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ERGONOMIC ANALYSIS OF BIOMECHANICAL ASPECTS AND ENVIRONMENTAL CONDITIONS OF THE CUTTING SECTOR IN WOODWORK

Joelene de Menezes de Freitas*

Jackeline Jhessy Santos Araújo*

Lara Patrícia Brandão de Santana*

Simone de Cássia Silva*
*Universidade Federal de Sergipe - UFS
scassia@gmail.com

Abstract: The study shows an ergonomic intervention directed to the cutting department in a joinery in the state of Sergipe. The Ergonomic Work Analysis (EWA) was the basis for the mapping of workers' characteristics, biomechanical conditions required for the tasks and environmental conditions of work. The results showed problems related discomforts in the regions of the shoulders and spine of operators and regulatory inadequacies related to temperature and illuminance. At the end they are presented ergonomic recommendations for maintaining good health and comfort of workers.

Keyword: Joinery, environmental working conditions, biomechanics.

1 INTRODUCTION

Ergonomics has an interdisciplinary character aimed at restructuring work, aiming to harmonize the productive activity of individuals in both the physical and cognitive aspects. In this study, the analysis of the behavior of active operators became observable through the grouping of a succession of methodological precepts with the intention of developing an operating model.

The observation was made in the cutting sector of a custom furniture manufacturer, in the State of Sergipe. To propose a diagnosis that would lead to a list of notes aimed at better working conditions, the biomechanical and environmental conditions of the sector were analyzed. Every carpentry is an environment where physical effort is highly required, as well as the risks of work accidents are easily perceived. The worker's body in task execution movements is the main part in this production process; His physical and cognitive well-being will be directly related to his and the company's productivity and health. Therefore, the application of ergonomics is quite necessary in analyzing the nature of work.

The objective is to identify how it is possible to improve the execution of tasks carried out in the cutting sector of a furniture industry, promoted by ergonomic interventions, using Ergonomic Work Analysis (AET) techniques. This study made it possible to present ergonomic recommendations based on examining the demands of activities from a biomechanical point of view and environmental working conditions.

2 THEORETICAL REFERENCE

Ager (1976) in his study reports on the constraints of workers in sawmills and carpentry industries. According to the author, the problems encountered are environmental in nature and related to work biomechanics. The doses of noise to which workers are exposed can damage their hearing. Still regarding environmental conditions, the nuisances generated by wood dust are also addressed in the study. The biomechanics of work, according to the author, is linked to the movements and postures of work as well as its static nature.

Ning et al. (2014), analyzed how the load handling position can be used in designing protection strategies against back injuries caused by sudden loading. In a biomechanical context, we sought to investigate the effects of load manipulation at certain heights combined with asymmetric loading. The results obtained allowed us to verify that it is likely that the handling of heavy loads requiring flexion and rotation of the trunk in an asymmetrical direction can generate serious chances of spinal twisting and shearing.

According to Menezes and Santos (2014), environmental working conditions can affect the performance of workers in the industry. In their study, using the AET methodology in a plastic packaging industry, it was analyzed that the comfort-oriented environment was compromised due to being located on a mezzanine with low natural ventilation convection and affecting thermal comfort and operator productivity. In this context, the difficulties encountered in carrying out the activities were diagnosed and, based on operational reliability, recommendations were proposed.

3 METHODOLOGY

The study was carried out using Ergonomic Work Analysis (AET), observing the operational activities of workers in a real execution situation. AET assists in the systematic observation procedure of the activity to analyze, diagnose and evaluate the risk aspects highlighted in the real situation (GUÉRIN et al., 2001; DIONÍSIO et al., 2011).

On-site visits were made to collect information necessary to carry out the analysis. With interviews initially carried out with the director (and owner) it was possible to understand the operational processes, the sectors involved and the activities carried out in each production sector. Thus, the cutting sector was defined to carry out the ergonomic analysis.

To collect data on biomechanics and environmental conditions, informal interviews were carried out with fifteen workers and direct observation of on-site activities was also carried out. These observations included understanding the tasks and content of the work, analyzing body movements, the postures adopted and the reason for adopting them.

