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ENVIRONMENTAL AND ORGANIZATIONAL ERGONOMIC ANALYSIS: CASE STUDY IN A TUBULAR FURNITURE INDUSTRY

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Summary: This work shows a case study carried out in a tubular furniture industry located in the state of Sergipe, Brazil. The object of the study is to carry out an environmental and organizational ergonomic analysis in the carpentry and upholstery sector. Experiments and empirical observations were carried out to collect data using the ergonomic work analysis (AET) methodology. With the collection of data regarding temperature, relative humidity, noise, luminosity and IBUTG index. The temperature and noise level were above the standards established, the other indices are complying with these limits. The analysis carried out using the OWAS method classified the posture as number 2, requiring corrective actions.

Keywords: Ergonomic analysis, Organizational ergonomic analysis, Furniture industry, Carpentry, Upholstery.

1. INTRODUCTION

The furniture market has undergone major changes in recent years due to economic growth and market demands from consumers, so pre-molded furniture industries have started to invest in innovation and technology in their products. Investments have surpassed national levels and can now be compared to international levels.

The main objective of ergonomics is the adaptation of work to the human being, seeking to eliminate the limitations of the operator system. Organizational ergonomics has as its object of study human-machine interactions, organizational structure, social aspects and work organization (MENEZES and SANTOS, 2014). Environmental ergonomics focuses on identifying problems related to adverse weather conditions in the work environment, such as thermal stress, noise, lighting, among others.

According to NR 17 (2002), ergonomic work analysis (AET) is a constructive and participatory process for solving a complex problem that requires knowledge of the tasks, the activity carried out to carry them out and the difficulties faced to achieve the performance and required productivity.

According to Guérin et al., 2001, AET is divided into five phases, demand analysis, task analysis, activity analysis, data interpretation, validation, diagnoses and recommendations.

The aim is to present an environmental and organizational assessment in a real industry situation, specifically in the upholstery sector of a tubular furniture and steel kitchen factory in the State of Sergipe. Among the specific objectives are: (i) the identification of critical factors in the work environment; ii) analysis of the tasks performed by operators, from socio-technical and organizational aspects.

2. THEORETICAL FOUNDATION

According to Wilson and Corlett (2005), the systemic approach to ergonomics covers all aspects of the worker's interaction with the work environment, both in the environmental, physical and psychological aspects. These interactions can bring positive or negative effects to the worker's health that can affect human performance. According to Kirwan (1994), human error, whether intentional or not, is any action or lack thereof that does not meet the limits of acceptability, which according to with Swain and Guttmann (1983) they are classified as error of omission and error of commission.

Rasmussen (1987) defines that the error of omission is characterized when the operator fails to perform a task in whole or in part, whereas the error of commission is when the operator makes a decision based on cognitive aspects and performed based on knowledge.

The organization of work in a company facilitates the flow of processes, information and materials (SIMOES et a., 2012). Fleury and Vargas (1983) report that administrators are responsible for organizing, scrutinizing and controlling all phases of the process, subjecting and subordinating workers to the outlined scheme. Adverse environmental conditions such as noise, temperature and humidity, in addition to causing risks to workers' health, can lead to accidents (FIEDLER et al., 2006).

Tamborlin and Macieski (2007) use a methodology for auditing the 5S senses that consists of giving scores from 1 to 5 for each sense in the environments that you want to apply, then adding up the scores obtained for each sense in the respective environment and add and then multiply by four.

Figure 1 shows the basic working postures for the OWAS method.

