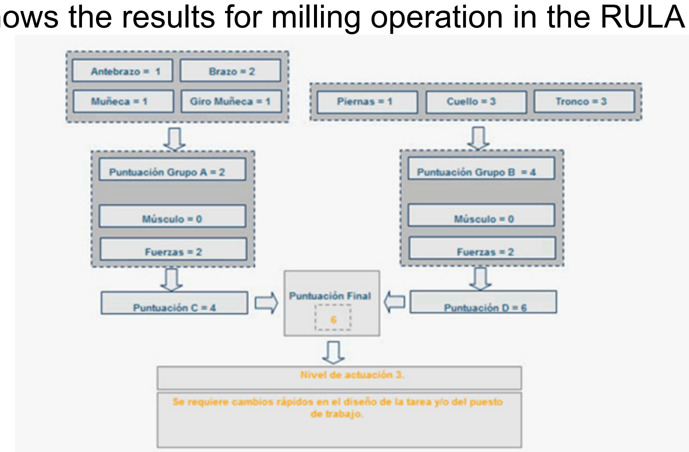

Figure 5. RULA results. Milling operation

The following chart shows the results for lathing operation in the RULA method application.

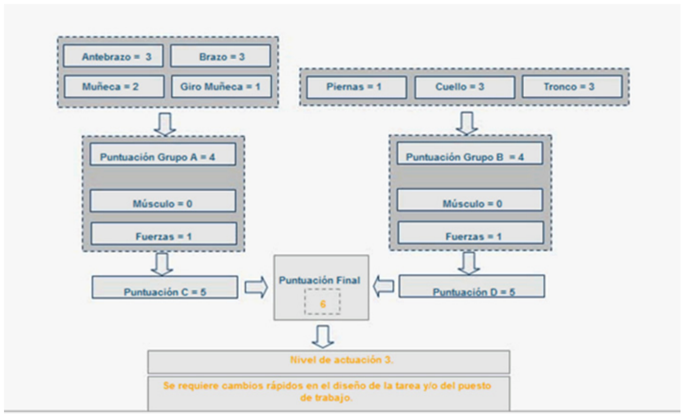

Figure 6. RULA results. Lathing operations.

4. DISCUSSION AND CONCLUTIONS

The factors that showed a higher index, according to the LEST graph, were: static load, dynamic load, noise and time demands. The factors that showed an intermediate index were: thermal environment, illumination and the relation with the head. On the contrary, the factors of smaller index were: vibrations, complexity and social status.

Referring us to the factors of greater index of ergonomic harmfulness, it is possible to said that, due to the weight of the tools (12 to 16 kg.) and the frequency of load and unloading (for turning, each half an hour; milling, every 4 hours), in both options, static and dynamic load, resulted with the highest risk index, in this case 10 points of score in the LEST method which is considered like injurious.

Too, the noise got the highest score of risk (10 points), this due to the combination of two important radiant bodies: the machines in the tool room and the presses of the forging area which is next to the tool room. Finally, time demands were factor of injurious risk because regularly they must work overtime, which cause an excessive extension of the labor day, typically until of 12 hours.

The graphic resultants of the application of method RULA show a 6 final score and an action level of 3 for both evaluated activities. In the case of the milling, the parts of the body with greater score was the arm, neck and trunk with scores of 2, 3, and 3 respectively; in turning, the parts with greater score were the forearm, arm, neck and trunk, all of them with scores of 3.

To improve working conditions in the activities evaluated, the following proposals to change work stations.

In the business of turning, the following modification:

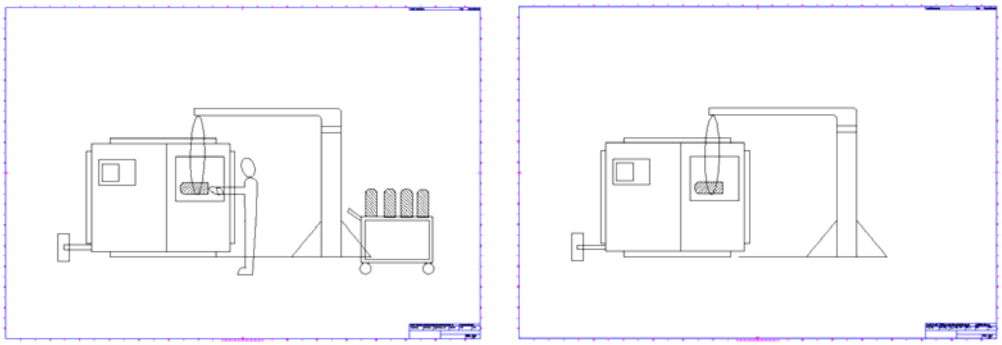

Figure 7. Modification of work station for lathing operation.

With this modification, the weight that loads the worker at the time of realizing the lathing of the punches will be reduced significantly.

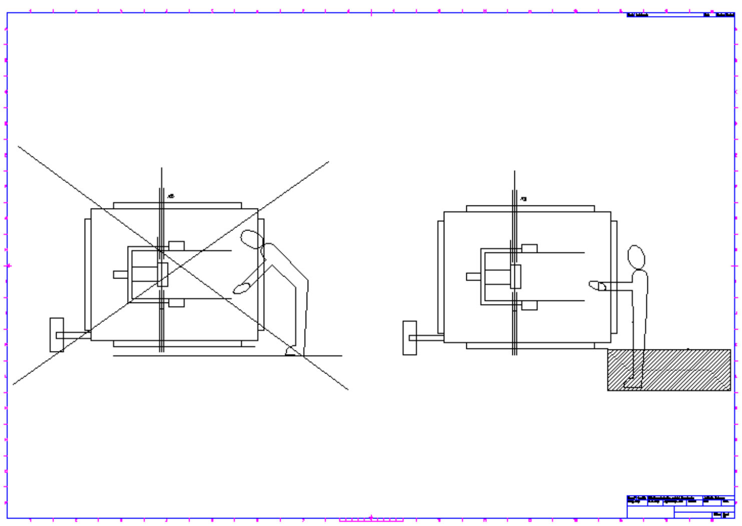

Figure 8. Modification of work station for milling operation

With this modification in the work station, the inclination that the worker realize at the time of doing the milling operation will be reduced and with that the incidences of injuries in the back will be able to be reduced.

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RULA method online: http://www.ergonautas.upv.es/metodos/rula/rula-ayuda.php

LEST method online : http://www.ergonautas.upv.es/metodos/lest/LEST_online.php

Redesign of the Furniture in the area of Moulding by Injection of a Company of the Electrical Branch

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RESUMEN

En una empresa dedicada a la fabricación de tableros y construcción de sujetadores eléctricos, se inician actividades referentes al moldeo por inyección con dos máquinas de 75 y 150 toneladas respectivamente, dando inicio a la fabricación de una palanca y una base de poli carbonato, mismas que al unirlas se utilizan para hacer pruebas en los mismos sujetadores eléctricos. Entre el equipo se encuentra una mesa de trabajo llamada “ponchadora” en la que se realiza la tarea del corte de neopreno. Transcurrido diez días de uso, los operadores comenzaron a manifestar dolores en cuello, hombros, brazos, espalda y piernas. En esta investigación se analizó el diseño de la mesa de trabajo, detectando que para su fabricación se omitieron reglas básicas de ergonomía provocando posturas inapropiadas y dolorosas. Utilizando el método Reba, para determinar las posiciones adoptadas por los miembros superiores del cuerpo, del tronco, del cuello y de las piernas, se rediseñó la “ponchadora” tomando medidas ergonómicamente establecidas tanto para hombres como para mujeres por lo que la altura de la mesa debe estar entre 75 y 120 cm. para realizar las actividades sentado y de pie.

Palabras Clave: Posturas, Método REBA

ABSTRACT

In a company dedicated to the manufacture of panels and electrical construction fasteners, referring activities to the moulding by injection with two machines of 75 and 150 tons begin respectively, giving to beginning to the manufacture of a handle and a base of poli carbonate, same that when uniting is used them to test in the same electrical supports. Between the equipment is a called table of work “ponchadora” in which the task of the neoprene cut is realised. Passed ten days of use, the operators began to indicate pains in neck, shoulders, arms, back and legs. In this investigation the design of the work table was analyzed, detecting that for their manufacture basic rules of ergonomics were omitted causing unsuitable and painful positions. Using the Reba method, to determine the positions adopted by the members superiors of the body, the trunk, the neck and the legs, the “ponchadora” was redesigned ergonomically taking measured established so much for men as for women reason why the height of the table must be between 75 and 120 cm in order to realise the activities seated and standing up.

Key words: Positions, REBA Method

1. INTRODUCTION

In a plant that dedicates to the manufacture of boards and construction of electrical holding, an area of moulding by injection exists and in this area a called product “Caps” is elaborated in which a circle of “Neoprene” is assembled, which are cut by a press installed in a work table, which is called “ponchadrora”, the joint of the neoprene in caps and the ponchadora machine neoprene is illustrated in figures 1,1 and 1,2 respectively.

Figure 1 Neopreno´s circle in the caps   Figure 2 Ponchadora´s Machine

In this table of called work “ponchadora” (figure 1,2), it consists of a hydraulic piston, an automatic pedal and an air tank, and when being operating it one at first sees ergonomic problems in which they detach to factors of occupational risk as they are the bad positions and repetitive efforts, as well as a mechanical risk of it catches by the piston when driving the machine and can exist a lack of coordination when being above the pedal and position the neoprene circle.

When designing this workstations did not consider the ergonomic tools in but minimum applying them to the principles of design of workstations as they show the figures to it 1,3 and 1,4 by which the operators To and set out B when being to factors of occupational risk with time finished with pains in neck, shoulders, arms, back and legs being able to turn these into you disorder of accumulated trauma (DTA} producing injuries in tendons, nerves and circulatory Stella.

By previously exposed one becomes necessary to carry out a postural analysis to the called workstation “ponchadrora” and to use the tools available of ergonomics to improve it and thus to fulfill its objective that is the one of the security and the comfort when realising the work and to increase the productivity of the company.

Figure 3 Operator A

Figure 4 Operator B

2. METHODOLOGY

In order to determine the correct position of the operator when using the work table, with which the bases of Neoprene take place, will be used the method REBA which allows to the joint analysis of the positions assumed by the members superiors of the body, the trunk, the neck and the legs. In addition, it defines other factors that consider determinants for the final valuation of the position, like the load or handled force, the type of takes hold or the type of muscular activity developed by the worker.

The analysis of the data for method REBA, will be made trough software called Rapid Entire Body Assessment which can be found in the page of Internet www.ergonautas.com.

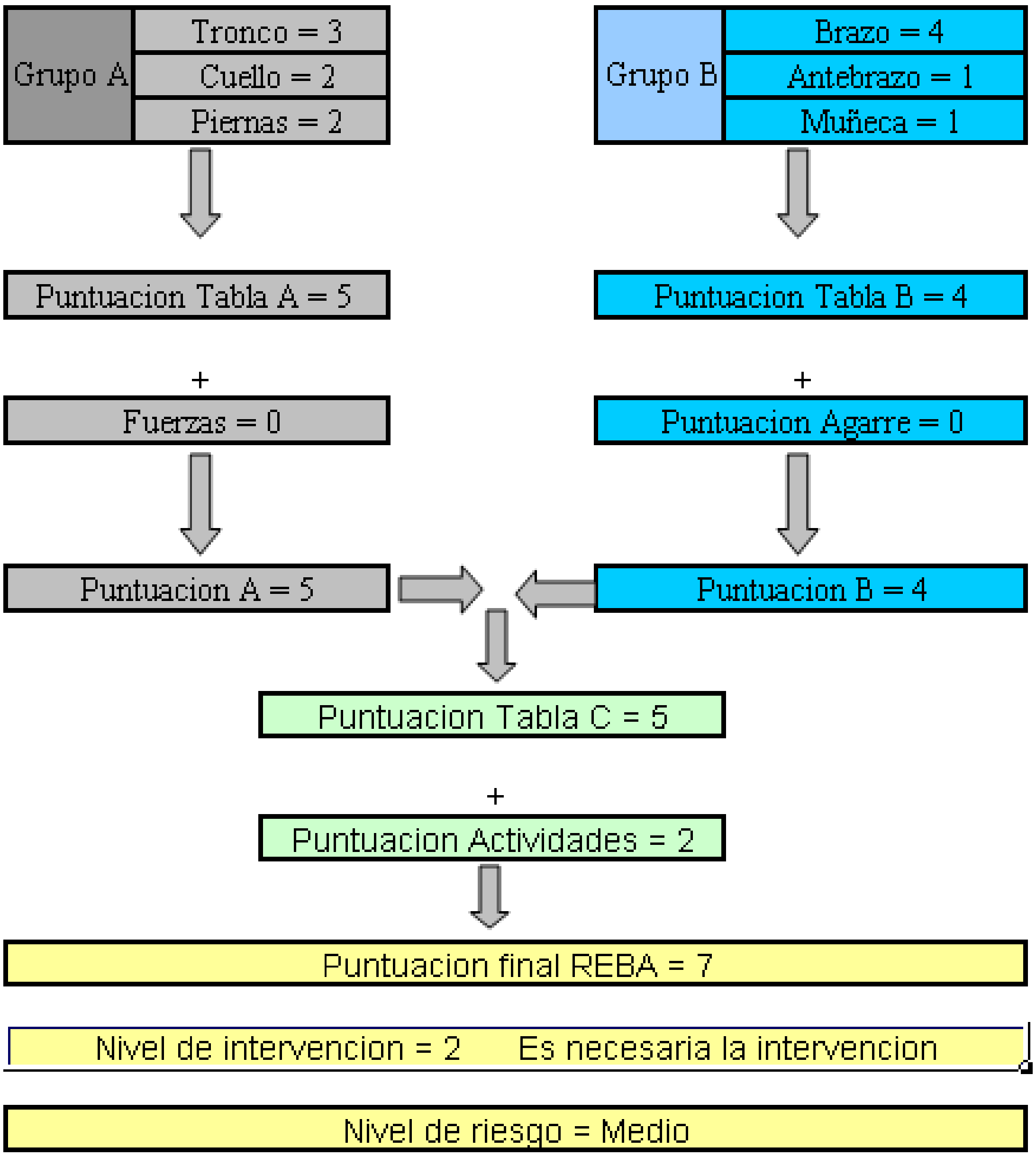
It allows the valuation of the muscular activity caused by static, dynamic or which had positions to abrupt or unexpected changes in the positions.

The result determines the risk level to suffer injuries being established the required level of action and the urgency of the intervention.

Method REBA evaluates the risk of concrete positions of independent form. Therefore, to evaluate a position their more representative positions will be due to select, or by their repetition in the time or its instability. The correct selection of the positions to evaluate will determine the results provided by method and the future actions.

Method REBA is applied separately alongside straight and alongside left of the body. Therefore, the evaluator according to its criterion and experience, will have to determine, for each selected position, the side of the body that entails a greater postural load.

Analysis and results of and the straight left side by method REBA.



The evaluation of the positions with method REBA gives a medium risk level, where, the recommendation is to modify the activity of the operator by means of an innovating redesign of the work table.

3. RESULTS

As a result of the ergonomic analysis by means of method REBA, an innovating design of the table of the "ponchadora" with three options sets out or forms to conduct the operation of cut of neoprene: seated, stopped and seat-unemployed. The redesign consists of the adjustability of the height of the cover of the table, which was included in the range of the anthropometric measures extremes from different users, either to work seated or stand up, as is shown in figure 3.1

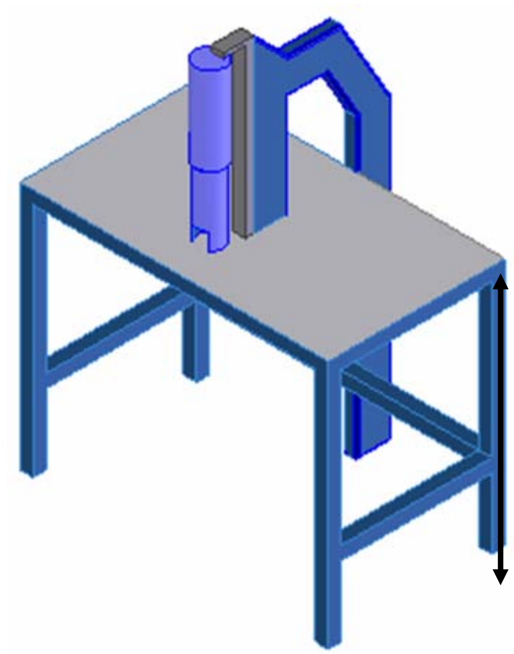


Figure 5.- Ranks in the measures in the table redesign of "ponchadora"

Option I: when performing the seated operation:

- The table cover will be adjusted to 75 cm height..
- One will approach the material containers to avoid long reaches.
- will be selected a ergonomic pedal ,
- An adjustable ergonomic chair of height will be selected as well as common support of type tarantula spider* for a greater balance of gravity center
- The table will be adapted support-feet ergonomic.
- To design a security guard to avoid the mechanical risk of supported.

* chair support with 5 legs minimum.

Option II: when performing the operation standing up.

- It was decided that the operator worked in a table to remain standing up not to limit his movements having long reaches and thus he has change of positions. and more facility of displacement in the work area of the molding machines.
- The height of the table cover will be adjusted from 90 to 120 cm. this will allow to maintain an elbow neutral position,and will also be possible to cover the ranges of elbow anthropometrics height measures of the personnel , most importantly ,this will to avoid the stress position of the neck when inclined more than 20 degrees which causes to a compression force in the cervical part of the operator.
- The pedal use will be eliminated and by reasons for safety purpose the machine will simultaneously drive by both hands by means of two micro switches buttons, these micros will be placed in the cover table edges ends in a vertical position so that the wrists assume a neutral position.
- The use of smooth, anti-fatigue and ergonomic rug is recommended, to that the operator does not require to apply effort, reason why if he does not require resistance for a easy displacement.

Option III: when performing the operation seated-standing up.

- The height of the table will be adjusted using the same characteristics of option II with the advantage that after a man-machine diagram study cis made othr activities could be performed.
- An ergonomic support will be assigned t (figure 3,2) having the opportunity to stand up,resulting in th e reduction of static efforts a when adopting the same position.

Figure 6.- Ergonomic support.

4. CONCLUSIONS

Nowadays, there are more than 100 techniques to evaluate work methods, but the most important issue to obtain the proper data on factor detection of occupational hazards is the information obtained by the medical department in the company, but most importantly by the operator, since he is the person that exposed in a daily basis to work stresses and injuries caused repetition, effort and postures. In conclusion the operator must provide this valuable feedback in order to improve work conditions in the work place. It is important to remark that it is required to have common sense besides engineering to resolve an ergonomic problem. We must not forget that ergonomics is “to adapt things to people and not people to things.”

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ErgoSoft

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Key words: *ergonomic job analysis, ergonomic software development.*

ABSTRACT

This project pretends to facilitate the process of knowledge construction of REBA and RULA methods in job analysis evaluation used in ergonomics, all that by using information technologies. Software allows users to evaluate jobs in a graphical and logical way with the purpose of eliminate risks of injuries and accidents with workers, as well as to improve worker's quality of life and increasing job comfort; this can be performed by visualizing and evaluating different corporal positions producing risk conditions or even injuries.

Nowadays educational software is very important in teaching-learning processes. Unfortunately, often this kind of software is very expensive. The purpose of this project is to explore ITCC technological capacities to save time and software costs and, at the same time to gain experience in software development.

RESUMEN

Este proyecto pretende facilitar el proceso de la construcción de conocimiento de los métodos de evaluación de puestos de trabajo REBA y RULA en Ergonomía, utilizando las nuevas tecnologías de la información. El software permite al usuario de una manera grafica y lógica evaluar puestos de trabajo con el fin de eliminar riesgos de lesiones y accidentes a los trabajadores, así como mejorar la calidad de vida de los mismos y aumentar el confort

laboral, esto visualizando y evaluando las diferentes posiciones corporales que producen las condiciones de riesgo.
El software educativo es de gran importancia en el proceso enseñanza aprendizaje. Por desgracia muchas veces este software tiene un costo muy alto. Se buscara explotar las capacidades tecnológicas con que cuenta el ITCC para ahorrarse el costo mencionado y al mismo tiempo ganar experiencia en el desarrollo de software.

Palabras clave: *Análisis ergonómico del trabajo, desarrollo de software ergonómico.*

1. INTRODUCTION

The importance of Information and Communications Technologies is undeniable (ICTs), this fact can't be ignored in the education sector; use of this type of technology allows the facilitation of the teaching-learning process. Ernesto Lecourtois in his article "Educational Software Use, Necessity or satisfaction?" mentioned how modern society demands to its citizens to be more and more prepare to challenges that they have to face up in their labor and/or familiar daily life, educators work becomes the pillar on which the transformation of the future generations rests, generations that successfully know how to confront assigned tasks to them; a tool helpful to fulfill this challenge definitively is the computer, this allows educators to develop new learning methods; on this point it is where educational software is pertinent.

At the moment we are facing transcendental technological consequences that force social changes, use of new technologies is more accelerated day by day; it is mentioned with insistence that this is a knowledge society, understood this as the behavior of better informed people with an uncertain future but decided to face up the challenges. Multidisciplinary concept is present in educators and students because it reflects its presence in any place and time.

