IDENTIFICATION OF ERGONOMIC RISK FACTORS IN MANUFACTURING AUTOMOTIVE WINDOW REGULATORS

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Resumen: A nivel internacional la industria automotriz genera uno de los índices generales de siniestralidad laboral más elevados en el sector manufacturero y las lesiones que genera son lo bastante graves para provocar pérdida de tiempo y errores en el trabajo de los empleados de este sector.

México se encuentra ente los diez principales países productores de automóviles a nivel mundial y en el estado de Sonora la industria de autopartes, elemento importante de la industria automotriz, impulsa la economía regional y genera una gran cantidad de trabajo en el sector, convirtiéndolo también en uno de los principales generadores de riesgos laborales.

La literatura especializada en salud y seguridad ocupacional ha demostrado que los riesgos ergonómicos son un factor importante que contribuyen a la buena salud de los trabajadores y que a partir de mantener buenas condiciones ergonómicas se puede mejorar su salud y seguridad.

El presente documento muestra los resultados de la investigación realizada en una empresa dedicada a la fabricación de elevalunas automotrices en Hermosillo, Sonora; identifica y caracteriza los factores de riesgo ergonómico y presenta una propuesta para la eliminación o reducción del posible impacto de los mismos en la salud de los trabajadores.

Palabras claves: riesgo ergonómico, elevalunas, salud ocupacional.

Abstract: Internationally the auto industry have one of the higher accident rate index in manufacturing sector and its injuries are as severe as to cause time loss and errors in employees job in this sector.

Mexico is one of the top ten car manufacturing countries worldwide and in the Sonora state the auto parts industry, an important element of the automotive industry, supports regional economy and generates a lot of work in the sector, making it also one of the main generators of occupational hazards.

Occupational health and safety researches have shown that ergonomic hazards are a major factor contributing with workers´ health and by a good ergonomics condition can improve your health and safety.

This paper aims at presenting the outcomes of an ergonomic evaluation carried out into an auto parts facility in which window regulators are manufactured. This firm is located in Hermosillo, Sonora, Mexico. Ergonomic risk factors are identified and characterized and proposals are made in order to eliminate or reduce their possible impact on this company workers' health.

Key words: ergonomic risk, window regulator, occupational health.

1. INTRODUCTION

Internationally the auto industry have one of the higher accident rate index in manufacturing sector and its injuries are severe enough to cause employees time loss and diseases in this factory.

Mexico is one of the top ten car manufacturing countries worldwide (OICA, 2010) and in Sonora state, the auto parts industry, an important element of the automotive industry, supports regional economy and generates a lot of work in the sector, making it also one of the main generators of occupational hazards (Marín, 2010).

Ergonomics is one of the most important topics for occupational health. If a workstation or a place where an employee is working it is not ergonomically designed, it can bothersome in

the long term, and it will end up causing him some injuries, a syndrome, an illness, and so forth and consequently, the employee's work absences.

In Mexico, job injuries represent an important problem for small, medium and even large companies. The transcendences of the study of ergonomic risk factors have already been accepted in businesses, and it is considered that once they are identified, firms are able to eliminate or control them; this is the main reason why it is necessary to increase the interest of those who are involved in achieving the diminishing of their impact on employees' health.

The International Labour Organization, ILO, estimates that economic losses due to occupational hazards occurrences represent for Latin America, from 9 to 12% of Gross Domestic Product, GDP (OPS, 2005).

Often, workers in the activities of job are exposed to of physical, chemical, biological, psychosocial and ergonomic risk factors, which can alter their state of health, one of the most frequent alterations it's the musculoskeletal system disease (Luttmann, 2004).

Currently musculoskeletal disease represents one of the main consequences of injuries and work-related illness that every year employers report to the Bureau of Labor Statistics of the United States of America (NIOSH, 2010).

European researches have shown that some musculoskeletal disorders such as back, neck and upper limbs pain are a health problem and have large-scale labor costs (AESST 2000). It is estimated that this condition is similar to developed countries to those in developing countries.