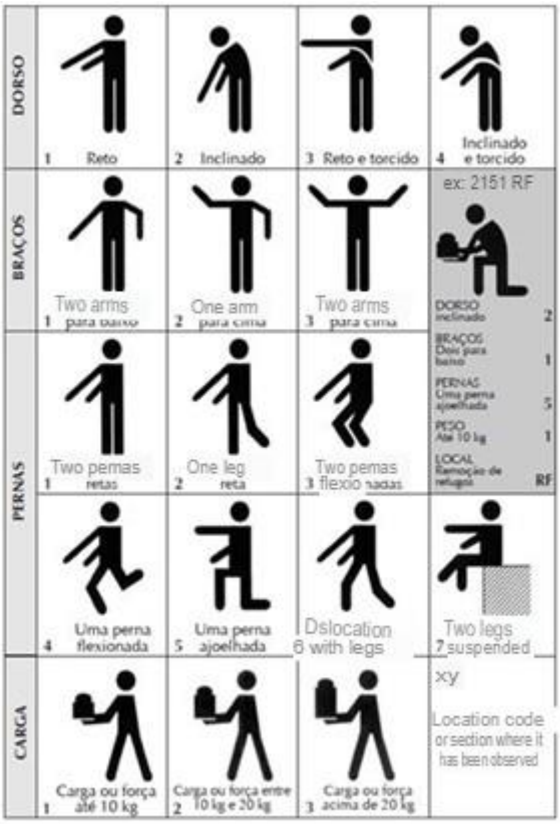

Figure 1 — Basic postures
Source: Iida (1990) Silva et al. (2003).

Table 1 presents the interaction matrix of the postures of the OWAS method.

Table 1 — OWAS interaction matrix

Back	**Arms**	**1**			**2**			**3**			**4**			**5**			**6**			**7**			**Legs**
		1	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**1**	**2**	**3**	**Strength**
1	**1**	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	
	2	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	1	
	3	1	1	1	1	1	1	1	1	1	2	2	2	2	2	2	1	1	1	1	1	2	
2	**1**	2	2	3	2	2	3	2	2	3	3	3	3	3	3	3	3	3	3	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	3	3	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	

Source: Prepared based on Wilson and Corlett (2005).

Table 2 shows the posture classes of the OWAS method and their respective descriptions.

Table 2 — OWAS posture classes

Classes OWAS	**Description**
Class 1	Working posture considered usual, without harmful effects on the musculoskeletal system. No changes in working posture are necessary.

Class 2	Working posture that has some harmful effects on the musculoskeletal system. No immediate changes are necessary, but the stance should be changed at the next methods review.
Class 3	Working posture that has a clearly visible detrimental effect on the musculoskeletal system. The working method must be changed as soon as possible.
Class 4	Working posture that is extremely harmful to the musculoskeletal system. The working method must be changed as soon as possible.

Source: Mattila et al. (1993)

3. METHODOLOGY

The study was carried out in 2015 in the upholstery sector of the company, which currently has six employees. The survey was carried out with all employees in the sector, all of whom were male.

The company a. specialized in manufacturing tubular furniture and steel kitchens. Founded in 1991. The company only manufactured tubular furniture and from 2002 it began operating in the steel kitchen sector, becoming the first industry to manufacture this type of product in the Northeast of Brazil. It currently has 120 employees who work 8 hours a day, from Monday to Friday.

On-site visits were made and four questionnaires were administered about working conditions, environment, level of education and ergonomic perception regarding the workplace, informing discomfort, fatigue and the intensity of efforts in operational situations.

The following instruments were used to collect environmental data: i) Thermo-Hygro-Decibel-Luximeter model THDL-400 ii) digital anemometer and iii) globe thermometer, as demonstrated by Silva and Texeira (2014) that the Regulatory Standard (NR) No. 15 analyzes only the Globe Thermometer Wet Bulb Index (IBUTG) for the characterization of unhealthy environments.

AET involved observing work organization, rhythm, execution time, mobility conditions, lighting, noise and thermal comfort. The activities were recorded by a digital camera. The OWAS technique (Ovako Working posture Assessment. System) was used to analyze working posture, based on Másculo and Vidal (2011).

. The experimental procedure to calculate the bulbometric indices was carried out in two different environments, the work environment and the rest environment. Successive measurements were taken until reaching a minimum difference between the last three measurements of 0.1 ºC.

The calculations and frameworks were carried out in accordance with the methodology present in NR 15 (BRASIL, 1978). Equation 1 was used to calculate the IBUTG in an indoor environment without solar load.

$$IBUTG = 0{,}7\ tbn + 0{,}3\ tg \quad (1)$$

Where:

Tbn: Natural wet bulb temperature.

Tg: Globe temperature.

To calculate the average metabolism, Equation 2 was used.

$$M = \frac{Mt \times Tt + Md \times Td}{60} \quad (2)$$

Where:

Mt: Metabolism rate in the workplace.

Tt: Sum of time, in minutes, spent at the workplace.

Md: Metabolism rate at resting place.

Td: Time, in minutes, spent in the resting place.

4. RESULTS OF DATA COLLECTION

4.1. Environmental analysis

Data regarding environmental conditions were collected, as shown in Table 3.

Table 3 — Measurement results for the carpentry environment.