The Mexican 2007-2012 Sectorial Education Program, establishes in its third objective that: "To impel the development and use of information and communication technologies in the educative system to support the learning of the students, to extend their competences in life and to favor their insertion in the society of the knowledge" and determines: "Didactic use of information and communication technologies, so that Mexico participates successfully in the society of the knowledge. Investigation, scientific and technological development and incorporation of technologies in the classrooms to support learning of the students will be promoted widely. Scientific and technological formation will be fortified starting from basic education, thus, this will contribute to the development of activities of investigation and production in these fields in Mexico"

Educative software is defined as "software destined to schooling and auto learning and, in addition, it allows the development of certain cognitive abilities, as well as it makes depth differences between existent pedagogical philosophies, thus, there are a wide range of approaches for creation of educative software taking in consideration different types of interaction that would have to exist between actors of the teaching-learning process: educator, beginner, knowledge, computer”.

At present there are an endless number of investigations that endorse the use of ICTs in the educative process as an important part of the pedagogical process; next, some articles are mentioned:

a. Latapi Sarre, Pablo. (2004). Mexican State educative politic since 1992.
b. López, María; Espinoza de los Monteros, Adolfo and Flores, Katiuzka. (2006). Perception on the information and communication technologies in the educators of a Mexican university: the South University Center of the University of Guadalajara.
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d. Lozano Díaz, Antonia (2004). Intelligent classroom: towards a new educative paradigm?
e. Martínez, Rubén; Montero, Yolanda and Pedrosa, María Eugenia. (2001). Computer and classroom activities: some perspectives in the general basic education in Buenos Aires province.
f. Organista, Javier and Backhoff, Eduardo. (2002). Opinion of students on the use of didactic supports on line in a university course.
g. Vázquez, Ángel and Manassero, María Antonia (2007). Extra-curricular activities related to science and the technology.
h. Waldegg Casanova, Guillermina (2002). Use of new technologies for teaching and learning science.

In this paper will be reported an educative software able to facilitate teaching of the ergonomic methods REBA (Rapid Entire Body Assesment) and RULA (Rapid Upper Limb Assesment) for workstations evaluation.

2. EXPOSITION OF THE PROBLEM

The course of Ergonomics is part of the specialty in Quality and Productivity of the Industrial Engineering degree of the Technological Institute of Cuauhtémoc City (ITCC). A fundamental part of this science is job analysis since the results that are obtain give us rules to identify risks of labor injuries and/or points of continuous improvement. In order to obtain these ergonomic analyses there are some techniques, among them the most recognized by its easiness of use are RULA and REBA.

The techniques previously mentioned are taught at present making use of formats and tables that were elaborated for such aim by the authors of these techniques, which represent in fact a learning process of little motivation for students; since nowadays they are used to use

keyboard and monitor instead of pencil and paper. On the other hand, once learned the techniques' principles it is needed to look for better means to apply them in a faster and more convenient way and, in this context, is when the use of the Information and Communication techniques are applied.
By mean of the software creation "ErgoSoft" it is pretended to improve the learning process in a classroom, by making use of ICTs, as well as to provide to students a tool in agreement with this time, so that, they can be more effective in their working future.

3. PROJECT JUSTIFICATION

Educative software is very important in the teaching-learning process; unfortunately it is very expensive, most of the time out of budget for a public school. It's pretended to operate some technological capacities of the ITCC, whereupon this institution could save money improve education, and at the same time, gain experience in software development.

4. SOFTWARE DEVELOPMENT

In this section the development procedure of ErgoSoft will be described.

4.1 DRAWINGS

In order to provide a very intuitive application of the ergonomic methods, a large amount of drawings were performed, the methodology is mention next:

1. Once the three-dimensional human body drawing is obtained from an autocad library (figure 1), it is send to a new autocad document where the necessary changes were made according to the required posture for the ergonomic software.

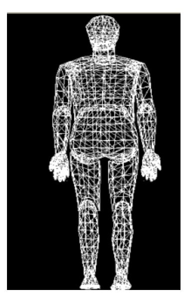

Figure 4. Tridimensional human body image (AUTOCAD)

2. As a following step a different layer is placed in each part of the body, identifying them with colors in order to carry out the task in a more practical and productive way (figure 2).

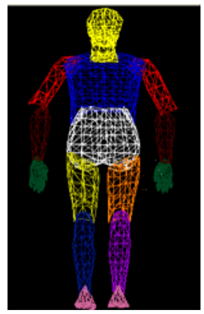

Figure 5. Step 2 in drawings generation process.

3. After having obtained the complete human body with each defined layer, each part of the drawing is cut according to the layer related to the corresponding task, so it can be turn and change according to the wished movements (figure 3).

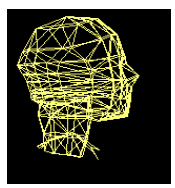

Figure 6. Step 3 in drawings generation process.

4. For this development the command COPY (CO) was used, with this, the drawing is duplicated in a sequence, in order to obtain later, the desire movement (figure 4).

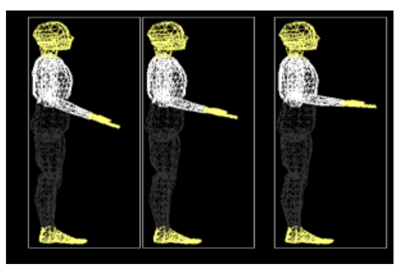

Figure 7. Phase 4 in drawings generation process.

5. For different postures the autocad command ROTATE (RO) is used to give movement to the head without moving body, arms, legs or wrists. By using the tool bar VIEW it facilitates the task of drawing a solid figure (see figure 5).

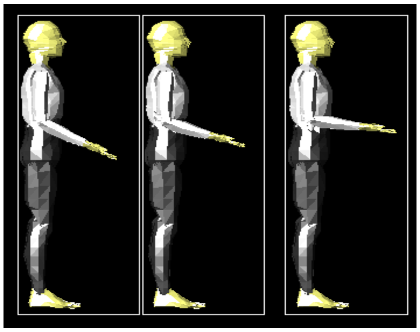

Figure 8. Phase 5 in drawings generation process.

6. When drawings for each movement were finished, they were copied to Paint's Windows Program by using the print screen key on the computer keyboard (figure 6).

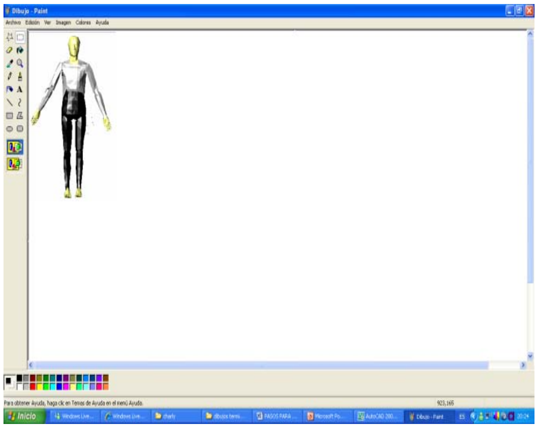

Figure 9. Phase 6 in drawings generation process.

7. Next, each image is cut making it to coincide to a previously determined size pattern (figure 7).

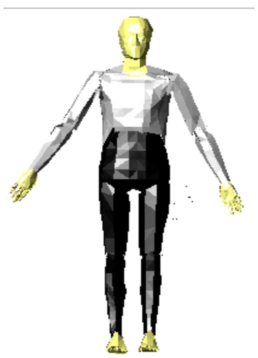

Figure 10. Final drawing example.

8. Once the desired image is obtained it is saved in PNG format for its later use in the ergonomic software (ErgoSoft).

4.2 Development Software Tool

In order to develop ErgoSoft, Visual J# 2005 was used; which is part of the suite of Microsoft Visual Studio 2005. Microsoft Visual J# 2005 allows developers to use the syntax of Java language to generate applications and services that will be executed in the .NET Framework. Visual J# integrates the syntax of Java in the Integrated Development Environment (IDE) of Visual Studio®. Visual J# also admits most of the functionality of J++ 6.0®, including the extensions of Microsoft. Visual J# is not a tool to develop applications that will be executed in a virtual machine of Java. The applications and services generated with Visual J# will be only executed in .NET Framework. Visual J# has been developed independently by Microsoft. It is not authenticated nor approved by Sun Microsystems, Inc.

Due to Visual J# is integrated with the IDE of Visual Studio, programmers of Visual J# can use Visual Studio shells to create services Web XML, pages of Web Forms and Windows Forms applications. The used methodology is that of the object-oriented programming.

The Object-oriented programming (OOP) is a programming paradigm that uses objects and their interactions to design applications and computer programs. It is based on several techniques, including inheritance, modularity, polymorphism and encapsulation. Its use became popular at the beginning of the decade of 1990. At the moment there are many programming languages that support OOP.

4.3 Graphic User Interface

The Graphic User Interface (GUI) is the part of the software which the end user will interact. Consider that the software is in a developing phase and the captured screen may not be representative of the aspect that will have the final software.

The program so far is divided in four main classes per method. The first class is an inherited class of System.Windows.Forms; here there are all the GUI elements. The second form is called data; here there is all data that is handled in the program and also the necessary methods to get to it. Also there is a class called drawings, in which are located the instances that make references to graphical objects and the methods to access to them. Finally the class called file in which are found the required methods to save and open files.

4.4 Results

The first screen when opening ErgoSoft gives the opportunity to select REBA or RULA methods, in this article the REBA method will be explained first, this is the one that is used en positions where the worker uses his entire body or is standing.

REBA

In this section the different screens that are integrated in the REBA part of the educative software will be presented, it is important to mention that each position (when applies) shows a movement that allows the user to choose the position present in the task. The first screen shown when the REBA method is selected (figure 8) is the one that allows the evaluation of the trunk positions, and, in addition to determine if there is torsion or lateral inclination. In the top right part, the score is accumulated according to the selection of positions and in the bottom right part there is a button that has the option to go to the following screen even though the trunk evaluation has not been finished or begun.

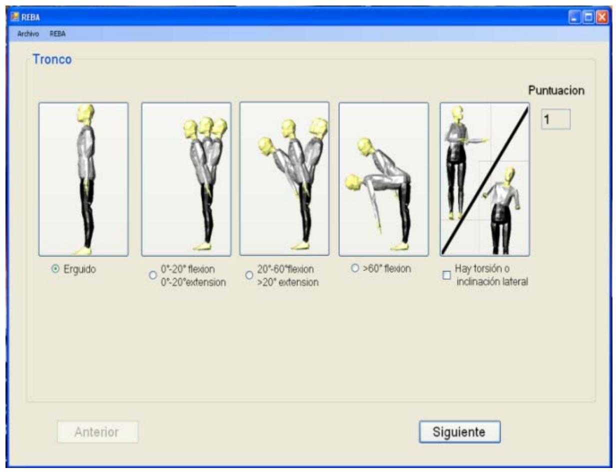

Figure 11. Trunk evaluation screen in REBA.

The following screen is shown in figure 9, it is the one referring to the neck's position, and adding in this screen a button in the bottom left part that allows the user to return to the previous screen.

Figure 12. Neck evaluation screen in REBA.

Figure 10 shows the third screen in which the positions of the legs are divided in two parts, first the one referring to the support, and next the one referring to the knees' flexion.

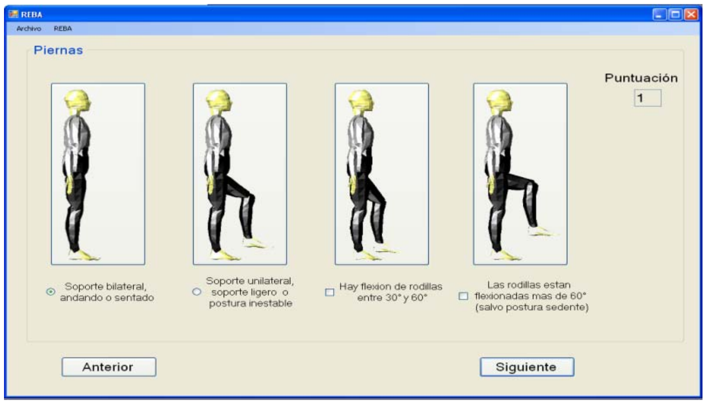

Figure 13. Legs evaluation screen in REBA.

The next screen evaluates the loads and force related to the task, also an extra point is given if the task has fast instauration. In this screen the score is on the top left part of the screen.

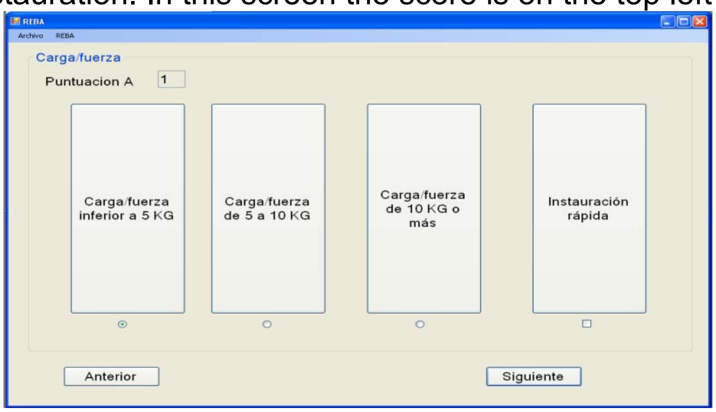

Figure 14. Load/Force evaluation screen in REBA.

In the fourth screen (figure 12) four arm positions are presented for their evaluation and also three more positions that included the existence of abduction or rotation, the shoulder rise and the existence of support or posture in favor of gravity.

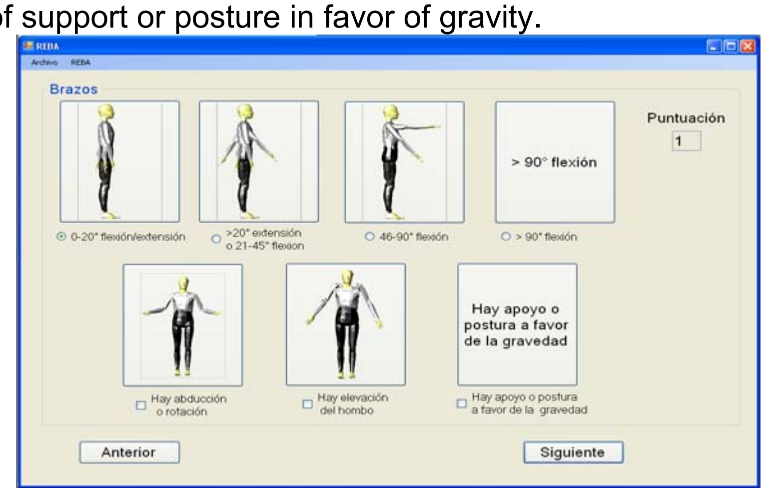

Figure 15. Arms evaluation screen in REBA.

The next screen (figure 13) shows the figures related to forearm position evaluation.

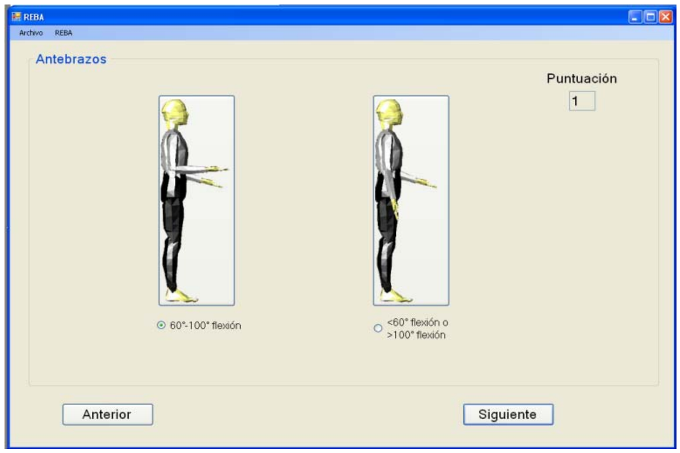

Figure 16. Forearm evaluation screen in REBA.

In the sixth screen (figure 14) wrist positions are evaluated, including extra points if there is wrist torsion or wrist deviation.

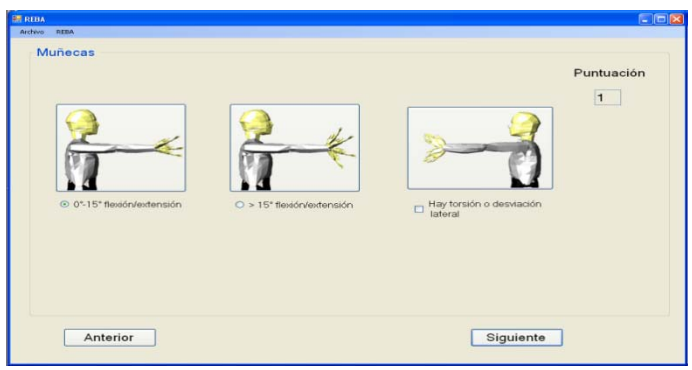

Figure 17. Wrists evaluation screen in REBA.

The following screen (figure 15) implies the evaluation of the holding that goes from a good holding with suitable handles and a strong hold, to an inconvenience and/or uncertain holding for the worker, without handles where the handling is unacceptable using other parts of the body.

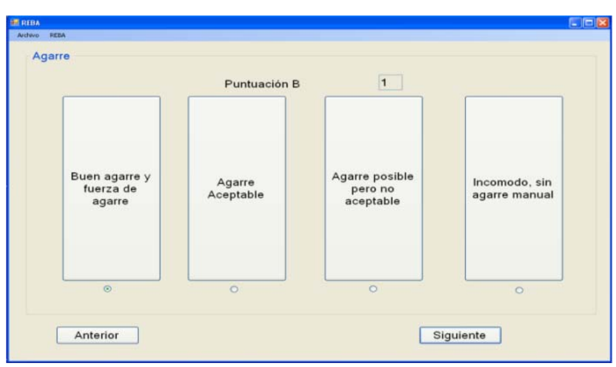

Figure 18. Holding evaluation screen in REBA.

The following screen (figure 16) is the final one, where the conditions in which the activity occurs are evaluated and the final score altogether with the partial scores are presented also the interpretation of the REBA score, which corresponds to a risk level that implies an action as well.

Figure 19. Activity evaluation and final score screen in REBA.

Finally it is important to say that in all screens on the top there is a File Menu (Figure 17) that includes the option to open a new or previous file, as well as the options save and save as and finally the option to quit the program. On the other hand there is a Menu for REBA (Figure 18) that includes the option to go to the different screens that conforms the REBA part of ErgoSoft.

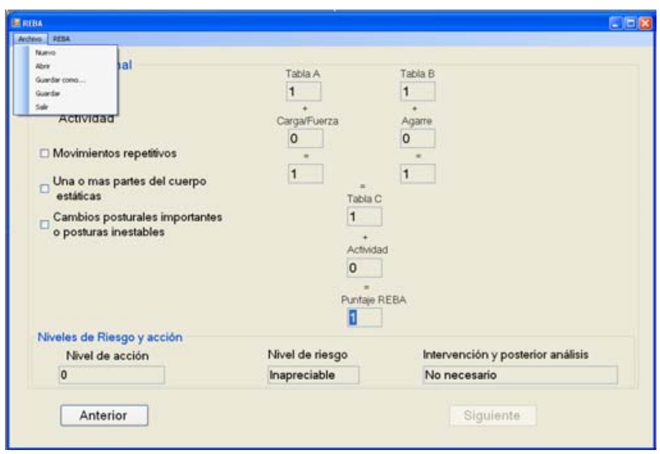

Figure 20. Menu 1 screen in REBA.

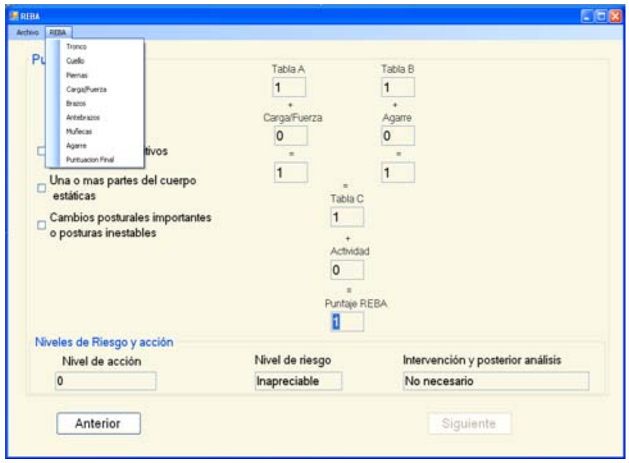

Figure 21. Menu 2 screen in REBA.

RULA

In the first screen (figure 19) four arm positions are shown, also three more options that include the existence of abduction or rotation, rise shoulders and support existence.

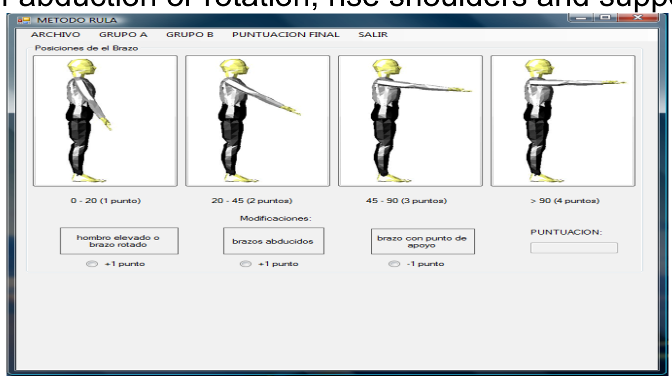

Figure 22. Window to evaluate arms positions in RULA.