For the diagnosis related to working conditions, the following methods were used: Ovako Working Posture Analyzing System (OWAS); Diagram of painful areas; and Nordic Questionnaire. Such analyzes result in the identification of non-conformities and subsequently the presentation of ergonomic recommendations according to each identified need.

To collect data on environmental variables noise, temperature, luminosity and humidity, the Thermo-Hygro-Decibel-Luxmeter model THDL-400 was used. Five measurements were taken at the studied workstation, with an interval of approximately ten minutes, and the value obtained for analysis was the average of the three central values (excluding the extremes). To collect the IBUTG (Wet Bulb Index-Globe Thermometer), the thermal stress meter was positioned at the height of the worker's torso, or, in the presence of a main source of heat, at the height of the most affected point, waiting for twenty-five minutes for the device to stabilize; then data from the globe, dry bulb, wet bulb and internal IBUTG were collected.

4 RESULTS

The data of the fifteen carpentry employees, such as age, education level, length of service at the company and number of absences due to health problems arising from operational activities are presented in Fig. 1 in percentage terms.

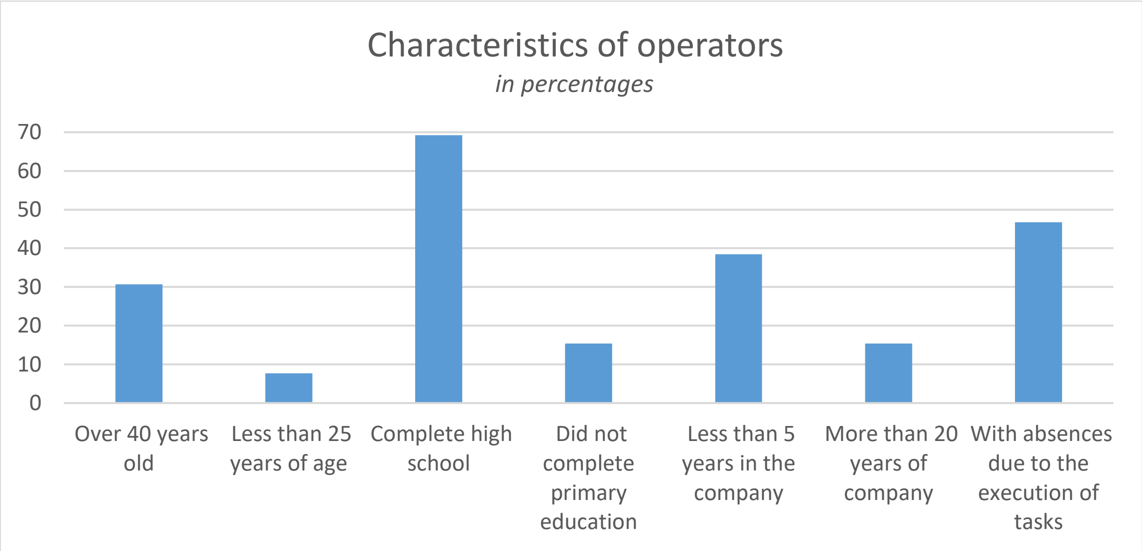

Figure 1: Characteristics of the fifteen workers observed in the study.

To proceed with the analysis, a micro flow of the actual task in the cutting sector was created, so that the work actions are presented in Figure 2.