Index	Real	Recommendation	Source
Temperature (°C)	30,7 ± 0,3	20 a 23	NR 17 NBR 10152
Moisture (%)	34 ± 0,8	40 - 80	NR 17
Luminosity (lux)	948,33 ± 1,1	500 - 1000	NBR 5413
Brightness in the machine (lux)	624,66 ± 0,7	150 - 300	NBR 5413
Noise (dB)	84,2 ± 0,9	65	NR 17

The temperature level was 7.7 ºC above the upper limit established by standard. The noise level is 19.2 dB above the limit established by standard. The remaining data are within the limit established in the NRs.

Table 4 presents data regarding environmental conditions for the upholstery environment.

Table 4 — Measurement results for the upholstery environment.

Index	Real	Recommendation	Source
Temperature (°C)	28,9 ± 0,4	20 a 23 °C	NR 17
Moisture (%)	34,53 ± 0,6	40 - 80	NR 17
Luminosity (lux)	473 ± 1,4	300 - 750	NBR 5413
Noise (dB)	81,66 ± 0,8	65	NR 17

The temperature is non-compliant at 5.9 ºC and the noise level is above 16.66 dB. Other quantities did not present any discrepancies.

Aiming for worker health, the company requires the use of ear protectors in areas with noise levels above the recommended level.

To provide a thermally comfortable working environment for the operator, the installation of axial exhaust fans is recommended. Axial exhaust fans promote convection and establish thermal balance.

Data relating to the globe thermometer wet bulb index are presented in Table 5.

Table 5 — Wet Bulb Globe Thermometer (IBUTG) Indices

	Average Metabolism	Recommended (maximum allowable IBUTG)	Source
Average IBUTG (°C) 31.3 ± 0.11	150 Kcal/h	31,3 °C	NHO - 06

The metabolic rate was obtained from table 1 of the FUNDACENTRO (NHO) Occupational Hygiene Standard No. 06 (2002) and the maximum permissible IBUTG from table 2.

The average value obtained from IBUTG was 31.3 ± 0.11 ºC, within the maximum permissible limit. For this limit situation, it is recommended to install axial exhaust fans in order to reduce the temperature and reduce the IBUTG.

4.2 Organizational Ergonomic Analysis

The poor spatial distribution of the current physical production arrangement implies unnecessary displacements and interruptions in the production flow, causing losses in time and performance. The provision of intermediate stocks, or already manufactured parts, in the work environment prevents the execution of the task from occurring safely and efficiently. Figure 2 shows the spatial organization of the materials, tools and bench used to assemble the chair seats.

Figure 2 — Spatial organization

The flow of materials in the assembly space for seats and chair backs becomes repetitive, materials are returned to the same bench unnecessarily, generating unnecessary time and travel. Operators carry out movements that are harmful to health, due to the poor disposal of raw materials used to make the seats and backs, which includes lifting weights at an angle greater than 120º, causing back pain.

Figure 3 shows how the upholstery task is performed.

Figure 3 — Upholstery Operation

For the upholstery workstation, the result shown in Table 6 was obtained, through photos and videos.

Table 6 – Digits of the OWAS method for the upholstery workstation.

Back	Arms	Legs	Charge
2	1	1	1

The operator who upholsters the seats and backs of chairs works with their backs inclined, with arms down, legs straight and with a load of less than ten kilograms. The combined posture is classified 2, according to Table 1 and requires corrections. These corrections can be made at the height of the bench, raising the height of the table by ten centimeters, to prevent the operator from working with an inclined back.

5. CONCLUSION

The regulation of temperature levels in carpentry and upholstery must be the target of immediate action. nd analysis of the noise levels showed that the carpentry exceeded by 19.2 dB and the upholstery exceeded by 16.66 dB, the value required by NR 17. Ergonomic actions began to be better monitored by the company to avoid hearing impairments, reduction of power of concentration, reduced level of productivity and possibilities of errors of omission and errors of commission, an immediate action taken was the guidance for the constant use of ear protectors.

The IBUTG index was within the limit permitted by standard, which does not characterize the environment as unhealthy. The company was recommended to add axial exhaust fans coupled to the walls to allow convection between the external and internal environments, reducing fatigue, dizziness and drops in performance.

Workers' posture is classified as a class 2 in the OWAS technique, which requires a routine review of work methods. In the short term, the height of the workstation will be increased by ten centimeters, to avoid bending the back while carrying out tasks.

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