Musculoskeletal disorders related to job are defined as a heterogeneous group of organic or functional disturbances in muscles, nerves, tendons, joints, cartilage and spinal discs, which are induced by neuromuscular fatigue due to very demanding jobs (Cueto, 2009).

Because many of these problems are associated with excessive physical work demands caused by poor workstation design, tools, and generally inadequate working methods, the literature on occupational safety and health suggests that ergonomic hazards made identify and from that apply ergonomic principles to design job demands and adapt it to the capabilities of the worker.

The information at local level published about the auto parts sector with regard to worker exposure to ergonomic hazards and assessing their potential impact on health and safety of themselves, so far has been revised is scarce.

It is known that in manufacturing processes for window regulators sometimes the worker must assume awkward postures, which leads him to be at increased risk of musculoskeletal disorders. However, despite being aware of these conditions and the impact on health worker in this industry in Mexico are few studies, mainly on ergonomic risk factors.

For this reason, the objective of this study is to identify and characterize the ergonomic risk factors involved in the manufacture of windows regulators and assess their potential impact on workers´ health

2. OBJECTIVES

The main purpose of this research is to identify, characterizes and quantify ergonomic risk factors associated with physical, functional and organizational characteristics of workplaces and their impact on workers' health.

Recommendations are given to reduce or eliminate those hazards, so job tasks carried out will be more efficient, productive and safe. That why we characterized important anthropometric data for personnel involved in the process of manufacturing windows regulators and identified the consequences for personnel working in manufacturing windows regulator of exposure to ergonomic risk.

3. METHODOLOGY

Research was conducted in a Ford Motor Company Tier 1 supplier, this factory has 223 total employees in the processes that it has, and it is located in Hermosillo, Sonora city.

We considered two types of assessments: 1) Workers or subjects: this included 31 workers from windows regulator area and 2) The workstation, were analyzed 25 workstation and their specific activities.

Since the company of auto parts was conceived as a unit, consisting of basic elements interact, such as technological, methodological and human, we used general systems theory to carry out this investigation.

By using the systems approach sought to understand the functioning of the company from a holistic and inclusive perspective, where the important thing was the relationship between components, and where components of the system are not physical components, but the functions they perform.

We kept in mind the fact that the study systems was conducted in Hermosillo, Sonora, Mexico, in an automotive window regulator manufacturing firm, from October to December 2010. A diagnosis of those who are involved in manufacturing these items for ergonomic risk factors was developed. And subsystems identified are outside inputs in different forms among which are: information, physical resources, or energy, these entries are subjected to transformation processes which produce results or outputs very special.

The strategy used in this study to maximize the validity and reliability of the information and thereby reduce errors in the results of the research was triangulation, and several instruments were used to study the object, as well as various information sources (Pranee, 1999) used this strategy because it is considered one of the most rewarding for qualitative research, to give the rigor and depth study (Benavides, 2005), this method allowed to obtain a clearer picture of operations and environment that develops the auto parts industry engaged in the manufacture of automotive windows in Hermosillo, Sonora.

A literature review was conducted to find out the newest in occupational health in the auto parts industry issue, the aim of this review was to identify and analyze what types of risks causing poor posture and improper movements and how can identify and evaluate, develop proposals for improvement. We used the database of the Mexican Social Security Institute IMSS to estimate the rate of musculoskeletal injuries, INEGI and ISI-Thomson databases where used, with the intention that this review reflects current information, important and accurate, the initial horizon search was 10 years

To ensure the quality and completeness of the selected material is used sources of primary and secondary information, preference was given to that information from refereed

journals and books, for databases access the information came from the Institutional Library System at the University of Sonora and the World Wide Web on the Internet. A very important source of information was the industry of auto parts in Hermosillo, Sonora when applying the instruments.