In the following screen (figure 20) the position of the forearm is evaluated and an adjustment is made if the arm is working crossing the medium line of the body or if the arm is working outside the corporal area.

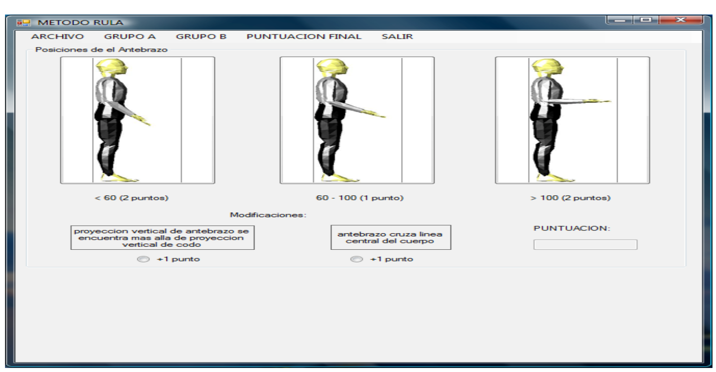

Figure 23. Window to evaluate forearms positions in RULA.

Next screen (figure 21) is where the position of the wrist is evaluated; including the analysis in case of radial or ulnar deviation and if a turn of the wrist exists.

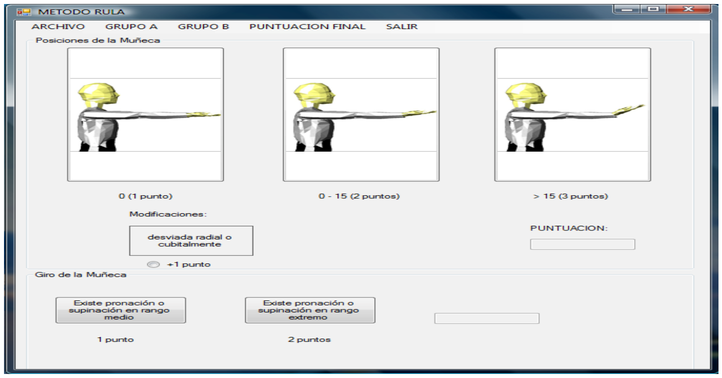

Figure 24. Window to evaluate wrists positions in RULA.

In the fourth screen (figure 22) the options to evaluate the neck are presented, including an adjustment if the neck is turned or inclined to any side.

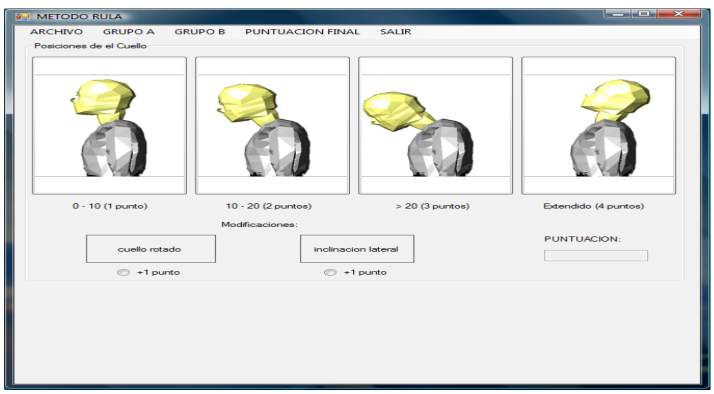

Figure 25. Window to evaluate neck positions in RULA.

Next (figure 23), the position of the trunk is evaluated, including an adjustment en case of torsion and/or trunk inclination.

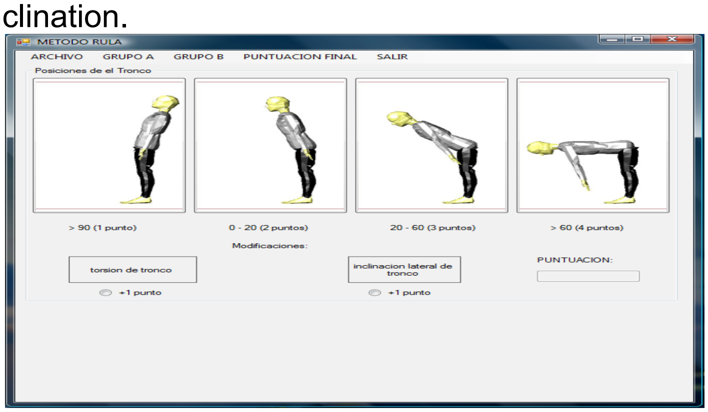

Figure 26. Window to evaluate trunk positions in RULA.

The last window (figure 24) displays the exerted evaluation of muscular activity and loads, as well as the final scores of each one of the body areas and total the final score of the evaluation.

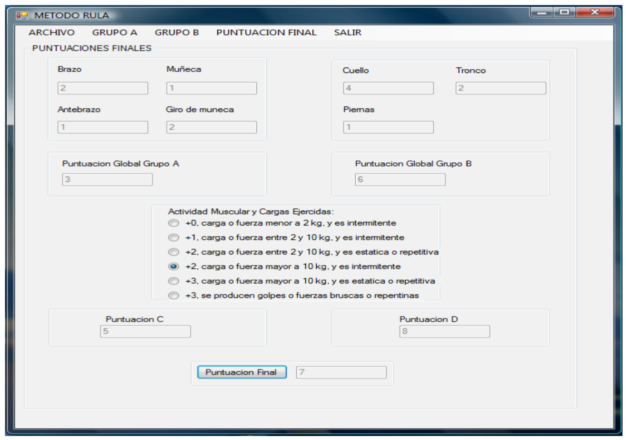

Figure 27. Final score window in RULA.

5. CONCLUSIONS

At the present state of ErgoSoft development the most important achievements are:

- The creation of an ample set of images developed in Autocad, which in conjunction they describe visually the different positions included in the ergonomic evaluation methods.
- An already functional software skeleton developed in Visual Studio 2005, which implements the ergonomic evaluation methods REBA and RULA producing as a final result a table that includes the score for each body part and the corresponding recommendation. This software skeleton is under a permanent improvement process feed with commentaries from ergonomics specialists and the proper software validation process.
- Deep work documentation has been made that will be used to create technical reports, user manuals, etc.; this will allow giving faith of the software capacities.

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Ergonomic Evaluation of Work Stations Related With the Operation of Advanced Manufacturing Technology Equipment: Two cases of study

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Abstract: This paper presents two cases of study where ergonomic evaluations were conducted in work stations related with the operation of Advanced Manufacturing Technology (AMT) equipment: Computer Numerical Control (CNC) Milling Machine and (CNC) Lathe. The Marley and Kumar (1996) Body Map format among 10 workers was conducted for pain in discomfort study and Hignett and Mc Atamney (2000) REBA method was used for ergonomic evaluation. Shoulders, middle back, hand and arm pain was identified. The evaluation results indicated a medium risk level for both work stations according to REBA. Recommendations for changes in equipment components and the work station are presented and it is found that models that would help identify and evaluate ergonomic aspects related with AMT equipment are desirable among decision makers, owners and users.

Keywords: Advanced Manufacturing Technology, Ergonomic Evaluation, REBA, Cumulative Trauma Disorders

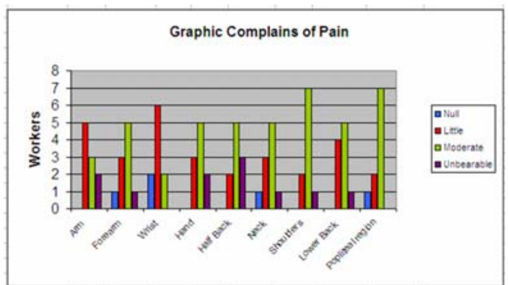
1. INTRODUCTION

This section presents the problem description, the objectives of this investigation its justification and finally the justification and the scope.

1.1 Problem Description

The work stations studied in this work use AMT equipment, such as the CNC lathe and the milling machine, which allow carry out several machine procedures on metallic or plastic parts achieving designs with high precision meeting specifications provided by engineering.

The companies studied, have no availability of medical data, records of complaints, accidents or injuries concerning these operations; nonetheless, the Marley and Kumar (1996) Body Format was conducted among 10 workers of the manufacturing area. Results are shown in Figure 1.



	Arm	Forearm	Wrist	Hand	Half Back	Neck	Shoulders	Lower Back	Popliteal region
Null	0	1	2	0	0	1	0	0	1
Little	5	3	6	3	2	3	2	4	2
Moderate	3	5	2	5	5	5	7	5	7
Unbearable	2	1	0	2	3	1	1	1	0

Figure 1. Evidence of Pain and Discomfort

As noted, the manifestation of pain classified as "moderate" is found mostly on the shoulders, lower back and popliteal region, and evidence of pain classified as "unbearable" in the middle of back, hand and arm. Therefore, presence of pain and discomfort among workers is observed when this equipment is operated. It was also observed, stressful body postures and repetitive movements of hands and arms. As a result an ergonomic assessment in these two case studies is proposed.

1.1.1 <u>Objectives</u>

The objectives in this work are divided into four specific and one general goal, which are explained below:

1.1.1.1 General Objective

To apply anthropometric and ergonomic principles and methods in two work stations which operate with AMT equipment: a CNC lathe and a Milling Machine respectively.

1.1.1.2 Specific Objectives
Specific objectives are:

Identify relevant anthropometric dimensions in human-machine interaction that could be related to stressful postures.

To conduct an ergonomic assessment by REBA method (Rapid Entire Body Assessment), determining the level of risk present in the operation and the recommended level of action.

To propose ergonomic interventions on work stations aiming to reduce the levels of risk for musculoskeletal disorders and finally recommend actions to continue the proposed study including the application of Ergonomics in this kind of work stations and AMT equipment ergonomic evaluation.

1.1.2 Justification and Scope

The results of this study concerns to AMT equipment such as CNC lathe and Milling Machine, analyzed under particular conditions, however, work stations with similar operational characteristics can be evaluated following the methodology proposed.

2. LITERATURE REVIEW

Work stations that use Advanced Manufacturing Technology suffer of a lack of attention in terms of health and safety, according to Karwowski and Salvendy (1994, 2005). In this way, health and safety aspects of AMT systems have been relegated in equipment evaluation and selection processes, so it has been difficult to determine the magnitude of its potential impact in this field according to Ayres and Miller (1985), Masterson (1987), Zimolong and Duda (1992). This is due to insufficient and / or incomplete information. Also, this is partly attributable to a high percentage of cases with AMT accidents are not recorded and reported, as Nicolaisen (1985), Karwowski et al. (1988) and Karwowski and Salvendi (1994) (2005), Sugimoto and Kawaguchi (1985) inform and therefore, it is difficult to link these events with this type of technology.

Studies related to the topic are scarce. Among them may be mentioned the studies done by Sugimoto (1987) for the Ministry of Labor in Japan on health and safety robots. Chan and Courtney (2001), present assessments of work stations with hybrid manufacturing systems where robots and humans interact, and in which ergonomics and safety aspects have been neglected, Vieira and Kumar (2007) inform about work related low back disorders among CNC workers and welders, McEwan (1998) Yu et. al. (1999), report that injuries related to machinery were the most frequent.

According to all above, also Sugimoto (1987), Helander (1984) and Chan and Courtney (2001) agree there is a general misunderstanding of the nature of automation and the AMT with false beliefs about the safety of it and its components and therefore, modest attention is given to these topics.

3. METHODOLOGY

Materials and methods are described in this section, in the first instance refer the characteristics of the equipment used and then describe the methodology applied to the study.

A (SONY Digital Handycam) video camera was used to record and take photos to the worker to identify stressful body postures during the operation; also we used a measurement tape and a computer to run REBA commercial software.

3.1 Registration of the operation on videotape

A video camera was used to observe and record the operation in both work stations analyzing the images and then assess the angles required by the software REBA more objectively. Similarly, video recording helped us to assess the frequency and duration of worker's body postures. Front, sagital and superior views were taken.

3.2 Description of the Operation

The operation of the lathe initiates when the operator walk to grasps a metallic plate, then he attaches it to the machine, and fastens it with tools and clamps involving considerable effort. Longitudinal and transverse movements begin to make the turning. Both hands in this action are always on the levers and the operator is simultaneously watching the visual display or the work piece, this requires high levels of control and coordination. (See Figure 2)

The operation with the milling machine starts when the operator twists his trunk to grasp the material in the work table located behind him, and then he places the material at the base of the machine and set the work piece using clamps, then uses several manual levers to shape the piece. Each lever is used for specific machining purposes such as perform a deep cut in a straight line or semicircular cuts among others. (See Figure 3)

3.3 Description of Work Stations

In relation with the lathe work station, due to the tool room, work table, and material are located far from the lathe, the operator needs walking around the workstation preventing in some way sustained static work load, but increasing energy expenditure. The vertical and horizontal reaches are in the normal range zone and remain within the midline of the body. However, the main visual displays are located out of the normal visual areas for two eyes.

In relation with the milling machine workstation, it has two areas: the machine table and auxiliary work table. Vertical and horizontal reaches are found in the normal range zone of movement but also in the maximum range zone and in some cases out of the maximum reach zone due to the fixed location of control devices and levers, particularly levers that are at the top of the machine.

3.4 Application of the REBA Method

Pictures (Figure 2 and Figure 4) and results of REBA (Figures 3 and Figure 5), for right side of the operator's body are shown below for the most critical operations.

CNC Lathe Work Station:

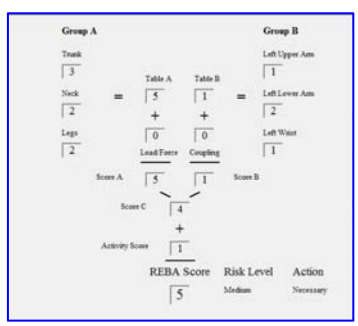


Figure 2. CNC Lathe's Operator   Figure 3. Scores for REBA (right side)

CNC Milling Machine Work Station:

Figure 4. Milling Machine's Operator

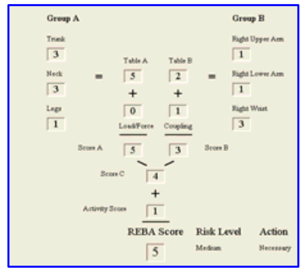


Figure 5. Scores for REBA (right side)

4. RESULTS

This section presents the results obtained in this evaluation.

4.1 REBA Results

As shown in the score sheets (Figure 3 and Figure 5), the risk level is medium for both activities and ergonomic intervention may be necessary.

Referring to the milling machine workstation, the right wrist is the most affected with a score of 3 because it has to be rotated in order to operate the right lever, producing also mechanical stress.

About the lathe workstation (Figure 3), REBA's results shows that the most affected body parts are the trunk with a score of 3, and legs with a score of 2 since the operation needs to be monitored constantly so that the operator's trunk must be bend to observe the part he is working with.

5. CONCLUSIONS AND RECOMMENDATIONS

This section concludes about the results obtained, and contrast the goals outlined in this work.

An ergonomic analysis was performed in which those relevant anthropometric dimensions involved in man-machine interaction were identified. Furthermore, the REBA method was effective determining the risk and action levels for these operations. Recommended ergonomic interventions for these workstations are listed below:

About the Milling Machine Workstation:

1. The most appropriate location for human operator in this case would be found in front of the machine. To achieve this, it is recommended that the main right lever dimension could

have an adjustable length or an extension device, in this way the operator does not need to stand aside for its manipulation twisting and bending his trunk.

2. Rearrange work station lay-out. Actual physical distribution of work station implies trunk twisting and bending also lifting and walking activities are executed. In this way rearrange the distribution of physical elements of the work is highly suggested aiming to diminish stressful postures and static work load.

About CNC Lathe Work Station:

An adjustable height and position of the visual display would be effective to reduce neck and trunk twisting and bending.

In these cases a cushion floor mat would be suitable for the operator in order to reduce foot fatigue; also a chair for a sit-stand posture would be helpful.

Bring to a close, the application of ergonomic principles would help to increase machine performance and productivity, but mostly help human operator to be comfortable and secure. Since at present time the vast majority of the companies acquired Advanced Manufacturing Technology in order to be competitive, ergonomic and safety aspects must be considered one of the most effective ways to accomplish this competitiveness and decision makers' owners and users need models that helps identify ergonomic aspects in AMT work stations.

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Evaluation system ergonomic work stations for manual assembly, in the processes of production in the factory industry in the northeastern state of Sonora.

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Summary: The Manual Assembly Work Stations in Serial Production Lines require that the worker has a high concentration. When performing their tasks, they keep a short cycle time that causes repeatability and monotony that leads in a short period of time to the called Fatigue Effect, affecting the worker life quality and the company productivity. This situation is hard to accurately evaluate, due to the diversity of tasks that are performed in these systems (nevertheless it is a necessary and urgent praxis). The following study, presents an Ergonomic Evaluation Computing System that associates the most significant movements that take part in the Manual Assembly with the Ergonomic Principles and Norms, through a quantification that relates the effect of developing the Implicit Work Tasks with the Accumulative Traumatic Disorders associated with the Tasks Performed by the Operator. The Quantification Procedure was made through the Multivariate Hierarchical, determining the Main Components of each of the Tasks and the Fatigue Effect Levels that are involved. Moreover, a Resigning Productive Time Project is contemplated. The Computing System is designed to be applied in a fast and easy way, through an Electronic Data Support, allowing the evaluation to be performed and analyzed in real-time. This generates a reliable diagnose, that helps us proposing useful physically achievable solutions in a short period of time.

Resumen. Las estaciones de trabajo con ensamble manual, en procesos de producción en serie, requieren de una alta concentración por parte del obrero al llevar a cabo su tarea, mantienen un tiempo de ciclo corto, por lo que la repetitividad y monotonía hacen que se presente, en poco tiempo, el efecto de la fatiga, afectando la calidad de vida del trabajador y la productividad de la empresa. Esta situación es difícil de evaluar con precisión, por la gran diversidad de tipos de tareas que se desarrollan en estos procesos, sin embargo es una praxis necesaria y urgente. En el presente trabajo, se desarrolla un sistema informático de evaluación ergonómica, que asocia los principales movimientos que intervienen en el ensamble manual, con los principios y normas ergonómicas, a través de cuantificar el efecto de desarrollar las tareas implícitas en el trabajo y los desordenes traumático acumulativos coligadas con las tareas ejecutadas por el operario. El procedimiento de cuantificación se lleva a cabo a través de la jerarquización multivariante, determinando los componentes principales de cada tarea y los niveles del efecto de la fatiga que presenta. Aunado a ello, se contempla una proyección del tiempo productivo de dimisión. El sistema informático está diseñado para aplicarse de manera sencilla y rápida, por medio de un soporte electrónico de datos, permitiendo que la evaluación se realice y analice en tiempo real, esto nos genera un diagnóstico confiable, que posibilita proponer soluciones físicamente realizables, económicamente útiles y en un periodo de tiempo corto.

Key words: Ergonomics, Assessment, Mobile Systems

I. INTRODUCTION

In the recent years, the rules of competitiveness have evolved. It has grown from a regional competition with a strategy based on mass production to a global competition, where the prevailing philosophy of the new world class manufacturing. Speaking of world-class manufacturing means contemplate new strategies to meet customer needs, in turn; the company has high quality requirements, flexibility and quantities of products, service and high interdependence of technology Schonberger (2008). With competitive firms require a strong organizational structure that allows them to develop highly flexible production systems to adapt to achieve the new requirements of global markets.

Production systems viewed as a synergistic combination of workers, machines, tools, materials, processes, procedures, policies, methods and environment, define the conversion of raw material to finished product must meet specifications defined by the competing claims of markets. However, this combination, only one meaning is commendable, when they focused their production capacity according to the interaction that occurs between the operator and his work space, structuring an interdependent relationship of productivity and efficiency. Productivity is only one incident with the employee and the efficiency is a function of the working environment, where this interaction is structured so as to reach in the repeated exposure to activities with high physical demand, monotony, vibration, posture uncomfortable, contact and mechanical stress, traumatic disorders are presented - cumulative (DTA's) Anderson , V. (1994), to the workers. These problems affect the muscular system - skeletal, basically tendons, nerves, joints and the neural system - vascular. The workstations with manual assembly, in the processes of production line, develop the conditions for the manifestation of the DTA's in a relatively short period of time, resulting in a decrease in quality of life of the operator and a reduction in the competitiveness of the company Fleishchmann (2002).