The OWAS method was applied to workers for assess the most awkward postures that require the activity in the work and also applied a musculoskeletal symptom questionnaire to understand their symptoms, and finally an anthropometric workers study to evaluate the fit that exists in every workplace and employee.

Several instruments were used but for the purpose of this paper, even though additional data are presented as the results of a questionnaire on musculoskeletal symptoms applied to understand their symptoms and an anthropometric study of workers are only the results of OWAS Method addressed in detail here.

The OWAS method (Ovako Working Analysis System) is used to assess postural efforts at work, was developed in response to the high prevalence of problems and musculoskeletal complaints, mainly low back pain among workers at a steel manufacturing company and its possible association with the positions work undertaken.

The method represents the classification of positions according to a conventional definition of four digits for each position. The first digit determines the position of the trunk, the second upper extremities, the third of the lower extremities, and the last digit of the magnitude of the load or applying force with your hands. In each of the defined working positions corresponding one of four categories representing the level of postural stress and this in turn is associated with a degree of urgency to implement corrective measures.

The positions classified for first category are not harmful and poses no degree of urgency which indicates that it requires remedial action. Those classified in category 2 indicate that this workstation involves positions with major stressors and degree of urgency which results in corrective measures should be implemented in the near future. The Category 3 positions correspond to positions involves working with very important stressors and indicating a degree of urgency which must implement corrective measures as soon as possible. The Category 4 indicates that the work involves postures with obvious harmful effects and

remedial measures should be implemented immediately. The values assigned to the evaluation are shown below:

Table 1. Categories of risk posture codes.

Legs		1			2			3			4			5			6			7		
Load/Force		1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Back	Arms																					
1	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1
	2	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1
	3	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1
2	1	2	2	3	2	2	3	2	2	3	3	3	3	3	3	3	2	2	2	3	3
	2	2	2	3	2	2	3	2	3	3	3	4	4	3	4	4	3	3	4	2	3	4
	3	3	3	4	2	2	3	3	3	3	3	4	4	4	4	4	4	4	4	2	3	4
3	1	1	1	1	1	1	1	1	1	2	3	3	3	4	4	4	1	1	1	1	1	1
	2	2	2	3	1	1	1	1	1	2	4	4	4	4	4	4	3	3	3	1	1	1
	3	2	2	3	1	1	1	2	3	3	4	4	4	4	4	4	4	4	4	1	1	1
4	1	2	3	3	2	2	3	2	2	3	4	4	4	4	4	4	4	4	4	2	3	4
	2	3	3	4	2	3	4	3	3	4	4	4	4	4	4	4	4	4	4	2	3	4
	3	4	4	4	2	3	4	3	3	4	4	4	4	4	4	4	4	4	4	2	3	4

Table 2. Classification of body positions categories according to their relative frequency.

Back	1	Right	1	1	1	1	1	1	1	1	1	1	1
	2	Leaning forward	1	1	1	2	2	2	2	2	3	3	
	3	With rotation	1	1	2	2	2	3	3	3	3	3	
	4	Angle and rotation	1	2	2	3	3	3	3	4	4	4	
Arms	1	Both below shoulder level	1	1	1	1	1	1	1	1	1	1	
	2	One above shoulder level	1	1	1	2	2	2	2	2	3	3	
	3	Both at or above shoulder	1	1	2	2	2	2	2	3	3	3	
Legs	1	Sitting	1	1	1	1	1	1	1	1	1	2	
	2	Right standing with both legs	1	1	1	1	1	1	1	1	2	2	
	3	Stand with right leg	1	1	1	2	2	2	2	2	3	3	
	4	Both knees bents	1	2	2	3	3	3	3	4	4	4	
	5	A bent knee	1	2	2	3	3	3	3	4	4	4	
	6	Kneeling	1	1	2	2	3	3	3	3	3	3	
	7	Walking	1	1	1	1	1	1	1	1	2	2	
% Time		0		20		40		60		80		100	

The postural efforts were evaluated and analyzed through the videotapes of each of the activities jobs. An analysis of the responses expressed in the questionnaire and the relative magnitudes of the symptoms reported by workers and the body regions affected was obtained. A table of 14 relevant anthropometric parameters to the type of work in the area manufacturer of windows regulator, which will be used to compare anthropometric data with the workspace and implement necessary improvements.