In Mexico, 1.6% of total risks are presented in the processing industry, coupled with this, it provides statistics that 65% of the DTA's are related to working conditions, memoria del IMSS (2007). This situation requires urgent and pragmatic action, which framed the guidelines to reduce these high rates. In regard, it is of utmost importance to have a procedure that will detect negative discrepancies that may exist between the positions demanded by the workstations and the best anatomical position, established the basic rules of ergonomics. This procedure should include the characteristics of work stations with manual assembly, as maintained by their actions and tasks of high physical demand, monotonous, repetitive, short cycle time, speed, contact and mechanical stress, vibration, detail, high concentration and static effort. The combination of these factors makes the ergonomic evaluation methods fail to assess general area as a whole and the interaction of positional factors of workstations assembly manual. About 60 ergonomic evaluation methods can be found in the state of the art Bentley (2003), but each method because it maintains a generalist global approach to the station and cannot include all actions and tasks that are presented in the assembly manual. This paper presents an ergonomic assessment system, allowing the main problems related to human interaction - the working environment and proposes measures to help reduce the problem to be diagnosed in an environment called factory industry, specifically in northeastern state of Sonora in Mexico. The work is based on the application of multivariate ranking of positions that are presented in the work stations with manual assembly and its relationship with the decrease of the productive capacity of the worker. For 2500 samples have been taken systematically compared their workers and ergonomic position for the procedure described and the reduction of productive capacity, thereby gaining an evaluation procedure validated and reliable for taking corrective and preventive actions, for each station work where the procedure. This procedure is transformed into a system of evaluation based on multivariate analysis system, which is used by applications for mobile devices, enabling real-time evaluation of the positions of workers in their workstation through a web server using Apache that connects to a database server for storage and management of evaluations, by manipulating various programming languages for Web applications, Which standardized the procedure for application and provided an easier interpretation of the diagnosis and recommendations for reducing the negative impact of the work stations with manual assembly.

II. MATERIALS AND METHODS

The method used for ergonomic evaluation system was defined in three stages in systematic and chronological order, which resulted from the analysis of theories, to implementation and validation of the system in the industry. In Figure 1 shows schematically the procedure that was used to structure the evaluation system. The components of the procedure are elaborated below.

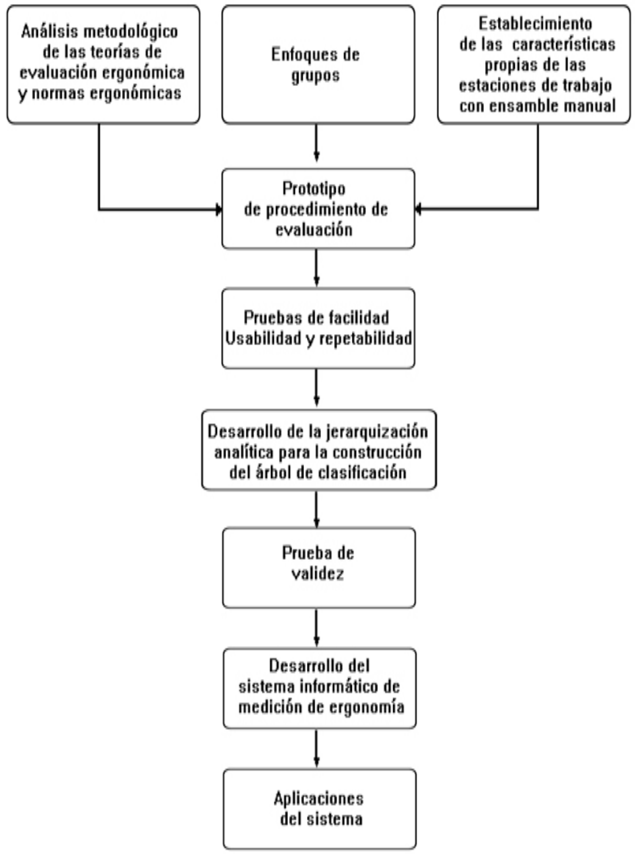

Figure 1. Procedures outline the development of ergonomic evaluation system

Phase 1
Methodological analysis of the theories.

The epidemiological evidence for the development of the system are based on a methodological analysis of the theories, which recognizes the awkward working positions and the appearance of the DTA'S, coupled with this, it is necessary to review how the evaluation Ergonomic and discrepancies, inefficiencies and adequacy of each method in the evaluation of work stations, an object of study for our research. Another point for development of the system is the standards, rules and guidelines for ergonomics, allowing the structure to implement recommendations for improving the system. With this theoretical structure is a platform for scientific support for the development of ergonomic assessment.

Characteristics of work stations with manual assembly:

The concept of export factory industry in Mexico, establishing a commitment to work between our country and United States of America, it structured the conditions necessary to develop low-tech jobs and high physical demands for operation. In this view, reflects the importance of defining the operational characteristics of these workstations, which have been called work stations with manual assembly. In Figure 2 we display a comparison of the behavior of the cumulative fatigue that occur in the assembly plants and various kinds of work in the factory Vázquez (2006). It is important to establish that the recovery time that occurs in the space of rest, not has the same effect in the work of the factory to them in different, mainly due to the high volume of repetitive work and low locomotion which is on the workstation, the operator causing a load on the muscle-skeletal system, which prevents a normal recovery, while the psychological stress of working conditions is a factor that adversely affects the physiological recovery of the operator factory. In this type of work, show high resistance to the monotonous, repetitive, short cycle time, speed, contact and mechanical stress, vibration, static effort and detail, this leads to high demands for consultation and an expenditure of metabolic energy very rapidly.

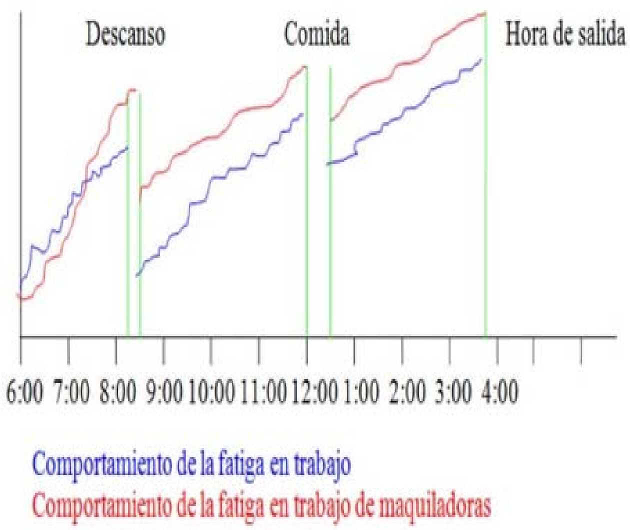

Figure 2. Comparing the behavior of the accumulated fatigue

Surveys and group-based approaches.

150 surveys were implemented at different layers of the factory industry, to hear concerns about the implementation and validation of existing methods for assessing ergonomic.

Exploration of the strata were divided into 3 line engineers, unions and joint committees of safety and health, and these strata which have more contact with operators, its needs and the design of work stations where they thrive manual assembly work. Coupled with this, there were 5 focus groups with specialists in ergonomics, epidemiology, medical, labor, industrial engineers and a group which joined the staff of the Ministry of Labor and Social prevention with the Mexican Institute of the social security. The practical conclusion of this research field is that the ergonomic evaluation methods exist, do not accurately reflect the impact of working conditions on workers due to the high physical demands of the seasons under study. Establish the need to structure an evaluation process that is commensurate with the demands of work stations with manual assembly.

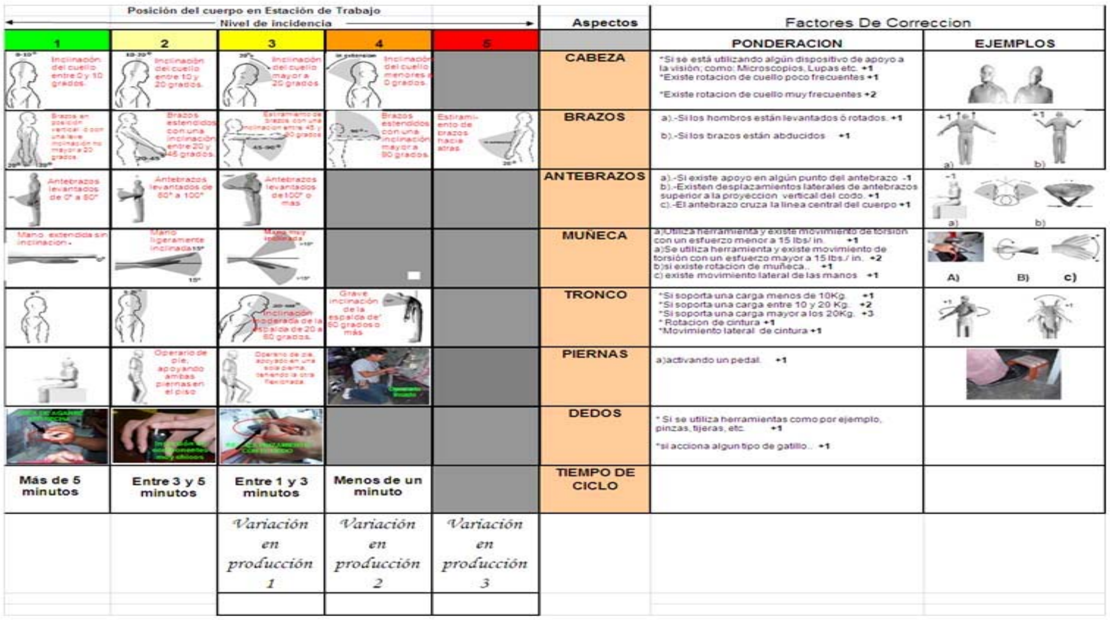

Figure 3. Prototype evaluation procedure.

Evidence of reliability and repeatability usability.

The implementation teams have been trained in the assessment of ergonomic work stations with manual assembly using the procedure established in the prototype by analyzing each of the points covered. Once developed, it is applied and repeatability tests reproducibility, which enabled us to find the most common mistakes you, can commit to implement the procedure. Again took a training process with applications in different areas, until the application errors were reduced to a minimum, the process of developing more reliable.

Phase 2.

Development of the analytic hierarchy.

We applied a total of 2500 samples with a systematic evaluation procedure, work stations with manual assembly within the Factory Export Industry, located in the northeastern state of Sonora in Mexico. Where a multivariate classification, according to the construction of a multivariate hierarchical tree, which compared the impact of the different positions of the operator to develop its work, with the decline in productive capacity, setting this variable as the difference in percentage production in three intervals of time in their workday. The intervals were classified according to the times of least negative impact to production, reducing the likelihood of distraction by rest, food and material supplies. The ranges are from 8am to 10am, 11am-1pm and 2pm to 4pm.

In determining the position of each body part of the operator, which is involved in achieving the task and compare it with the resignation of its productive capacity, we are able to rank the influence of the position according to the percentage of decrease in production . In this article we present the results of the analytic hierarchy developed in the statistical software SPSS version 15, which we classified into 4 categories, the influence of body position for the development of the task, with the decline of the productive capacity of the operator in the work stations with manual assembly.

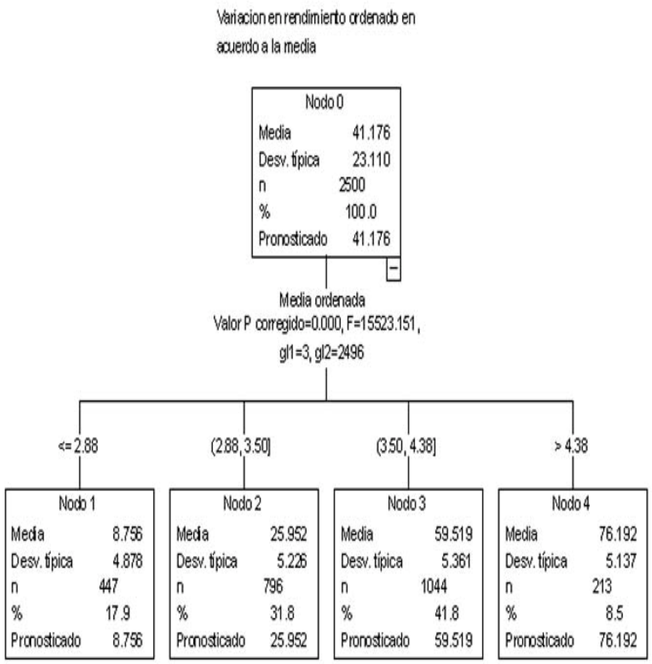

Figure 4. Analytic hierarchy tree multivariate

In Figure 4 shows the analytic hierarchy tree, where the classification structure of the impact of employee positions, with the average rate of decline for each classification, as set out in the table nodes. For the first node maintains an average rating on workstations and less equal to 2.88 on average have reduced the productive capacity of workers to 87.56%, considering a stable working condition for the task. For the second node, we have a range of average evaluations (2.88-3.50] generating a 25.952% decrease in capacity, referring to a condition for the development of half the task. In the three node denotes an interval (3.5-4.38] and an average decrease of 59.519% in its productive capacity, indicating a risk for the development of the task. In the fourth node is specified more than half and a 4.38 average decrease of 76.192% which is considered a critical condition for developing the work.

Test of validity

The procedure has been validated by comparing their evaluations with three ergonomic evaluation methods used so far by the industry, methods RULA, and OWAS LEST. Results from the procedure are equivalent in form, but more precise in their diagnosis, as it concerns information that is similar to other methods, adding details, focusing on the work stations with manual assembly.

Development of ergonomic evaluation system.

This system will allow the evaluator the opportunity to give a real-time diagnosis of the state's ergonomic worker using a mobile communication device where you installed a program that makes a connection to the web server to enable the assessment using the Multivariate system parameters, in turn, the user has the ability to store each of the analysis to make a comparative assessment in the course of time and be able to analyze the improvement in the work stations evaluated in Figure 5 shows how mobile devices will make your Internet connection to the data servers to access the program to assess the data being generated on the jobsite of the worker.

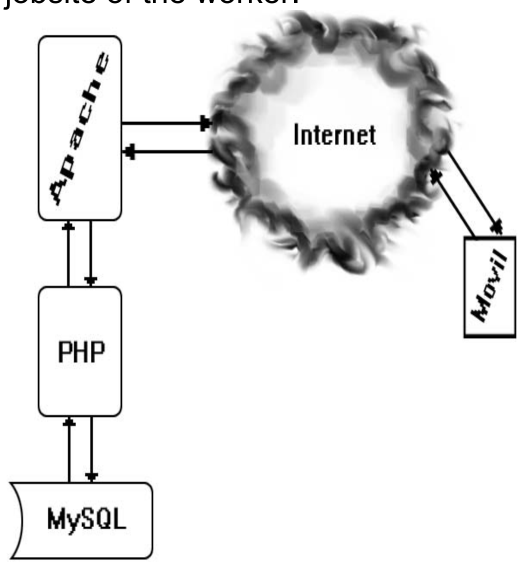

Figure 5. Process Connection Program

Phase3.
System applications.
Once developed the system, with support in the procedures in the prototype, and implement the standards and methods of ergonomics. The system presents the classification of the workstation, the prognosis for reducing the productive capacity of the operator and possible actions to be undertaken by the company to reduce the classification level achieved in the implementation of the ergonomic assessment work station with manual assembly.

III. RESULTS AND DISCUSSION

In this work, provides for the multivariate statistics, specifically with the multivariate technique of hierarchical tree, with this technique we developed a quantitative classification of the assessment in ergonomic work stations with manual assembly. The workstations with manual assembly, maintain its own characteristics that are difficult to assess, especially when made by means of quantitative methods, most of the ergonomic evaluation methods are based on epidemiological structures, which are rated by experts in this area, depending on experience, indirect measurements, consultations with operators, plant engineers' views, generate a description of the working position at the station, a valid as a quick reference, which gives us some suggestions and plans action. The ergonomic evaluation system, based its assessment on the quantitative parameters that relate the scores obtained on the workstation, with the decline in competitive ability of the operator, it calculated as the difference between production levels at defined time intervals from the negative influence of minor distraction in production. Additionally, the system is designed to evaluate the characteristics of work stations with manual assembly, gathering as much information describing the task and classified into 4 stages, depending on the level of risk that could keep the work station and providing a forecast of the percentage reduction in production will be taken on the workstation. Another important aspect is that the system is the analysis for each part of the human body involved in the task, providing suggestions for action to achieve the correct position uncomfortable and reduce the risk of injury or harm to the employee.

The prototype created was based on three important aspects, the first thorough investigation of the theories concerning the ergonomic evaluation methods, standards and procedures ergonomic job description. After a series of interviews that took place in the factory industry, to define the characteristics of work stations with manual assembly. Finally depth sessions were conducted to find major discrepancies between the characteristics of work stations and assembly manual ergonomic evaluation methods exist, the need for establishing an evaluation method that will evaluate the characteristics of these tasks, These guidelines were developed with the prototype, confirmed by studies of R & R, for implementation after 2500 to implement and analyze samples of the systematic method, the construction of the system. This generated a useful platform for ergonomic evaluation of the Factory Export Industry, located in the northeastern border state of Sonora in Mexico.

IV. CONCLUSIONS

The evaluation system ergonomic work stations for manual assembly, allows for real-time evaluation of the working conditions of Mexican operate 4 times in classifying the degree of risk to the worker. In addition to proposing solutions to problems in parts of the body involved in the task and includes a forecast of the percentage decrease in production in this task over time productive, which allows the company to build action plans that provide guidelines improvement in the design or redesign of work stations with manual assembly.

Multivariate analysis applied to the evaluation of ergonomic work stations with manual assembly, provides a quantitative process, effectively linking the positions of work, with the decline in productive capacity of the operator, in a scheme of multivariate analytic hierarchy tree, allowing a clear and strategic classification.

Productivity is a phenomenon directly related to the operator, efficiency is a function of the work environment in a dynamic interaction. We find that an evaluation mechanism to establish the quality of interaction, supports a classification of risk and prognosis of resignation in the percentage of production, enables companies to create a platform to develop guidelines for improvement, leading to improving the quality of life for workers and improve the competitiveness of the Factory Export Industry, located in the northeastern state of Sonora in Mexico.

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DETERMINATION OF PHYSICAL FATIGUE IN WORKERS FROM POPULAR MARKETS AT LOS MOCHIS, SINALOA

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Abstract: INTRODUCTION. Work is a source of psychological and social welfare, valuable for all human beings. However, it can cause negative effects. One of those effects is fatigue, present in all activities that require effort and tension. The symptoms are: reduction in work ability and increment of errors in development. There are many persons who work in popular markets at Los Mochis, Sin., and as it supposes there is physical fatigue and possible Accumulated Trauma Disorders (ATD's) in those persons, by now there isn't any kind of studies about it, so it is not possible to make any kind of suggestions to avoid physical problems for those workers in their future life. OBJECTIVES. Determine physical fatigue in popular markets workers from Los Mochis, Sin. thorugh subjective evaluation methods: Yoshitake, Luke. Define the grade of fatigue present in the group. Use los results to make a future objective investigation about possible ATD's in the group of workers. PROBLEM DELIMITATION. This Project was developed analyzing the workers from the popular markets at Los Mochis, Sinaloa. METODOLOGY. A sample of more than 30 workers was taken from the different popular markets at Los Mochis, Sinaloa. Alter that, fatigue was determined using Yoshitake and Luke methods, and possible ATD's with Corlett & Bishop method. RESULTS. The analysis shows different fatigue percentages in workers, besides different types of nuisances and pain in different parts of the body. CONCLUSION. There is enough statistical evidence to say that exist physic fatigue in workers due to their labor, besides ATD's in those persons.

Key words: fatigue, ATD's, popular markets.

Resumen: INTRODUCCIÓN. El trabajo constituye una fuente de bienestar psicológico y social valiosa para los seres humanos. Sin embargo, puede provocar efectos negativos. Uno de ellos es la fatiga, presente en todas las actividades que requieren esfuerzo y tensión. Sus signos son: disminución de la capacidad de trabajo y aumento de errores en el desempeño. Existen muchas personas que laboran en los mercados populares de la ciudad de Los Mochis, Sin., y aunque se supone que existe fatiga física y posibles desórdenes de trauma acumulados (DTA's) en ese sector, a la fecha no existen estudios que lo demuestren, por lo que no es posible hacer sugerencias para evitar los problemas físicos que con el tiempo sufrirán esos trabajadores. OBJETIVOS. Determinar la fatiga física de trabajadores de mercados populares de la ciudad de Los Mochis, Sin. mediante la aplicación de métodos de evaluación subjetivos: Yosihtake, 4 puntos de Luke. Definir el grado de fatiga que se presenta en ese grupo. Utilizar los resultados para realizar una futura investigación objetiva sobre los posibles DTA's en el grupo bajo estudio. DELIMITACIÓN DEL PROBLEMA Este proyecto se realizó analizando a los trabajadores de los mercados populares de la ciudad de Los Mochis, Sin. METODOLOGÍA. Se tomó una muestra de más de 30 trabajadores de los diferentes mercados populares de la ciudad de Los Mochis. Luego se determinó la fatiga utilizando los métodos Yoshitake y 4 puntos de Luke, y los posibles DTA's mediante el Mapeo de Corlett & Bishop. RESULTADOS. El análisis presenta diversos porcentajes de fatiga en los trabajadores encuestados, además de variados tipos de molestias y dolores en diferentes partes del cuerpo. CONCLUSIONES. Existe suficiente evidencia estadística para decir que se presenta fatiga laboral, además de desordenes de traumas acumulados (DTA) en las personas que participan en la encuesta.

Palabras clave: fatiga, DTA's, mercados populares.

1. INTRODUCTION

Work is a source of psychological and social welfare, valuable for all human beings. However, it can cause negative effects. One of those effects is fatigue, present in all activities that require effort and tension.

The interest of this study is to know if there is fatigue in persons who work in popular markets at Los Mochis Sinaloa. In this city, as in many other cities of Mexican Republic, thousands of men and women work daily for long periods to gain the money for their family's maintenance, having as a consequence physical and mental health problems, such as diverse kind of pain, affecting directly their development at work. Those men and women can suffer some kind of fatigue due to excessive work or lack of rest to recover energy. Nevertheless, laboral fatigue can be also caused by incorrect corporal positions at work, making routinary tasks that demand continued similar efforts and movements or an excessive mental effort. Laboral fatigue can cause different kinds of physical pain and even mental health problems, such as depression, loss of appetite, headaches and decrement in the capacity of concentration, among others.

2. OBJECTIVES

1. Determine physical fatigue in persons who work in popular markets at Los Mochis, Sinaloa using subjective evaluation methods: Yoshitake and Luke .
2. Define by age ranges the grade of fatigue present in the group under study.
3. Determine possible Accumulated Trauma Disorders (ATD's) in the group under investigation, using Corlett & Bishop method.

3. METHODOLOGY

A sample of 62 workers is taken from different popular markets at Los Mochis, Sinaloa, due to it's de number of persons that agreed to answer the questionnaires daily. This sample is divided by 2 groups of 31 workers each. Then proceeds to determine fatigue in the first group, using Yoshitake and Luke methods, and possible ATD's in second group using Corlett & Bishop method.

3.1 Measure of fatigue and possible ATD's

There are some methods, so much objective as subjective, to evaluate muscular, physical or mental fatigue, and possible ATD's. In this work, Yoshitake (1978) and Luke subjective methods are used to evaluate fatigue, and Corlett & Bishop method is used to determine possible ATD's.

Rosa y Col. (1998), used Yoshitake questionnaire to measure fatigue; it was validated due to it offered similar results than objective tests. The work they developed was a manual operation using upper and lower body extremities. The questionnaire captures fatigue presence or absence making 30 questions for industrial work (Couto et al., 1981; Almirall & Reyes, 1982). Questionnaire is divided into 3 groups of questions: first group is composed by 10 questions about monotony and monotony symptoms, second group have another 10 questions related to concentration difficulty and the third group has the last 10 questions about corporal symptoms or physical damage. After the questionnaire, Fatigue Complaints Frequency (FCF) is calculated in percentage, dividing the number of "yes" answers by the total number of questions, and multiplying the results by 100.

Luke y Col. (1999), used a scale to determine fatigue level. This scale is known as 4 Points of Luke, or simply Luke, and it catalogues fatigue levels alter a normal work day. The measure scale is: "nothing tired" 1 point, "tired" 2 points, "very tired" 3 points and "extremely tired" 4 points.

3.2 Method to determine fatigue

1. Talk to the worker's boss and ask for his help to select the workers that will participate in the study; tell the workers what the study tries about and the benefits they will gain and ask for their collaboration, to obtain more confident answers.
2. Obtain the answers for a general questionnaire about laboral conditions, and make one daily evaluation to each worker during three weeks, filling in the Yoshitake and Luke questionnaires to determine fatigue.
3. Use Excel software to concentrate obtained answers.
4. Analyze answers, interpret them and make suggestions.

3.3 Method to determine ATD's

1. Talk to the worker's boss and ask for his help to select the workers that will participate in the study; tell the workers what the study tries about and the benefits they will gain and ask for their collaboration, to obtain more confident answers.
2. Obtain the answers for a general questionnaire about laboral conditions, and make one daily evaluation to each worker during three weeks, filling in the Corlett & Bishop

questionnaires to determine possible ATD's.
3. Use Excel software to concentrate obtained answers.
4. Analize answers, interpret them and make suggestions.

4. RESULTS

4.1 Determination of fatigue

About fatigue determination in the first worker's group, 45% of them are men and 55% are women. 64% is 30 or more years old, 21% is between 25 y 30 and15% is between 18 y 24 years old. Respect to the number of hours worked daily, 51% of them work more than 8 hours a day, 40% works 7 to 8 hours a day and 9% works 5 to 6 hours a day. 73% work 7 days a week and 27% worked 5 to 6 days a week. About the activity they develop, 15% is studying and working, and 85% is only working.

40% of the workers were not tired at the end of their work, and 60% feel kind of tired at that time. Consequences for those symptoms include: 60% for fatigue, 26% for mental tiredness, 7% has have some accident due to work and 7% has anyone specific symptom. 84% doesn't feed their selves before work and 16% does it. About the kind of transport they use to go to their work, 62% uses their own vehicle, 20% walks to their work, 16% goes by bus and 2% rides a bicycle to go to work.

4.1.1 <u>Main activities workers develope at work</u>

- Carry heavy bags with fruits and vegetables.
- Sweeping and mopping the workplace.
- Locate fruits, vegetables and merchandise on their respective places.
- Unload wood boxes with fruits and vegetables from trucks.
- Attending customers.
- Stowing wood boxes with fruits and vegetables.

Figures 1 to 19 show the obtained results.

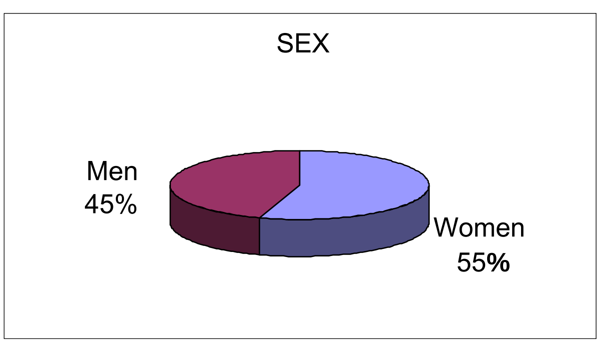


Figure 1. Gender.

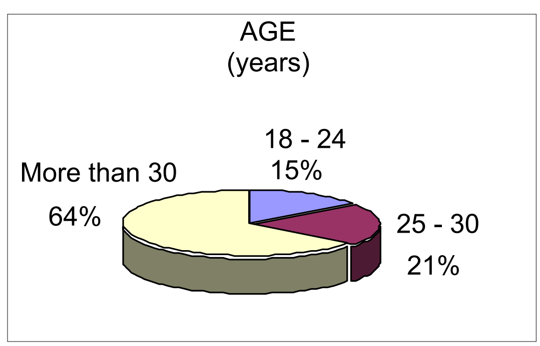


Figure 2. Age.

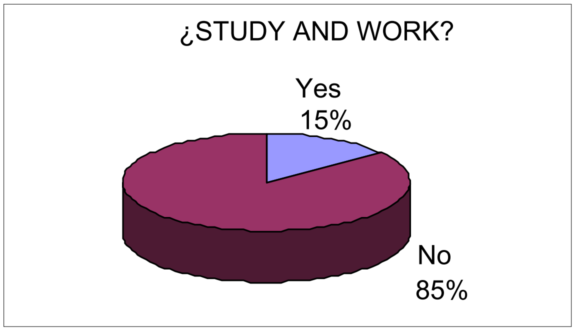


Figure 3. Extra activities.

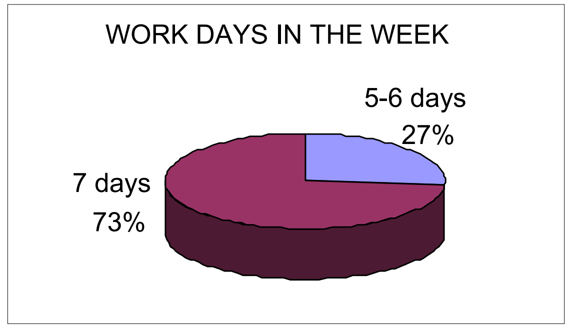


Figure 4. Work days in the week.

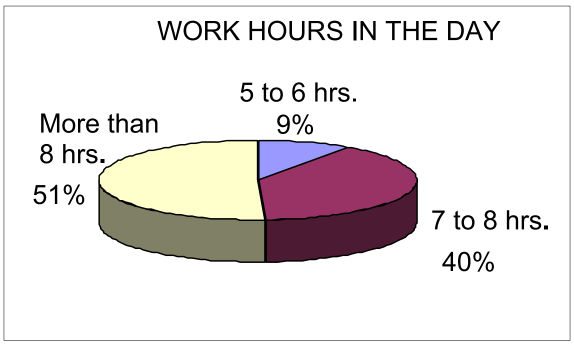


Figure 5. Work hours in the day.

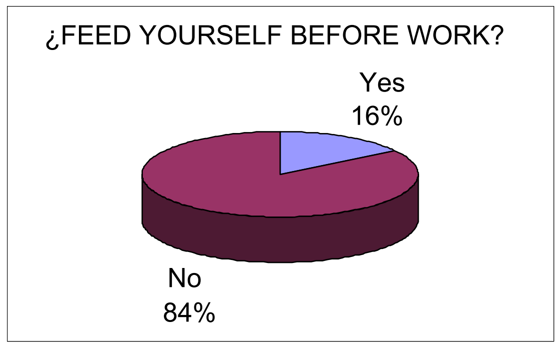


Figure 6. Feeding.

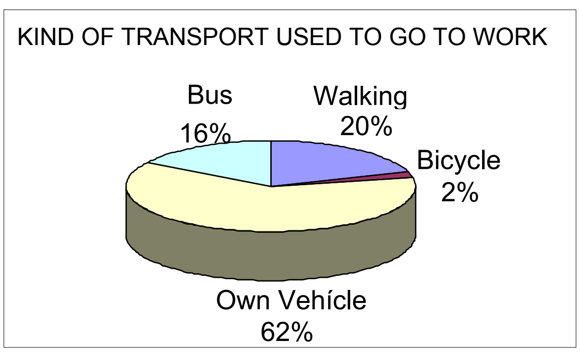


Figure 7. Kind of transportation.

Figure 8. Tiredness.

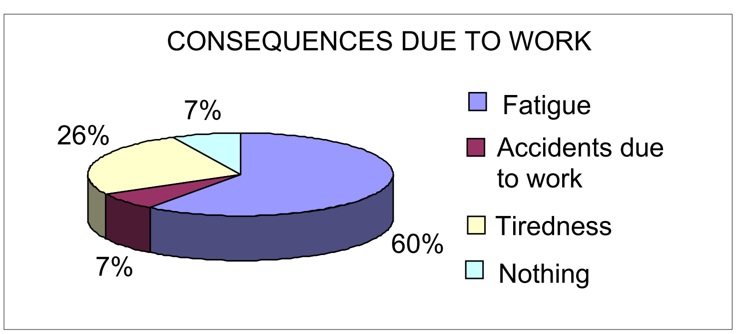
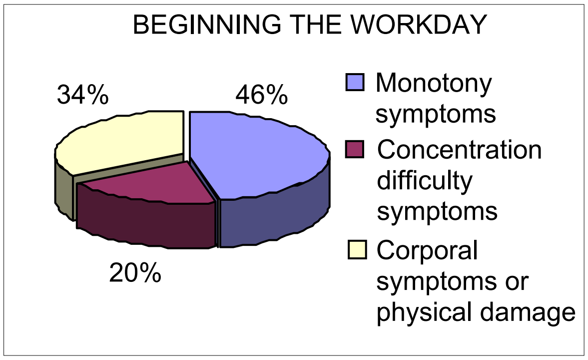


Figure 9. Consequences due to work .

4.1.2 Women results



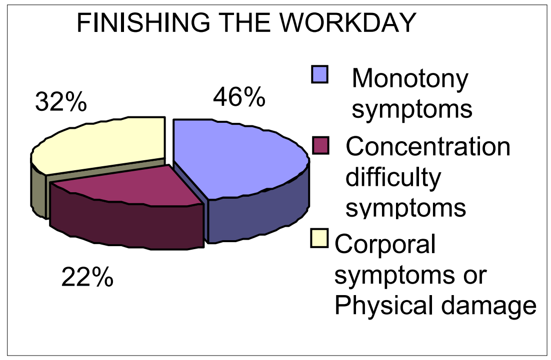
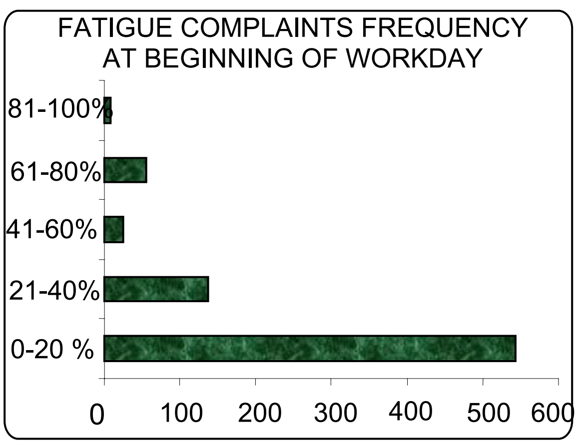


Figure 10. Symptoms at begin. Figure 11. Symptoms at the end.

Fatigue Complaints Frequency (FCF) is calculated as follow:

$$((\text{Monotony} + \text{Concentration} + \text{Physical condition}) / 30)*100$$

This factor indicates the percentage of fatigue present in the Yorker at beginning and the end of workday. The higher the percentage, the higher is the tiredness the worker feels.



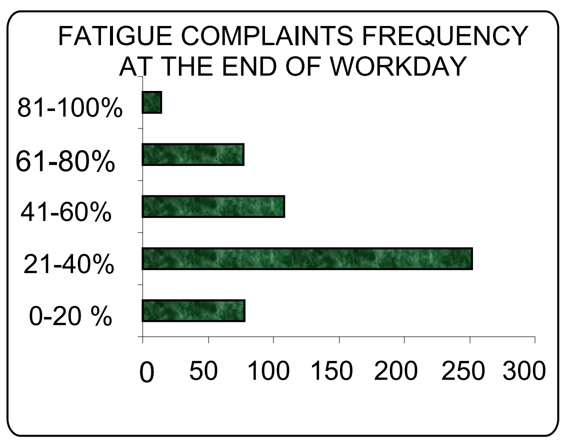


Figure 12. FCF at beginning of workday Figure 13. FCF at the end of workday

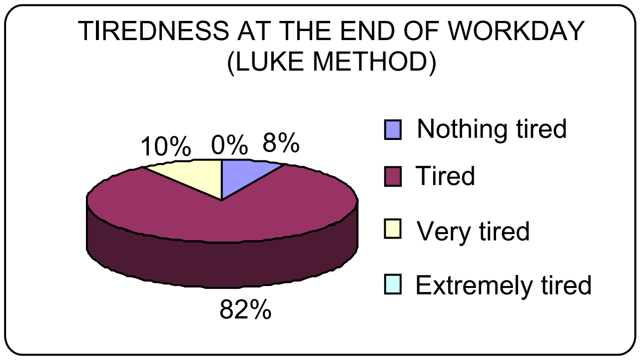
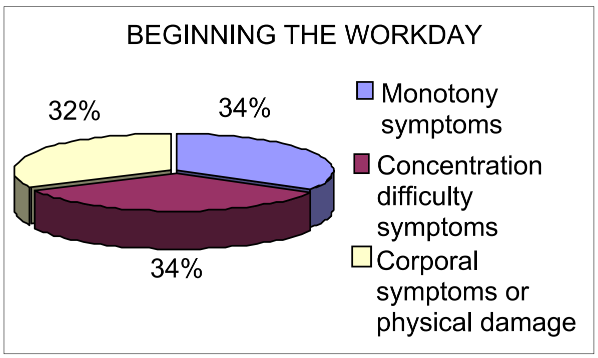


Figure 14. Tiredness at the end of workday (Luke)

4.1.3 Men results



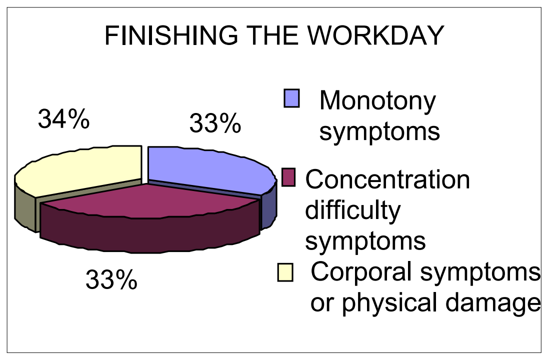
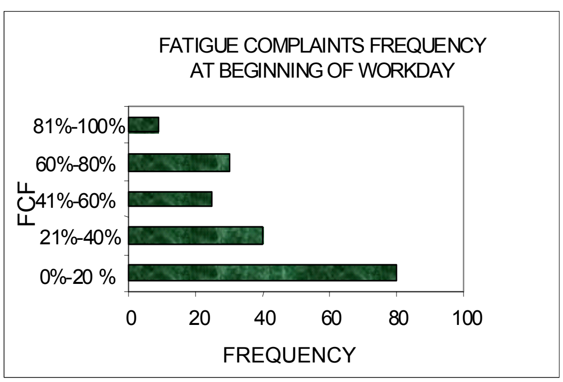


Figure 15. Symptoms at begin. Figure 16. Symptoms at the end.



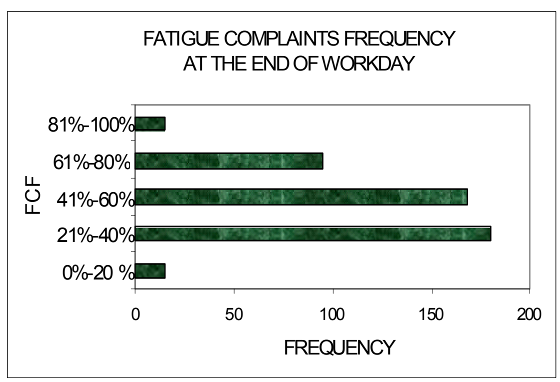


Figure 17. FCF at beginning of workday Figure 18. FCF at the end of workday

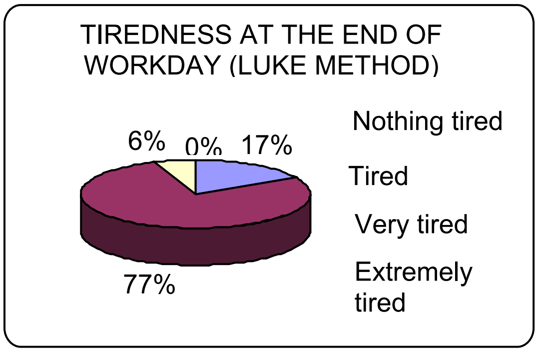


Figure 19. Tiredness at the end of workday (Luke)

4.2 Determination of Accumulated Trauma Disorders (ATD's)

As a result of the analysis in the second group of workers, 53% of them are men and 47% are women. 38% is 31 to 50 years old, 24% is 18 to 24, 18% is 25 to 30, 11% is more than 50 and 8% is less than 18 years old. Respect to the number of hours worked daily, 79% work more than 8 hours a day, and 21% works 7 to 8 hours a day. El 89% work 7 days a week, 8% work 5 to 6 days and 3% work 2 to 4 days a week. About the activity they develop, 3% is studying and working, and 97% is only working.

16% of the workers were not tired at the end of their work, y el 84% feel kind of tired at that time. Consequences for those symptoms include: 50% for fatigue, 22% for mental tiredness and 28% has have some accident due to work. El 53% doesn't feed their selves before work and 47% does it. About the kind of transport they use to go to their work, 55% uses their own vehicle, 39% goes by bus, 3% walks to their work and 3% rides a bicycle to go to work.

4.2.1 Main activities workers develope at work

- Carry heavy bags with fruits and vegetables.
- Sweeping and mopping the workplace.
- Locate fruits, vegetables and merchandise on their respective places.
- Unload wood boxes with fruits and vegetables from trucks.
- Attending customers.
- Stowing wood boxes with fruits and vegetables.

Figures 20 to 28 show the obtained results.

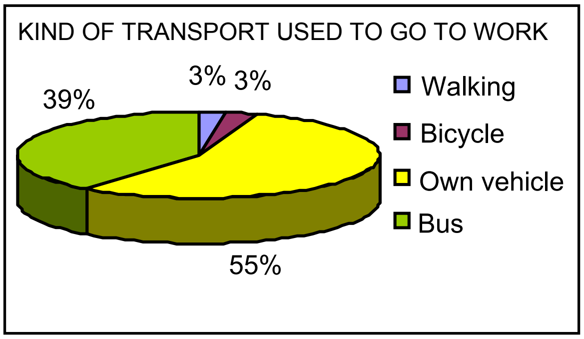


Figure 26. Kind of transportation.

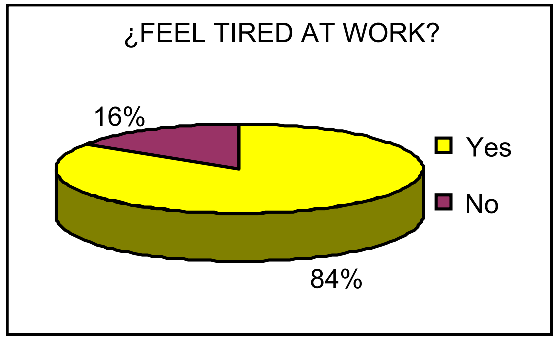


Figure 27. Tiredness.

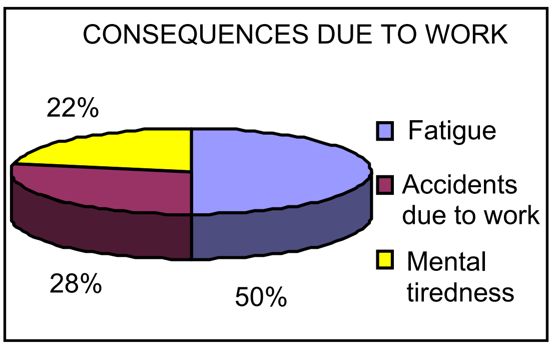


Figure 28. Consequences due to work.