4. RESULTS

The analysis of results revealed varying degrees of dangerousness of different ergonomic risk factors; here are some results from the analysis.

Table 3. Summary of postural stress analysis for Ford windows regulator

N°	awkward posture/ workstation	1	2	3	4	Action	Risk level
1	10	4	1	3	1	4	High Risk
2	20D	1	2	2	1	3	Moderate Risk
3	20T	2	2	2	1	3	Moderate Risk
4	30	3	3	2	2	4	High Risk
5	40DI	2	1	3	1	4	High Risk
6	40DD	2	3	2	1	3	High Risk
7	40T	1	3	2	1	3	Moderate Risk

Table 4. Summary of postural stress analysis for Chrysler front windows regulator

N°	awkward posture/ workstation	1	2	3	4	Action	Risk level
8	05 CHD	3	1	2	1	3	Moderate Risk
9	10CHD	4	1	2	1	3	Moderate Risk
10	20CHD	2	1	2	2	4	High Risk
11	30CHD	1	3	2	2	4	High Risk
12	40CHD	2	1	3	1	4	High Risk
13	50CHD	1	3	2	2	4	High Risk
14	60CHD	1	2	2	1	3	Moderate Risk
15	70CHD	3	3	2	1	3	Moderate Risk
16	front Inspection	1	3	2	2	4	High Risk

Table 5. Summary of postural stress analysis for Chrysler back windows regulator

N°	awkward posture/ workstation	1	2	3	4	Action	Risk level
17	10 CHT	4	1	2	1	3	Moderate Risk
18	20 CHT	2	1	2	2	4	High Risk
19	30 CHT	3	1	2	1	3	Moderate Risk
20	40 CHT	2	1	3	2	4	High Risk
21	50 CHT	1	3	2	2	4	High Risk
22	60 CHT	2	2	2	1	3	Moderate Risk
23	70 CHT	1	2	2	1	3	High Risk
24	80 CHT	3	3	2	1	3	Riesgo Alto
25	Back Inspection	1	3	2	2	4	High Risk

The symptom questionnaire applied to 31 workers in the study, showed that a significant number of workers surveyed have or have had any musculoskeletal discomfort considered to be work related in the last year (81%).

Table. 6. Workers who have or have had symptoms.

Presence of symptoms	Frequency	%
yes	25	81
no	6	19
Total	31	100

From employees who reported symptoms in the last year, 48% report be presented in more than one body region discomfort.

Table 7. Number of body regions with symptoms

Number of body regions with symptoms	Frequency	%
1	13	52
2	8	32
3	4	16
Total	25	100

For the distribution of complaints by body region, we note that the complaints filed by employees that have or have had discomfort, the first place is for shoulder discomfort with

40%, followed by back discomfort with 36 % where 20% corresponds to the upper back and 16% for lower back, and finally the hassle of hand/wrist and ankle/foot with 12% each.

Table 8. Number of complaints by body region

Body Region	Frequency	%
lower back	4	16
shoulder	10	40
hand/wrist	3	12
ankle/foot	3	12
upper back	5	20
Total	25	100