4.2.2 CORLETT & BISHOP

Table 1. Bother and pain frequency

Part of the body	Bother	Pain		Part of the body	Bother	Pain
Head	43	42		Wrist and hands	27	17
Neck	43	15		Bottom	13	3
Shoulder	84	46		Thigh	30	4
Upper arms	25	4		Knees	32	21
Lower arms	66	7		Legs	158	79
Upper back	30	25		Ankles	62	26
Middle back	39	12		Feet	156	40
Lower back	17	18				

5. CONCLUSIONS

According to the results, there is enough statistical evidence to say that exist physic fatigue in workers under study due to their labor, besides ATD's in those persons.

Luke method shows that 81 % of the workers finish the workday with tiredness. One of the most important reasons for this is that they don't feed properly, given that 84% of workers don't eat anything before work, and the persons who eat before work are more productives in their development at work or studies. (Alimentación Sana-AM01).

It's impossible to find some activity requiring any kind of effort that don't generate fatigue, and if to this is added a lack of rest, incorrect body postures, bad feeding and daily stress, those factors cause a continuous accumulation of damage in the body. Other bother with the highest percentage is the bother of lower back.

On the other hand, workers that already have or that are developing an ATD, work 7 days a week, more than 8 hours a day, as a common factor, and most of them don't feed before work.

6. RECOMENDATIONS

It's recommendable to make another investigation to determine the number of rest periods and the length of them during the workday, in order to counteract fatigue during the work and try to avoid the causes that originate monotony and boredom symptoms.

About fatigue caused by physical damage, it's recommendable to teach workers how to assume correct body postures to avoid bothers, exercises to reduce bother and pain in damaged parts of the body, and a program of postural hygiene. It's also recommendable to develop an ergonomics program that includes those aspects.

A good proposition is to make ergonomic exercises, including straightening and breathing exercises without the need to move from workstation. Those exercises are based on Tai Chi Chuan technique, digito acupunture, masages and yoga, making a special emphasis on breathing. This straightening routine can be done by older persons, overweight persons, pregnant women, sportmen, musicians and any person who wants to feel better.

Other important alternative is the training in how to arise and carry loads correctly. Arising and carrying are operations physically exhaustive, and the risk of accidents is permanent, specially back and arms injuries. To avoid those risks, it's important to estimate load's weight, manipulation level effect and the environment in which the load is arisen. It is also recommendable to use objective methods to measure fatigue.

6.1 Strategy to apply ergonomic improvements in workplace:

1. Get information to identify areas with problems.
2. Study the areas with problems suspictions.
3. Get suggestions from workers.
4. Impulse necessary changes.
5. Maintain continuous communication with workers.

6.2 Recomendations to avoid ATD's:

1. Feed before work.
2. Work 8 hours a day, resting at the middle of the period.
3. Make exercises for 15 minutes before begin working.
4. Use visual aiders to point correct body postures.
5. Attend courses about ATD's risks.
6. Use aiders to maintain correct postures, just as: ergonomic corsets, special shoes, ergonomic chairs and antifatigue mattings.

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ANALYSIS OF THE FACTORS THAT CAUSE INJURIES AND/OR INDUSTRIAL ACCIDENTS

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Resumen:

Las empresas deben contar con manuales de seguridad, normas básicas y reglamentarias que cumplan la legislación laboral; por lo tanto es pertinente para la empresa en la cual se realizó el análisis, que sus trabajadores se encuentren cómodos y seguros, que se desarrollen sistemas de seguridad que proporcionen al trabajador un ambiente libre de accidentes y/o lesiones en el área laboral. No tomar acciones influye en la disminución de la eficiencia, productividad y desempeño tanto de los trabajadores como de la misma empresa. Se identificaron los factores que aumentan el número de accidentes y lesiones en una empresa que produce arneses automotrices. Se aplicó un diagrama de causa y efecto para identificar los factores que provocan lesiones; las categorías de análisis involucran a el método, la maquinaria, el medio ambiente, la mano de obra y la medición. Se encontró que los factores que provocaron una mayor cantidad de accidentes y/o lesiones en el área de trabajo fueron, la falta de guardas de seguridad en la maquinaria con un 57%, la distracción de los operadores con el 40% y la falta de entrenamiento con un 30%. Se propuso a la alta administración un plan de acción para prevenir, crear y diseñar métodos o dispositivos de seguridad considerando todos y cada uno de los factores que alteran la salud laboral de los operadores.

***Palabras Clave**: Factores de lesiones, desempeño y salud laboral*

Abstract:

Each company must count on prescribed basic norm, hazard reports and according to the governmental laws in the work. Therefore he is advisable for the company in which the study is being carried out, that their workers are comfortable and safe, that security systems are developed that provide to the worker a free atmosphere of accidents and/or injuries in the labor area. The previous thing brings about the diminution of the efficiency, productivity and performance as much of the workers as of the same company. An analysis is realised to identify the factors that contribute to the greater number of accidents and injuries in a company that produces automotive harnesses by means of a measuring instrument. A cause and effect diagram is used to analyze the factors that cause injuries, in which the method, machinery, environment, manpower and measurement become jumbled, is decided to use this tool to appreciate how causes of the injuries are subdivided to the main factors. One is that the factors that bring about a greater amount of accidents and/or injuries in the work area are, the lack of guards of security in 57%, the distraction of the operators in the 40% and the lack of training in 30%. An action plan sets out to the high management of the company to prevent, to create and to design methods or safeties being considered each and every one of the factors that alter the labor health of the operators.

Key words: *Factors of injuries, performance and labor health*

1. INTRODUCTION

The analysis of the work has constituted an important tool for Industrial Engineering. Frederick Taylor, known as the father Industrial Engineering and author of the “study of times” and the spouses Frank and Lilian Gilbreth, to those who the “study of movements” is attributed to them studied the work in order to do it more efficient and to reduce the fatigue in the worker. Later, the principles of the “studies of times and movements” are combined to form the predetermined times.

The Systems of Predeterminate Times (PMTS), traditionally have been used in the industry to classify, to register, and to measure the work manual executed by the workers when carrying out their tasks. Between these systems of measurement the following can be mentioned: Factor of work (Quick a the 1962), MODAPTS (Heyde, 1985), MTM (H.B. Maynard, 1948) and MOST (ZANDIN, 1990). Nevertheless, the PMTS present/display a great deficiency from the ergonomic point of view because they do not provide postural data necessary to validate the contained biomechanic data in the data bases. From ergonomics arises called science there. The ergonomics, whose word has Greek roots “Ergos” Work, and “Nomos” Laws are an effective science that deals with the interaction between the people, their place of work and the atmosphere. The Ergonomics considers the abilities and limitations of the human being, in the design of equipment, facilities, methods of work and tools.

1.1 Problem Description

The numbers are clear: Near two million people they die every year in the world because of the work who make. Other 160 million suffer diseases related to the same, according to the International Labour Convention (IEO).

The lack of pursuit to the different injuries that appear most frequently in the workers causes that the causes are not identified originate that them and therefore preventive actions are not taken causing an increase in the costs by incapacities and low productivity.

1.2 Objetivs

- To analyze by means of a measuring instrument the factors that contribute to the greater number of accidents/injuries in a company that produces automotive harnesses.
- To evaluate the main accidents and injuries that occur as much in the areas of manufacture by area as in turn.
- To propose to the high management of the company a plan of action in a matter of coming up, when creating, to devise, to design methods or safeties being considered each and every one of the factors that alter the labor health of the operators.

2. METHODOLOGY

One designed a survey of 13 questions with which the causes were detected and/or factors that bring about accidents and/or injuries in the work area; The tools of industrial engineering are described that were used during the development of this project and by means of which the factors will be obtained that bring about accidents and/or injuries in the work area:

* Graphs of Pareto. It allows to analyze of graphical and simple form the factors that contribute to the accidents and/or injuries of work.

* Diagram of Cause and Effect. It is used to appreciate how causes of the injuries are subdivided to the main factors, taking into account the Method, Machinery, Environment, Manpower and Measurement

3. RESULTS

The survey applied to the operators of the line of production of an export company assembly plant of the automotive branch showed the results as far as the factors that take part in an injury and/or labor accident. Within the analyzed factors are those of environmental ergonomics, being these the illumination, noise, temperature and vibration, also, the related ones to the machinery, human materials and methods and resources.

The cause diagram - previous effect shows the factors analyzed during the investigation and taken in account for the design from the questionnaire. According to the results obtained in the survey, the factors that bring about the accidents and/or injuries of work, concentrate in the elements Machinery and human Resource, nevertheless, the diagram causes - presented/displayed effect previously, shows the different elements that conform problematic to that they must fight the companies.

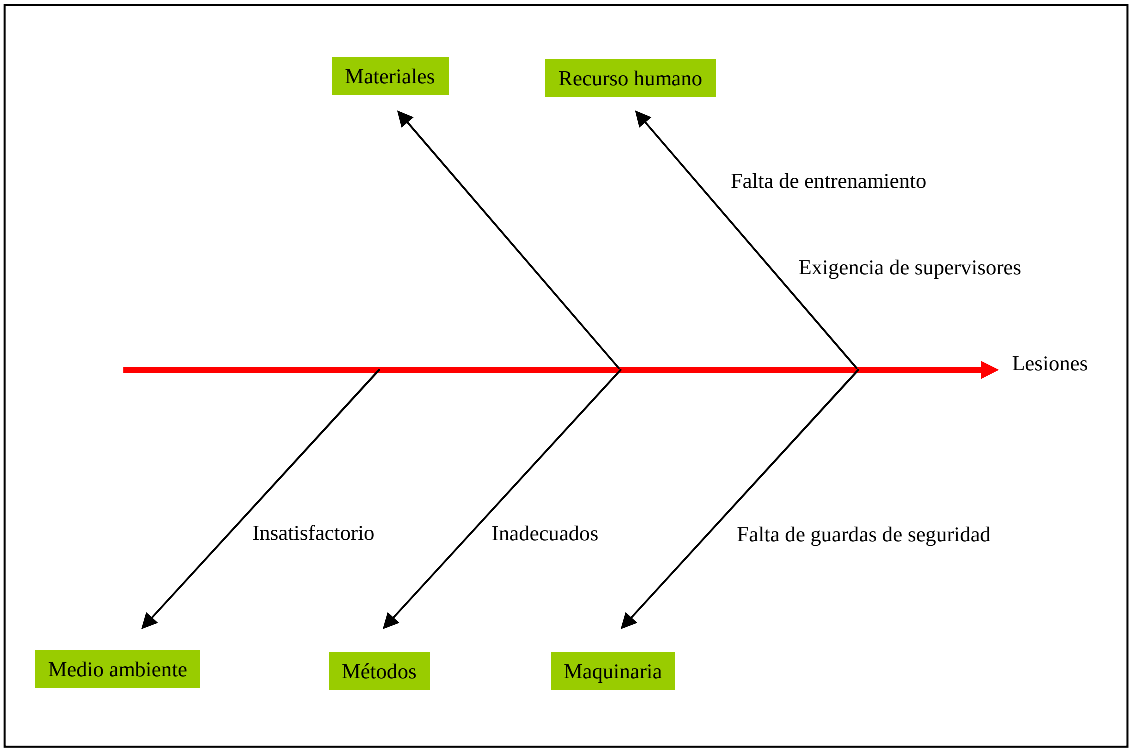

Figure 1.1 Representation of an Cause-Effect diagram

Is that the factors illumination, temperature and vibrations are not determining or factors are not from risk for the operators, nevertheless, the factor noise is considered according to the answers of the survey a factor contributor in the industrial accidents (33%), therefore, is important to determine that volume degree to use in floor not to generate annoyance or distraction in the operators and who of this form can carry out their work without feeling uncomfortable.

The distraction of the operators while they make it his activities, if it contributes to a large extent to the accidents and/or injuries that appear in the labor areas (40%), since, specifically for the production of harnesses meticulous attention to the processes is required to make the cuts, pressings and cut out. Otherwise bad use will become of the machinery and it will not follow with the standards and specifications of the product.

The lack of training of the operators contributes of important way in the accidents and/or labor injuries (30%). Because in the lines of production of automotive harnesses, machines in their majority are used semiautomatic manuals and, it is important that the operators fulfill a program of training at the time of entering the company, and in which is credited to the same like 100% able to correctly use the tools that are provided to him to make a specific activity.

One is that the lack of clarity in the methods or ground visual aids does not contribute of excellent form (10%) in the presence of accidents and/or injuries within the labor areas, nevertheless is important that as much the area of engineering of methods as production has the communication necessary to design and to create ground visual aids and clear methods for the operator and of this form to be able to avoid that accidents due to the lack of attention of these two areas towards their work instructions appear.

An important aspect is the security of the worker reason why the results of the survey sample that, the lack of guards of security in the machinery if it to a great extent contributes (57%) to the accidents and/or injuries of the operators, by this reason is of extreme importance of evaluating the danger of each machine used in the line of production and thus to implement and to construct security guards who prevent the operator him to hurt themselves and to be caused a damage that could cause the incapacity to him.

La parte psicológica, específicamente el estrés que provoca la continua exigencia de los supervisores de producción a los operadores, es causante de accidentes y/o lesiones (30%), por lo tanto, se tiene que tomar en cuenta la cantidad de piezas a producir por operador y la agilidad o habilidad que este tenga para construir o formar un arnés, dependiendo de la actividad que desempeñe, en base a eso el supervisor tiene que tener la conciencia y el criterio para acomodar a sus operadores en las actividades donde estos sean mas eficientes y puedan explotar mas dicha área de oportunidad.

Is on the other side, that the factors illumination and vibration do not influence in the presence of industrial accidents, the temperature (27%) and the noise (37%) unquestionably affects the state of intention of the operators, who, do not have much freedom to express their annoyance since often pressed or indifferent they do not realize that these factors by subjective which they are cannot let pass themselves through stop since they comprise of the “environment” that surrounds the operator and it allows him to do well his work.

It is possible to be concluded according to the apply survey the operators, who the factors that cause a greater amount of accidents and/or injuries in the work area are:

- The lack of security guards (57%)
- The distraction of the operators (40%)
- The lack of training (30%)

Therefore, he is indispensable that the high management along with the production supervisors designs and implements an action plan that allows to analyze each one of the areas of opportunity in which improvements can be make it to avoid that the operators injure themselves. It is important to take into account the 3 described factors previously, since they are those that agreed to the make survey have a greater index of accidents.

The supervisors do not have to forget that the operators are essential part of the company, since they are the producing force, and if they are not within a safe and comfortable atmosphere in which they can realise his labor activities, is very probable that rotation exists, lack of motivation, low productivity, dissatisfaction and mainly accidents which cause injuries

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CATEGORIZATION OF FACTORS CAUSING ASTHENOPIA IN RESEARCH PROFESSORS AT THE ITCJ BY READING WITH VDT: A SHARED EXPERIENCE

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Abstract: The objective of this work was to classify the factors that may generate a risk of asthenopia among the researchers of the ITCJ, as a result of reading with VDT, thanks to the work of a focal team. A descriptive study was done. Twelve research professors participated: their age ranking between 25 to 55 years. The methodology used was of quality and participation nature (focusing on emic). The following activities were carried out: brainstorming from an investigation question, ranking and classifying the information, analyzing and interpreting data and determining the categories. The research participation techniques used were brainstorming and focal group. The risk factors identified by the focal team were: screen brightness, exposition time, lighting, type of monitor, size of screen, font type, font size, reader posture, colors used, quality of text printing, human factors and amicable software. The proposed categories by the participants were: equipment, material, environment and people. The main conclusion unfolds the rescuing of the strength displayed by the participation techniques in the investigations towards explaining any problem, and the abundance of knowledge of the group of people. In this work, we have accomplished the classification of factors that cause visual problems, by the general consensus of the participants which coincides with international literature; furthermore, it shows the practicability of using the focal group technique in explaining an ergonomic problem related to labor health.

Key words: asthenopia, focal group, brainstorming, research professors.

Resumen: El objetivo del trabajo fue categorizar los factores que pueden provocar riesgo de astenopia entre los profesores investigadores del ITCJ como resultado de la actividad de lectura con VDT, por medio del trabajo de un grupo focal. Se realizó un estudio descriptivo. Participaron 12 profesores investigadores, con un rango de entre los 25 y 55 años. La metodología empleada fue de naturaleza cualitativa y participativa (enfoque emic). Se realizaron las siguientes actividades: generar las ideas a partir de la pregunta de investigación, ordenar y clasificar la información, analizar e interpretar los datos y determinar las categorías. Las técnicas participativas utilizadas fueron tormenta de ideas y grupo focal. Los factores de riesgo identificados por el grupo focal fueron: brillo de la pantalla, tiempo de

exposición, iluminación, tipo de monitor, tamaño de pantalla, tamaño de letra, formato de texto, postura del lector, tipo de letra, calidad de impresión, colores utilizados, factores humanos y amigabilidad del software. Las categorías propuestas por los participantes fueron: equipo, material, ambiente y persona.La principal conclusión permite rescatar la fortaleza que presentan las técnicas participativas en las investigaciones orientadas a explicar alguna problemática, y la riqueza del conocimiento que posee un grupo de personas .En este trabajo se logra categorizar los factores que influyen en la fatiga visual , a partir del conocimiento empírico de los participantes el cual coincide en gran parte con la literatura internacional ,además se muestra el uso de las técnica de grupo focal en la explicación de un problema ergonómico relacionado con la salud laboral.
Palabras clave: astenopia, grupo focal, tormenta de ideas, profesores investigadores.

1. INTRODUCTION

In 1978, the amount of PCs used in work places in the United States, was of 600,000 units which at present has increased to more than 100 million. This massive phenomenon came about at the beginning of the 70s when a series of special visual alterations happened. The computer visual syndrome, which was present among workers using screens, has increased the visits to ophthalmologists in the U. S. (Ansell, 2007; AOA, 1995; Sheedy, 2007).

Most of the studies related to visual problems show that the symptoms of visual problems occur in more than a 75% in computer users (Dain, McCathy, and Chang-Ling, 1988; Smith, Cohen, and Stammerjohn, 1981; Ashel, 2007; Leavitt, 1995; AOA, 1995; Tamez, Ortiz and Martinez, 2003). Among the more frequently reported problems are: farsightedness, blurry vision, headache, dry eye or eye irritation, pain on the neck or back and double sight. A study about health risks and damages among newspaper workers, who were exposed to the use of visual screens, found out that the most frequent illness was asthenopia (visual fatigue) in 85%, lightly higher to the rest of other users (Tamez et al, 2003; Gobba, Broglia, Sarti, Luberto y Cavalleri, 1988).

Working with a PCs may contribute to increase asthenopia due to the reduced blinking that increases the symptomology of dry eye (Sheedy, 2007; Isreb et al, 2003; Clark, 2006; U.S. Department of Labor, 2004; Ousler, Gomes, Crampton and Abelson, 1999; Nakamory, Odawara, Nakajima, Mizutani and Tsubota, 1999; Nakaishi and Yamada, 1999; Yaginuma, Yamada and Nagai, 1990; Tsubota and Nakomon, 1993; Dianoff, Happ and Crane, 1981; Rossignol, Pechter, Summers and Pagnotto, 1987). The people devoted to research who read electronic material from a screen are subject to suffer asthopia symptoms (Ukai and Howarth, 2008). It is under this setting where the interest of studying this problem in a labor group little dealt with research professors.

The problem of asthopia produced by reading electronic material has been studied from the quantitative paradigm and none were found from the use of the emic (the actor's point of view).For that reason, it was decided to do this work as a start to contribute to the identification of the factors producing asthenopia, using shared investigation, which rescues the rich experience and knowledge of the participants. Discussing the matter within focal groups provides a technique for this purpose.

According to Morgan (1998), the focal groups were developed in three periods: the first one in 1920 to 1930 and emphasizes its use in a large variety of aims, among them the development of widespread questionnaires by social scientists. The second period, between the Second World War and the 70s which was used by the focal groups mainly by the mark researchers to have an insight on the wishes and needs of the people. Finally, from 1980 on, they have been used by different kind of professionals to investigate about health, family, education and sexual behavior and other social issues. In the last few years, the social scientists have considered that, sure enough, the focal group is an important research quality technique and its use has spread considerably in every field of human science.

The objective of the investigation by the focal was: to categorize the factors that generate a risk of asthenopia among the ITCJ research professors as a result of reading with VDT, focused on emic (from the knowledge and experience of the participants.)

2. METHODOLOGY

The focal group is a collective method for doing research, more than being individualistic; it is centered in the variety of different attitudes, knowledges, experiences and beliefs of the participants, thus obtaining information in a relatively short period. Its essential objective is to pursue the discovery of a structure with a sense of sharing, by consensus if possible, or, in any case, well based on the group members contributions.

The focal group technique can be used during the preliminary or exploratory stages of a study, to evaluate, develop or complement a scientific feature of such a study, or when it has been completed to evaluate its impact or to produce new investigation procedures. They can be used as a specific technique of data collection as complement to others, specially the triangulation and validating techniques (Morgan, 1998).

The focal group was formed by twelve research professors: two of which are PhDs, four Masters and six undergraduates, five Master students and one PhD student, between 25 to 55 years old. It was established that the participants were doing investigation by reading electronic material from a computer screen and that they devoted to this activity a minimum of two hours daily. Nineteen professors complying with these requirements were summoned. They volunteered to participate under the exclusion criteria of lacking of interest and/or time.