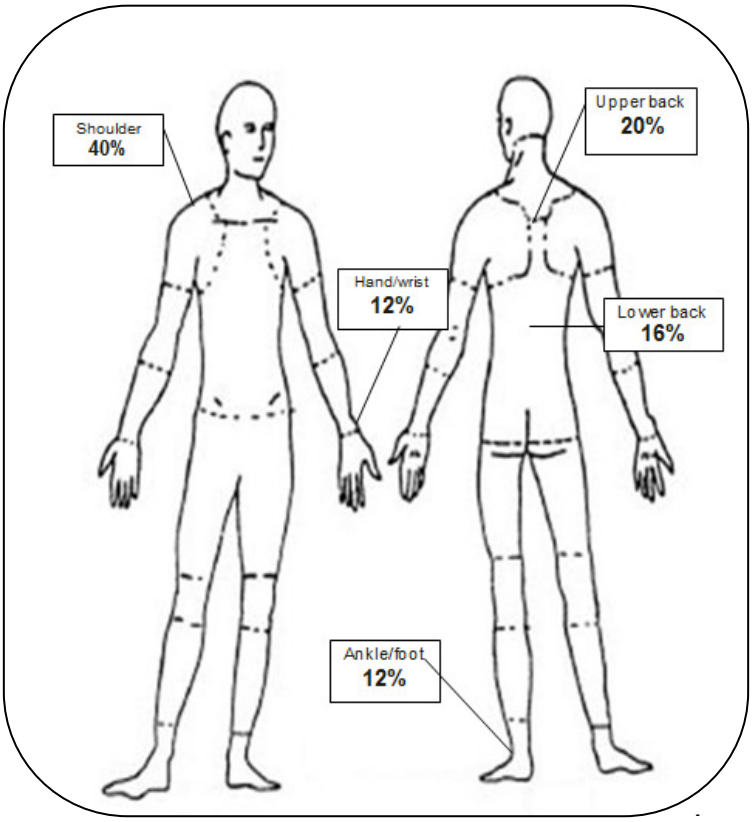

Figure 1. Complaints by body region (%)

Table 9. Anthropometric data (cm)

Parameter	μ	σ	P_5	P_{50}	P_{95}	Máx	Mín
Age	30.06	4.82	24.5	29	39.5	41	24
Weight	79.49	16.54	56.15	80.5	105	112.5	46.5
Height	167.5	9.34	153.5	165.5	182	186	150.5
Eye Height	156.82	9.76	141.75	156	173	175	139
Shoulder Height	138.73	8.09	126.5	137.5	150.25	154.5	122
Elbow Height	107.27	6	98	106.5	115.75	120	95
Waist Height	103.53	6.14	96	103	113	117.5	91
Wrist Height	81.76	7.46	66.75	82	90.75	93.5	61.5
Height to the middle finger	64.95	3.83	58.5	65	70	74	57
Long arm	73.77	5.64	66	72.5	81.75	84.5	61.5
Long arm from wall	84.85	6.18	76	85.5	95.25	96	74
Distance from the wall to the center of the fist	76.02	7.99	65.5	75.5	86	103.5	64
shoulder width	48.69	4.06	42.25	49	54.25	57	38.5
Grip diameter (interior)	40.97	3.77	36	41	47.5	48	35

5. CONCLUSIONS

In this study, ergonomic hazards were identifying which affected the good performance worker and evaluates their potential impact and consequences on the health of every one of them.

Workers expressed musculoskeletal disorders which they considered related with, repetitive movements of upper limbs as well as manual materials handling which implies an effort on his shoulders, or maintained static postures or abduction or flexion greater than 60 degrees; some of this factors was founded in tasks such as driving Tools about the height of the head or take and leave material during the manufacturing process.

It is found that 44% of the task measured with OWAS presents a moderated level risk and the other 66% was classified as high risk.

The musculoskeletal symptom questionnaire shows that 81% of participants in this study have or have had some musculoskeletal disorders in the past year associated with the tasks of their job. The affected body part are as follow, it is reported that 40% of sore shoulders, a back 36%, 12% in the lower extremities and another 12% in the upper extremities

From the foregoing, we conclude that for the company to improve the occupational health of their employees need to perform consistently ergonomic improvements, major efforts should be contemplated should include: the design or redesign of the areas, working in this area is important to consider anthropometric dimensions of the working population, it have to work in a training on working procedures, and establish administrative controls that carry a enhance the conditions on which, if carried out Tasks.

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