2.1 Methodology description

The focal group technique for data collection was used. It was done during a three-hour session. At the beginning of the session, written material describing the techniques being used was handed out to the participants. An ice-breaking dynamics for introducing the participants was directed to enhance a friendly atmosphere and participation. The introductions were made by couples.

The instructor suggested to the group the following investigation questions: 1) Which are the factors that can produce the risk of visual fatigue among the ITCJ research professors as a result of reading electronic material from a VDT? And 2) Which are the most important factors producing the risk of visual fatigue among the ITCJ research professors as a result of reading electronic material on a VDT?. Later on, she (or he) asked the participants to write out on cards provided, three ideas that could respond to the first question. The guidelines were to write an idea on each card and to explain the idea in case it was not clear enough.

The cards were classified as follows: a member of the group was asked to read one of the cards which later was posted on the board. Then, the group was asked if anyone had written the same or a similar idea on the same subject. They read the cards and posted all the cards in columns. To make the classification of ideas easier, those that seemed confusing to the group were sustained by the participant who suggested the idea and which was subject to the group judgment. The classified cards were posted in columns and were read over in order to give each column a name according to the main idea which was being expressed. In this case, the names given were those of the factors.

To demonstrate the importance of the factors, the group was asked to suggest the procedures for ranging the information. Two procedures were suggested: The first one was to vote on the factors found and arrange them accordingly to their importance starting with the ones with the majority of votes. This procedure was rejected by the participants as they decided the second procedure was more practical.

The second procedure, accepted generally, was developed as follows: First, the thirteen factors obtained from the classification, were listed. Then, each participant ranged these factors by importance starting from 1 as the most important to 13, the least important. Later, a member of the group collected the data and filled out a table drawn on the board in which the information was organized scoring them according to the participants consensus had given to each factor and added them up, as directed by one of the participants. Finally, the scores were ranged starting with the highest in importance; thus, the factors were arranged, according to the knowledge and experience of the participants (fig. 1).

Figure1. Collecting and classification of data.

2.2 Data analysis and interpretation

In order to do the data analysis, the score variables given to the factors and the degree of variability among the responses were used. The ideal response was defined as the case in which all the participants agreed on the ranging and the gap between the ideal and real values. The values of the ideal responses and their gap are shown on table 1. Notice that the analysis was done with the results of only 11 of the 12 participants due to the fact that one of them had to abandon the session for personal reasons.

Table 1.Analysis of data

	Participants												
Factor	1	2	3	4	5	6	7	8	9	10	11	Sum	Gap	Ideal
Screen brightness	0	2	4	5	1	1	10	2	4	2	1	32	21	11
Time of exposure	3	4	1	8	8	4	3	12	1	5	2	51	29	22
Lighting	4	3	5	4	2	3	8	8	9	11	3	60	27	33
Type of monitor	2	12	11	3	12	13	1	1	2	4	4	65	21	44
Screen size	7	13	6	3	6	10	7	6	3	3	5	68	13	55
Font type	13	5	7	1	3	5	5	13	5	7	6	70	4	66
Test format	11	7	9	7	5	7	6	3	12	1	7	75	2	77
Reader posture	9	1	10	9	7	8	4	4	6	13	9	80	8	88
Font size	8	6	8	6	4	6	9	7	11	8	8	81	18	99
Printing quality of text	10	8	3	12	12	2	2	10	8	10	11	88	22	110
Colors used	5	9	2	11	9	11	11	11	7	6	10	92	29	121
Human factors	6	11	12	13	13	9	2	5	10	12	12	105	27	132
Amicable software.	12	10	13	10	10	12	12	9	15	9	13	125	18	143

3. RESULTS

The importance given to the factors is shown graphically in figure 2; as observed, the factors are ranged according to their importance perceived by the group. Such arrangement is listed as follows: screen brightness, time of exposure, lighting, type of monitor, screen size, font type, test format, reader posture, font size, printing quality of text, colors used, human factors, and amicable software.

The first five factors are the most important, as assigned by the group of people assessed, who coincide in their responses, except for the first factor (screen brightness) scored differently by all concerned. If everybody had arranged brightness in the first place, the results would have been 11 points from 11 participants. However, it amounted to 32, which gap indicates that there were participants who did not give that much weight to brightness. Nevertheless, brightness was voted on as the most important factor.

In relation to the variability of the responses, the score obtained from the ranged list was compared to that of ideal responses, in case everyone would agreed on the same response;

this difference is the gap in "uniformity" through which we perceive that the assessment has been representative and its degree of representativeness. Notice the factors 1,2,3,4,10,11,12, y 13 display a greater gap and though these factors have been ranged so, the appraisal of the focal group should have been validated by a survey and ponder other variables such as age and occupation (fig.2.)

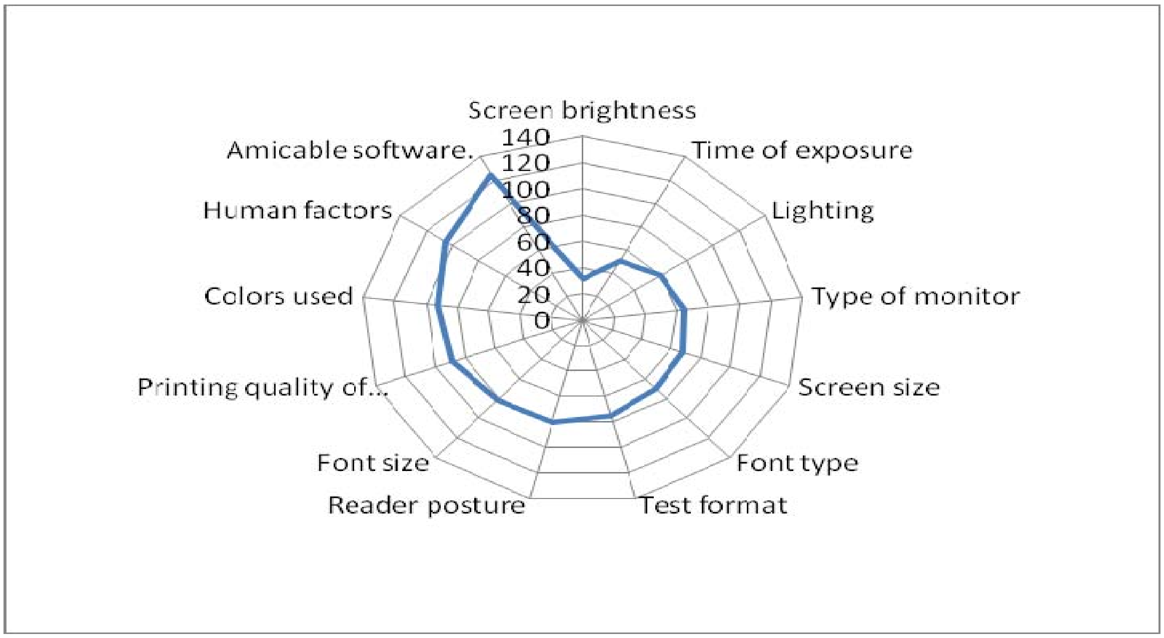

Figure 2. Factors ranked by importance

As shown in fig. 3, the focal group agreed on a valid arrangement, even though the rank of importance has the same behavior as that of the ideal case, the real scores obtained have the same trend: gaps on the arrangement diversion. This is due to two different situations: the first concerns the views of a PhD that differ from those of a Master or other people of different academic background, because of their habits and types of equipment they use for reading their electronic texts; the second, of no less importance, is the age.

3.1 Definition of the categories

To determine the categories it was decided to establish the first classification into two: controllable and uncontrollable factors; most of them (54%) were found controllable, that is, they can be adjusted to an operating level in such a way as to minimize the effect on asthenopia. The controllable factors were 1, 2, 3, 8, 11, 12 and 13, while the uncontrollable were 4, 5, 6, 7, 9 and 10 (fig. 4)

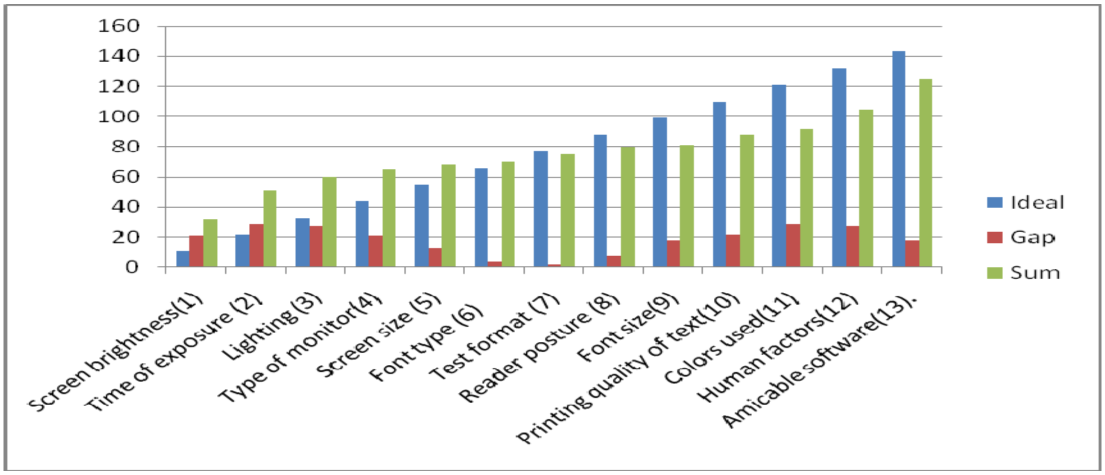

Figure 3 Uniformity of responses.

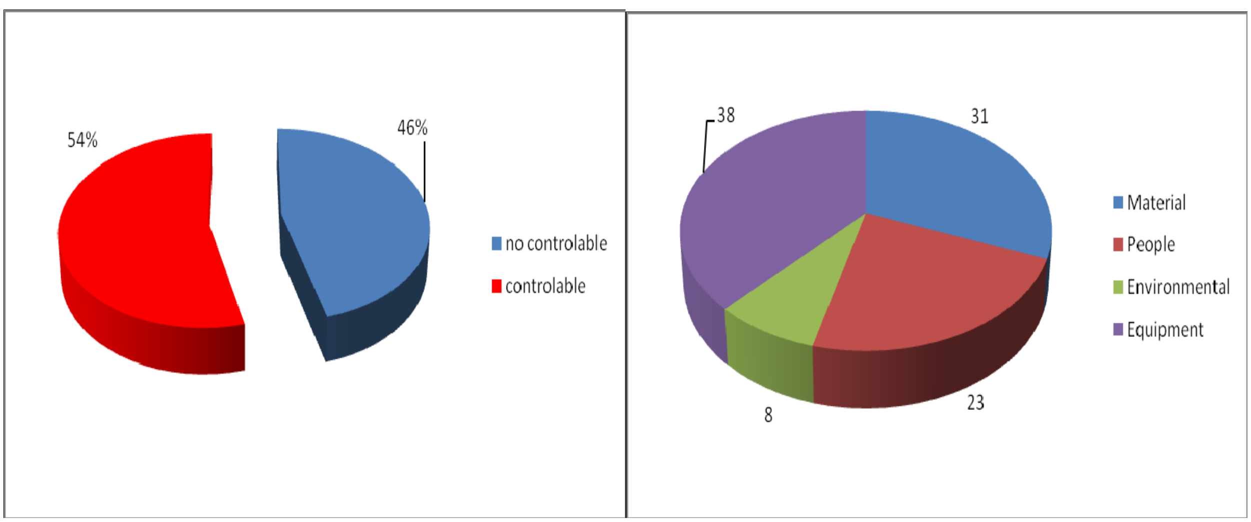

Figure 4. Categories for the factors that affect the asthenopia

A second classification permitted to obtain the categories according to their origin. These categories were due to equipment, material, environment and people. Most of the factors rise mainly from the equipment (38%), that is, the computer used, mainly its technical specifications and dimensions. Then, the material factor amounted to 31% due to the nature of the electronic reading, where very little can affect the printing of the scanned text or choice of the font type: these characteristics are already defined in the articles. The effects due to the people represent 23%; this means that even if they are just a few does not mean they are less important. An experimental design could measure the contribution of each factor to the visual fatigue, in case it's decided to model the process. Finally, very few factors are attributed to the environment (8 %.)

The resulting gap is an indicator that measures the participant agreement with certain arrangement; in our case there are not very important gaps, but our attention is drawn to the fact that the ranging was done with both very important factors and those which are not at all important. This unrelated feature could indicate a bias to be solved in future investigations whether by other instruments for collecting data, such as surveys or interviews at depth. The outcome obtained from the knowledge and experiences of the participants are the risk factors for asthenopia. Figure 6 shows their classification by range, drawn from the cultural domain of the focal group members.

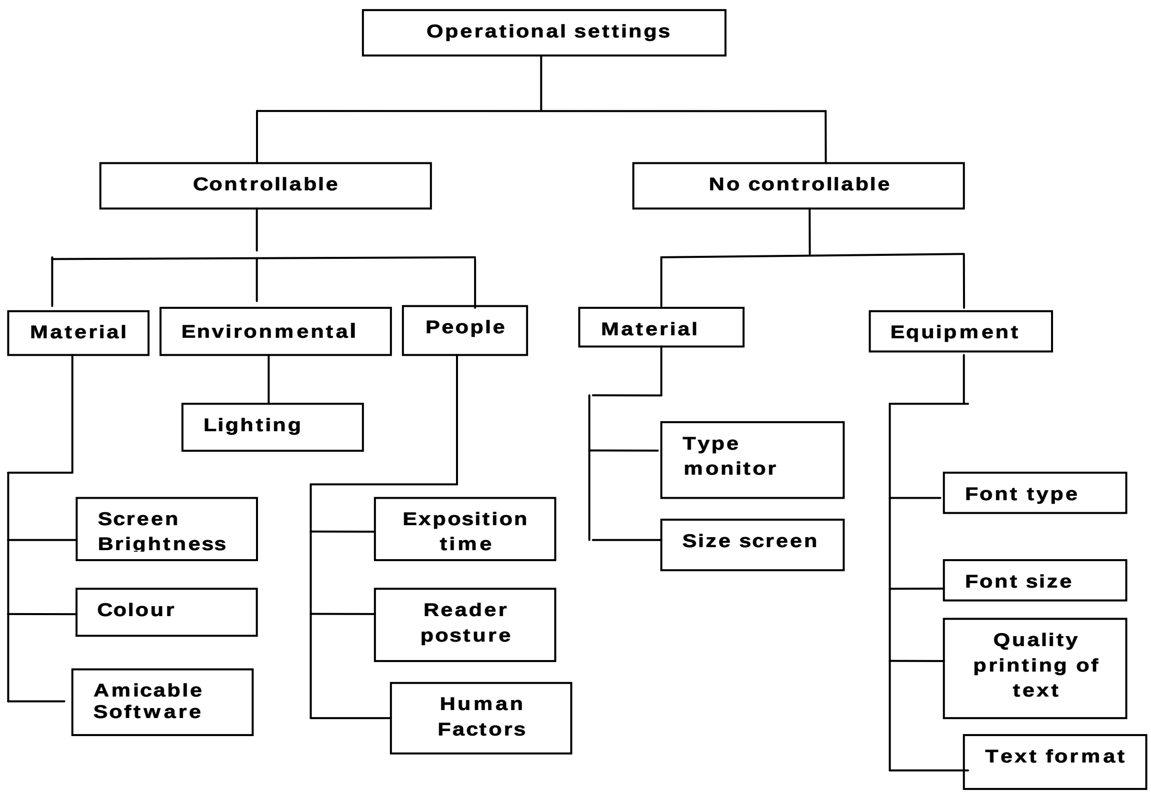

Figure 6. Categorization of asthenopia factors

4. DISCUSSION

Some previous studies mention that lighting has been one of the most important factors affecting asthenopia on workers at their working places by using visual screens (Lin, Hwang, Jeng y Liao, 2008; Sheedy, Smith and Hayes, 2005). Likewise, some investigators have discussed lighting effects on legibility and the effect of font size under a lighted environment or different light sources (Wang and Chen, 2003; Anshel, 2007). Thereby, lighting can diminish legibility because of an undesirable glare (Kim and Koga, 2004; Lin at al, 20008; Sanders and McCormick, 1993.) In this sense, the results obtained by the focal group coincide with the lighting, screen brightness or glare factors, and for readability with its text format, font type and size.

One of the main factors that affects asthenopia is time exposure. In this sense, Knave et al (1985) quoted by Howarth and Bullimore in Wilson and Corlett (2005) have reported that a group of people exposed to more than five-hour period of working with visual screens shows major symptoms of visual discomfort, drawn from a study of cases and controls. The consensus of the group coincides with the American Association of Optometry who declares that one of the causes the Computer Vision Syndrome occurs because the visual requirement of the task exceeds the individual´s capacity to perform comfortably. Therefore, those people who use the computer two or more continued hours per day are prone to a greater risk of developing this visual problem. (AOA, 1995.)

The group also coincides in the color factor. In this regard, investigators mention that the inappropriate use of color could result in a poor performance and as a high cause of visual discomfort (Wang and Chen, 2003; Mathews, 1987). The worker posture is a factor widely studied and related to the musculoskeletal disorders (Turville, Psihoglios, Ulmer and Mirka, 1998.)

Even though asthenopia originates from the reading with VDT, it is considered to be of a multiple factors nature. Not all the identified and classified factors by the focal group were based on literature. Such is the case of the human factors, which particularly in this context seem vague and uncertain. The quality of text printing could likewise cause confusion since it applies to printed material on paper and not to an electronic reading. While the amicable software is an important factor in software and web page design.

So, in this work the factors that cause asthenopia are classified based on the experience of the participants which coincide greatly with international literature. More so, it shows the use of the focal group technique for explaining an ergonomic problem related to labor health which information can be used by research professors to prevent it.

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CARPAL TUNNEL AND THE LACK OF INFORMATION BY THE USER

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Resumen: Actualmente la industria maquiladora busca producir a menor costo, tiempo y mayor escala, y no observan el factor humano; esto se ve reflejado en la decadencia del nivel de vida del trabajador. La mano es una de las regiones más expuestas en la actividad laboral, y ésta desarrolla tareas relacionadas con esfuerzos manuales intensos y movimientos repetitivos. Los objetivos de este estudio fueron: Demostrar que en el entorno laboral administrativo de la Ciudad de Chihuahua se presentan los síntomas del STC, identificar las prácticas inadecuadas por las cuales se tiene este tipo de incidencia, exponer el daño físico y generar información para futuros estudios. El estudio se realizo con personal de nivel licenciatura. La investigación consistió en aplicar una encuesta a personal que labora en la industria del sector Salud, Aeroespacial, Automotriz, Electrónica y Eléctrica de la Cd. de Chihuahua. Con un tamaño de muestra de 50 personas, se obtuvieron dos categorías: personal de Área de Diseño y personal Administrativo en General, esto por el número de horas al día que utilizan la computadora. El estudio arrojo los siguientes resultados: 63% de ambas categorías desconocen el tema. El 94% aceptaron sentir o haber sentido algún síntoma. Los síntomas que presentaron una mayor periodicidad en los sujetos de ambas categorías fueron: Entumecimiento u Hormigueo en la mano con 49% y dolor de la muñeca 27%. La gran mayoría no conoce la forma adecuada de manejar el ratón de la computadora ni cuentan con el apropiado. 83% aceptaron no usar algún accesorio para evitar la fatiga de la mano. El instrumento utilizado para el estudio fue el Método Sue Rodgers, se obtuvo la combinación 343, esto es: se tienen niveles de esfuerzo fuertes (3), la duración del esfuerzo es superior a 15 minutos, entonces se asigna muy Alta prioridad (4) y la frecuencia de esfuerzos por minuto es elevada, esto es el numero de click's que se le dan al mouse durante el día (3).

De lo anterior se concluye, que la mayor parte de las personas desconocen la enfermedad como tampoco saben si la padecen, porque la mayoría de las veces solo han sentido molestia y no le han dado importancia. Las áreas de trabajo no son ergonómicas y los empleados se adaptan a las mismas; en lugar de ser lo contrario.

Abstract: Nowadays factory industries look forward to produce less cost, time consuming and higher scales, and they don't see the real picture; this is shown or reflected with the declined of the worker life level. The hand is one of the region's most exposed in the labor activity, and this develops tasks related to intensive manual labor and repetitive movements. The objectives of this investigation were: to demonstrate in the administrative environment from the city of Chihuahua the following symptoms manifest the carpal tunnel syndrome, to identify inadequate practices for which we have the following symptoms, to explain physical damages and to generate information for future studies. The investigation was done by personal with a degree. The application consisted of applying a survey to employees of the company Health sector, Aerospace, Automotive, Electronics and Electric of the city of Chihuahua. With a sample size of 50 persons, two categories were personally obtained: from the area of design and general personal administrative, this is for the amount of hours that the computer is use. The investigation shows: 63% of the people are not familiar with the topic. 94% have accepted felt or had felt some symptoms. The symptoms that represent more regularity on the people are: numbness or creeps in the hand with 94% and pain in the wrist 27%. The great majority does not know the form adapted handling the mouse of computer nor having the appropriate one. 83% of the people don't use any accessories to avoid fatigue on the wrist. Applying Sue Rodger's method, we obtained the grouping 343, this is: we have levels of hard effort (3), continuous effort duration is over 15 minute, therefore it is assigned to a very high priority (4) and the frequency effort by minute is elevated, this is the numbers of clicks when we use the mouse during the day (3).

It is confirmed that the great majority does not know the sickness and neither knows if they have it, because they have only felt annoyances and they haven't priorities the sickness. The work areas aren't ergonomics and the employees adapt to the same environment; instead of doing the opposite.

1. INTRODUCTION

The carpal tunnel is a narrow tunnel in the wrist form by ligaments and bones. The median nerve which carries impulses from the brain to the hand, passes through the carpal tunnel along with the tendons that allow the hand to be closed. When the tendons are strain, they swell inside the tunnel and compress the median nerve. Carpal tunnel syndrome (CTS) is a condition that can be caused by doing repeated tensioning movements with the hand or by having the hand in the same position for long periods. This syndrome has been known for a long time. Meat packers started to complain about pain and the lost of function in the hand in the year 1860. Back then, these complaints were attributed in greater part to bad circulation. But the nature of work has changed through the years. (Montoro, 2006) Carpal tunnel syndrome is a relatively common pathology. It's more frequent in women between the ages of 30-60. It's characterized by tingling and pain in the second and third finger. (CCOTT, 2005)

Nowadays, many jobs are highly specialized and require the repetitive use of the hands. With the increase in the number of people who use computers, keyboards, and computer mouse, CTS is a concern or real threat for all the people who are subject to repetitive work without taking any breaks by determined prolonged labor effort.

All these excesses or complications in the work are due in a large extent to the lack of programming in production and therefore appear the so called emergencies of the clients and consequently attention to the human factor is not lent and this gives rise to upsets of repetitive movements such as bursitis, tendonitis, writer's cramp, CTS, etc.

Numerous articles related to CTS have been written, but in this occasion it will be known the lack of attention in the ergonomic aspect on the part of the employer-employee as well as the little diffusion of the subject that is counted among the population of several companies in the State of Chihuahua.

2. OBJECTIVES

1. To demonstrate that in the administrative labor environment in the City of Chihuahua the symptoms of CTS appear in the same way as in other regions and countries of the world.
2. To identify the inadequate behaviors or practices by which this type of incidence is had, this with the purpose of exposing how it can be avoided.
3. To expose the physical damage, as a result of the discomfort derived by bad posture.
4. To generate data for the decision making with respect to other diseases even of the professional type.
5. To generate information for future study.
6. To avoid or prevent the incidence of CTS.
7. To make awareness of the good use of the computer mouse and to outline the necessary actions to apply the changes in the habits.

3. DELIMITATIONS

It is not possible to compare among the operative personnel in the present investigation since the study was conducted among personnel with a college degree. Furthermore, the results are not generalizable in PyME´S since the study was conducted in the private industry and in some federal government offices.

4. DEVELOPMENT

CTS is a quiet disease, if we don't have some knowledge about the subject we will only let the symptoms pass as simple passing pains without taking into account its respective precautions to avoid future complications. With this the investigation was focused to make an analysis in the companies and especially in the people who work in them and that in addition pass great part of their day in front of a computer.

4.1 Historical Antecedents

In 1854, Sir James Paget describes for the first time the sintomatology of the compression of the carpal tunnel due to traumatism on the wrist. Marie and Foix, in 1913, describe the compression of the median nerve in a necropsy. The term "carpal tunnel syndrome" was coined by Moersch in 1938 and the clinical symptoms are correlated with the anatomopathological ones, until that moment it was believed that the sintomatology presented by the patients affected by CTS was caused by a cervical rib. Learmonth performs the first decompression of the carpal tunnel in a symptomatic patient, but it is not until 1947 when the first results of the surgical treatment were published. Phalan, in 1951, makes studies in which he includes more than 1,200 hands; being him the true introducer of said pathology in the surgery of the hand in modern medicine. In 1966 a transcendental step took place, when George Phalen published his series with more than 650 cases and made an ample description of the disease, its diagnosis and treatment by surgical methods. However, it has not been until a couple of decades when there has been more advancement in the knowledge of this disease, possibly by its increasing incidence and its economic repercussion. (Ojeda, 2001 and Aran, 2003)

4.2 What is CTS?

The carpal tunnel is formed behind and the sides by the bones of the wrist, and in front by the transverse ligament of the carpal. The median nerve passes through this space and its pinning in the tunnel produces typical neurological manifestations (see figure 1). The median nerve controls the sensations of the back part of the fingers (except the little finger), as well as the impulses of some small muscles in the hand that allow the fingers and the thumb to move. The carpal tunnel is a narrow and rigid passage of the ligament and the bones in the base of the hand-it contains the median nerve and sinews. Sometimes, the thickening of the irritated sinews or other swellings narrows the tunnel and cause that the median nerve be compressed. The result can be pain, weakness or numbness of the hand and the wrist, spreading through the entire arm. Among the many causes of this syndrome are traumatisms, the fibrous sclerosis of the sheaths tendons and rheumatism. (Harrison, 1973)

Figure 1. STC (University of Virginia, 2007)

4.3 Causes

These can occur by: fluid level variations (sugar in the blood in diabetics), muscular alterations, diseases of the joints or bones, hormonal changes, bad ergonomic positions (bad posture), previous injuries like fractures, some repetitive hand work, and genetic inheritance. (Aguirre-Cavazos, 2007)

One of the main causes in which we will do emphasis will be in the ones that are produced by bad posture and the one that is observed commonly among the employees who carry out tasks and/or works that require repetition of a same movement of the hands or fingers during prolonged periods. Figure 2 shows a clear example of the bad posture with the computer mouse, keyboard, monitor, and desk and in some operations. (Melo 2005)

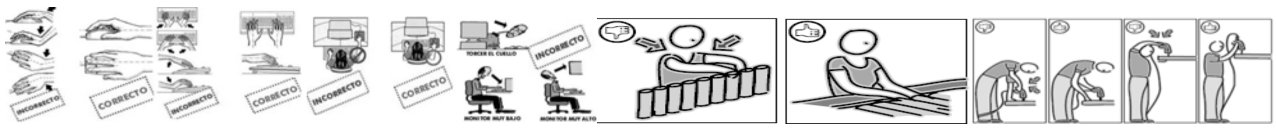


Figure 2. Wrong Ergonomics' Position

4.4 Sintomatology

There is pain and burning sensation of the four fingers, almost always bilateral, that worsen during the night. Some of the most frequent symptoms could be: tingling in the fingers, numbness of the fingers, pain in the thumb, burning sensation from the wrist to the fingers, Changes in the touch or sensitivity to temperature, clumsiness of the hands., weakness to take hold, ability to puncture, and other actions with the fingers, swelling of the hand and the forearm, Changes in the pattern of sweat of the hands. (Montoro, 2006 and Harrison, 1973)

4.5 Statistical Information

The hand is one of the most exposed regions in labor activity; according to statistics from the Instituto Mexicano del Seguro Social, in the year 2006, 309.539 workers suffered Industrial accidents according to Anatomical Region and age group and 31,8% were hand and wrist injuries (including wounds, traumatisms and fractures); furthermore if one reviews the Industrial accident according to Anatomical region and type of injury we can see that out of the total of workers at a national level, the 31,9% are represented by injuries in the wrist and hand. (IMSS, 2006)

Another important data is that CTS has an incidence of 99:100 000 person-year, and its prevalence is 3, 4% in women and 0, 6% in men; it has the highest average of labor absence when it is compared with other pathologies related to the work. (Aguirre-Cavazos, 2007)

These data is very useful to give account of the enormous problem that this type of injury constitutes.

In Mexico, the injuries by industrial accident by anatomical region hand-wrist represent an important part of the consultations and an economic loss as much for the employer as for the employee; this is caused by absenteeism. Statistically this represents in the State of Chihuahua a 0.45% in relation with the rest of the country. In 2006 Chihuahua presented incapacities by diseases cause by work in a 2.75% at a national level. (IMSS, 2006) The incidence of the referred disease cannot be specified statistically, since the table of diseases of the Federal Law of Work dates from 1930 and it has not been modified. This data only gives us an idea of the problem, but these sufferings are not a recognized reason for incapacity, since problems that are generated by stress, depression among others, bring about other types of general diseases by which the incapacity must be extended, but not like work risk. But this will not continue to occur when the laws are modified and the government takes into account ¨new diseases¨ produced by the excess of labor days. According to the news agency NOTIMEX, which says that the interinstitutional committee, from the Research center in Work of the IMSS, integrated by experts in the subject elaborated the proposal of new diseases and risks of work which they give to legislators of the House of

Representatives, this list includes other diseases like cancers, stress, burn out syndrome among other 63 sufferings. (NOTIMEX, 2008)

4.6 Federal Law of Work

According to the Federal Law of Work, Title Ninth refers to the Risks of Work; article 513 mentions the table of work diseases, but they were only found to be like affections derived from industrial fatigue: Bursitis (141), Tenosynovitis (159) and Cramps (157), in all the cases the only people taken into account are: telegraphers, radio operators, violinists, pianists, typists, writers, secretaries, handling of calculators, laborers, bricklayers, shovelers, adjusters, machinists, miners, shippers, sanders, dock workers, etc. [9]. We can give account that no modifications have been made to the law in this matter for three decades, and labor days tend to be of greater intensity and the cases of muscles and skeleton upset have increased for those of who are put under repetitive labors. CTS is not valued like a disease produced by the execution of repeated movements, therefore the employer does not take the bother to present or to provide the necessary information of the disease, does not change the ergonomics of the place nor rehabilitates or pays the medical expenses of the eventuality.

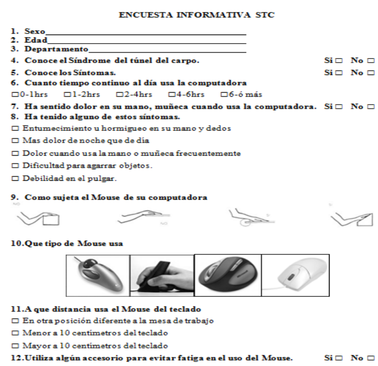
4.7 Sue Rodgers Method

There exist diverse techniques of job position evaluation, each of them are applicable under a series of conditioners, for example Rogers Muscle Fatigue Analysis, known as Sue Rodgers Method. The analysis of muscular fatigue was proposed by Sue Rodgers as a mean to evaluate the amount of fatigue accumulated in the muscles during several working patterns within 5 minutes of the same. The hypothesis is that a fast muscular fatigue is more susceptible to injuries and inflammation. This method for the analysis of work is more appropriate to evaluate the risk by fatigue (accumulation) in tasks that are carried out in one hour or more and where bad posture is present. The Sue Rodgers method of analysis studies the effort, the duration and the frequency required by each part of the body to carry out a certain task. The interaction of the level of effort is evaluated, as well as the duration of the effort before relaxation (or before passing to a smaller level of effort), and so is the frequency of activation of the muscles per minute for each muscle group. From these parameters a prediction of the muscular fatigue is made.

Each one of the parameters: effort, duration and frequency are evaluated individually, in a scale from 1 to 3, for each part of the body. The Degree of Severity is determined from the combination of the values assigned to each parameter: effort-duration-frequency. (Rodríguez, 2003 and Rodgers, 2006)

5. METHODOLOGY

The investigation consisted on applying a survey to several people who work in the factory industry in the Health, Aerospace, Automotive, Electronic and Electrical sector in the city of Chihuahua. The study was conducted due to the fact that the symptoms have been presenting in some fellow workers of the factory industries. The poll was made to a total of 50 people, but from the total of the inquiry, it would be sufficient to select 44 in a simple random form, considering that it has been worked with a 95% confidence level, to commit a 5% of error and of that in our sample 8% did not meet the characteristics of the population; reason why it is possible to be said that our data is representative. Two categories were obtained: personnel of the Area of Design on one hand and General Administrative personnel on the other, this occurred by the number of hours per day that the computer is used. With the application of the survey to other work areas the lack of knowledge of the referred subject clearly reflected. The questions that were asked were in relation to the application of the ergonomics in the places of work and with emphasis in the good posture that the user must have in the use of the computer mouse as well as the correct positioning of the hand-wrist and also to the previous knowledge of CST and the information that the employee must have in case any of the symptoms present. The survey had the following format:


ENCUESTA INFORMATIVA STC

1. **Sexo**________________
2. **Edad**________________
3. **Departamento**________________
4. **Conoce el Síndrome del túnel del carpo.** Si ☐ No ☐
5. **Conoce los Síntomas.** Si ☐ No ☐
6. **Cuanto tiempo continuo al día usa la computadora**
☐0-1hrs ☐1-2hrs ☐2-4hrs ☐4-6hrs ☐6-ó más
7. **Ha sentido dolor en su mano, muñeca cuando usa la computadora.** Si ☐ No ☐
8. **Ha tenido alguno de estos síntomas.**
☐ Entumecimiento u hormigueo en su mano y dedos
☐ Mas dolor de noche que de día
☐ Dolor cuando usa la mano o muñeca frecuentemente
☐ Dificultad para agarrar objetos.
☐ Debilidad en el pulgar.
9. **Como sujeta el Mouse de su computadora**
10. **Que tipo de Mouse usa**
11. **A que distancia usa el Mouse del teclado**
☐ En otra posición diferente a la mesa de trabajo
☐ Menor a 10 centímetros del teclado
☐ Mayor a 10 centímetros del teclado
12. **Utiliza algún accesorio para evitar fatiga en el uso del Mouse.** Si ☐ No ☐

Format 2. Poll

The survey was tried to be applied to Departments of Security and Hygiene, but they did not accept to answer it. Only in one company, was mentioned that they have an ¨Ergonomic Commission¨, but this only applies for the operator level and the project in which they are only focusing at this moment is the implementation of anti-fatigue mats.

On the other hand, the analysis of the position of the hand-wrist-fingers with the Sue Rodgers method was also made, the format is the following (Rodgers, 2006):

Rodgers Muscle Fatigue Analysis by Task

Task	SINDROME DEL TUNEL DEL CARPO

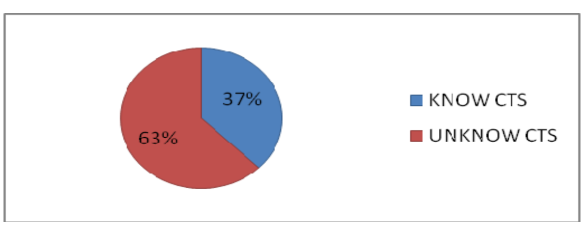
	Effort Level (If the effort cannot be exerted by most people, enter 4 for Effort and VH for Priority)			Scores			Priority
Region	Light -- 1	Moderate -- 2	Heavy -- 3	Effort	Dur	Freq	
Neck	Head turned partly to side, back or slightly forward	Head turned to side; head fully back; head forward about 20°	Same as Moderate but with force or weight; head stretched forward				
Shoulders	Arms slightly away from sides; arms extended with some support	Arms away from body, no support; working overhead	Exerting forces or holding weight with arms away from body or overhead	Right			
				Left			
Back	Leaning to side or bending arching back	Bending forward; no load; lifting moderately heavy loads near body; working overhead	Lifting or exerting force while twisting; high force or load while bending				
Arms / Elbow	Arms away from body, no load; light forces lifting near body	Rotating arms while exerting moderate force	High forces exerted with rotation; lifting with arms extended	Right			
				Left			
Wrists / Hands / Fingers	Light forces or weights handled close to body; straight wrists; comfortable power grips	Grips with wide or narrow span; moderate risk angles, especially flexion; use of gloves with moderate forces	Pinch grips; strong wrist angles; slippery surfaces	Right			
				Left			
Legs / Knees	Standing, walking without bending or leaning; weight on both feet	Bending forward, learning on table; weight on one side; pivoting while exerting force	Exerting high force while pulling or lifting, crouching while exerting force	Right			
				Left			
Ankles / Feet / Toes	Standing, walking without bending or leaning; weight on both feet	Bending forward, leaning on table; weight on one side; pivoting while exerting force	Exerting high force while pulling or lifting; crouching while exerting force	Right			
				Left			

Continuous Effort Duration	< 6 s 1	6 - 20 s 2	20 - 30 s 3	> 30 s 4 (Enter VH for Priority)
Effort Frequency	< 1 / min 1	1 - 5 / min 2	> 5 - 15 / min 3	> 15 / min 4 (Enter VH for Priority)

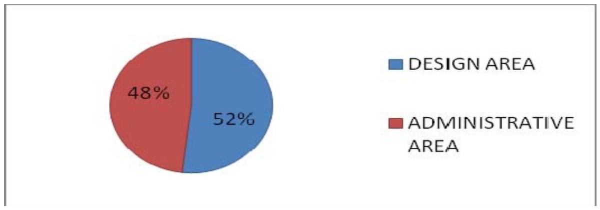
Format 3. Sue Rodgers Method

6. RESULTS

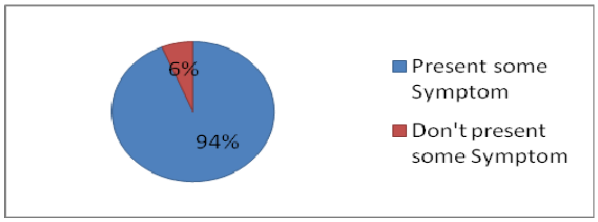
The results of the surveys made in the city of Chihuahua are presented next. For security reasons, the surveyed personnel asked not to disclose the name of the company where they work. As it was previously mentioned, altogether were 50 surveyed people pertaining to 8 companies of the selected factory industries. When the questionnaire was being applied, the majority of the people did not know of the existence of CTS. The data of the study showed that 63% of the people do not know about the subject (Graphical 3.1). The appearance of the upset in the hand-wrist by work site was almost similar since 52% of the people who work in design presented the pain as well as 48% of the administrative area (Graphic 3.2).Other important data, we know that the majority of the people do not know the subject, nevertheless they present the majority of the symptoms that where mentioned in the survey, 94% accepted to feel or to have felt some indication of it(Graphic 3.3), but they left it as something fleeting and did not give importance to the matter. The symptoms that presented a greater regularity are: Numbness or tingling in the hand and fingers with a frequency of 49% and wrist pain 27% respectively. And as it was to be expected, the majority of the individuals do not know the correct form to use the computer mouse nor have a suitable one. As well as they do not use or have not been provided by the company with an accessory to eliminate or to avoid fatigue in the wrist, 83% accepted not to use it (Graphical 3.4).



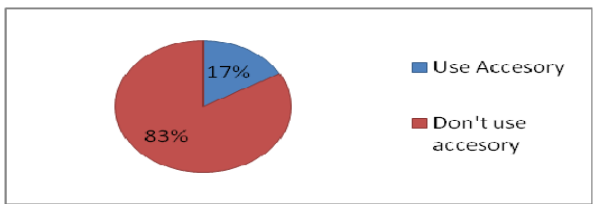
Graphical 3.1 General Knowledge



Graphical 3.2 Incidence of Pain by Work Area



Graphical 3.3 Presence of Symptoms



Graphical 3.4 Use accessory to avoid fatigue

On the other hand when doing the analysis with the Sue Rodgers Method the combination 343 was obtained, this means that strong levels of effort are had (3), the duration of the effort is higher to 15 minutes, so there is sufficient reason to assign a very High priority (4) and obviously the frequency of efforts per minute is elevated, this is the number of click's that are given to the computer mouse during the day (3).

Low (L)	Moderate (M)	High (H)	Very High (VH)
111	123	223	323
112	132	313	331
113	213	321	332
211	222	322	4xx, x4x, xx4*
121	231		
212	232		
311	312		
122			
131			
221			

Format 4. Category turned out grouped by priority for the change in the Order of effort, effort continued Duration and Frequency. (Rodgers, 2006)

7. DISCUSSION

We can infer that most of the people do not know the disease as well as not knowing if they suffer it or not, because the majority of the times they have only felt annoyance and they have not given it any priority and they ignore the consequences in a not so distant future. The places or work areas are not ergonomic and the employees rather adapt to them; instead of doing the contrary. The only thing they know is that they must ¨produce and produce¨. We cannot blame everything on the companies, for the lack of information or not having suitable spaces to work harmoniously; since the laws do not force the employer to do it, since no sanctions or restrictions exist so that this is fulfilled. If only the government would worry to give priority to the risk factors of the physical type that provoke diseases that are not known as a result of work, our perspective would be totally different, but they only argue on saying that no disease has a unique cause. When one has begun to undergo some of the symptoms of this suffering the best course of action, before the disease worsens and must be put under surgery, is to carry out the following indications and/or recommendations: to immobilize the wrist by using a cast during the night, to use a wristband when using the computer mouse apart from resting the arms in such a way that they are not outside the desk and/or chair. This suffering can only be prevented if the companies had some type of previous education, for example, there exist several methods for evaluation of posture in the work place, that serves us to realize how badly designed the work zones are but these are not used, it is not known if it is because of the lack of knowledge or because they just choose to omit them. They are easy to apply and they can optimize the tasks of labor risk prevention. But since CTS is a no recognized disease by labor laws; we can only know about the subject by means of communication like this one. This is the first part of a series of investigations that will be done and articles that will be written to spread the subject, to help create awareness in the companies about the prevention of the problem besides teaching and alerting the workers with latent risk to suffer CTS, due to the characteristics of their work.

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