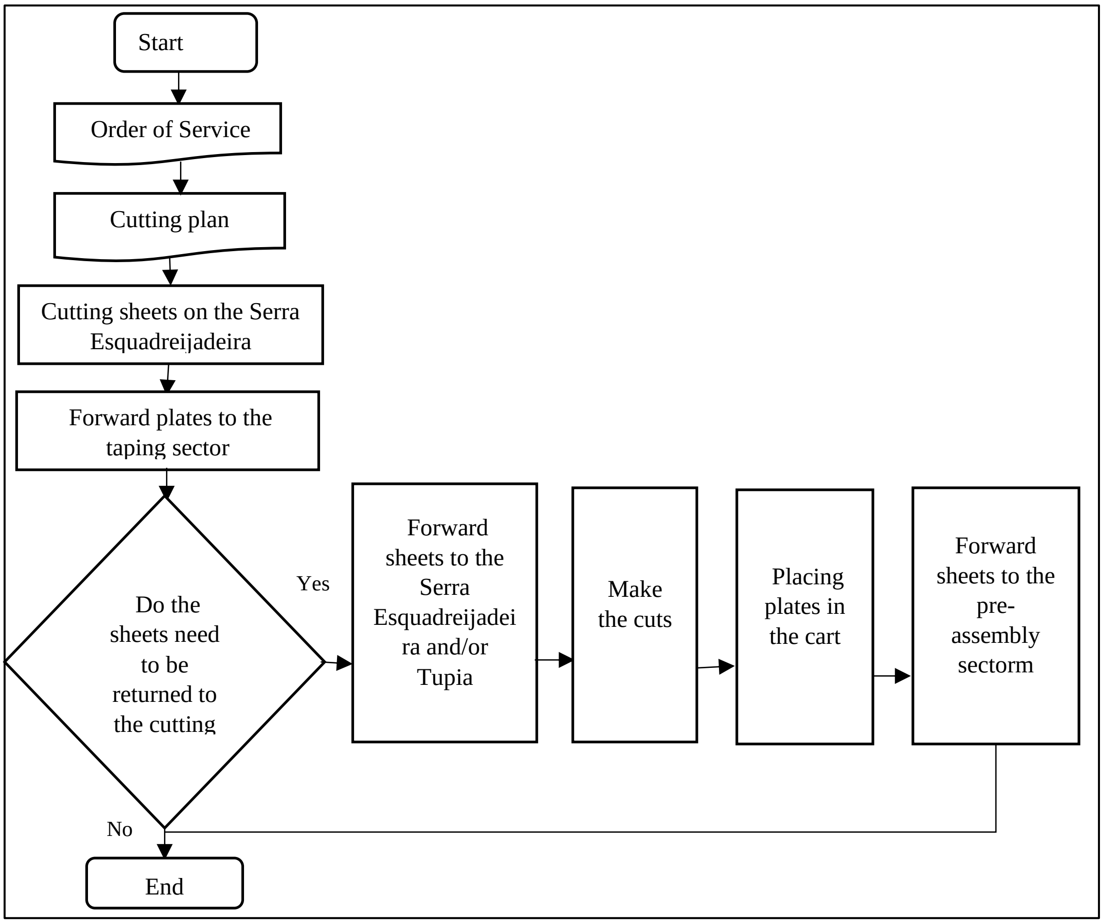

Figure 2: Flowchart of the cutting sector
Source: Authors themselves.

To analyze the discomforts in carrying out the operation, the task was divided into steps: (i) taking the plate from the stock and depositing it on the Circular Square Saw; (ii) remove the plate from the machine; (iii) place the sign on the Tupia; (iv) carry out the cutting at Tupia. Table 1 describes the most common body movements used during the task.

Quadro 1: Descrição dos movimentos adotados na realização da tarefa do corte

Tasks	Body movements
(i) Take the plate from the stock and place it on the Circular Square Saw	Flexion of the shoulder, biceps, forearm and elbow, hyperextension and flexion of the wrist.
(ii) Remove the plate from the machine	Shoulder abduction, biceps flexion, elbows, wrist extension, trunk flexion and inclination.
(iii) Place the plate on the Tupia	Rotation and flexion of the trunk, flexion of the biceps and elbows and extension of the wrist.
(iv) Carry out the cut on the Tupia	Extension of the shoulder, back, elbow and ulnar deviation of the wrist.

When analyzing the postures using OWAS, it was found that the positioning adopted by the operators on the circular saw saw resulted in combination 1111, indicating that the posture is within normal limits. Soon after, the tool was applied to the activity carried out by operators at Tupia. The general result 2123 shows that the posture taken during the execution of the actions deserves attention in the short term. Figure 3 shows the execution of the task on both machines.

Figure 3: (A) Posture on the circular saw; (B) posture in Tupia.
Source: Authors themselves s.

The results of the Pain Diagram showed that there is moderate discomfort in the shoulder, back and leg regions. The Nordic Questionnaire was applied with the aim of identifying musculoskeletal symptoms within 7 days and 12 months. Responded by fifteen workers in the cutting sector, the result indicated that the areas with the highest number of symptoms were the shoulder, dorsal spine and lumbar spine regions. Symptoms identified in the shoulder region were reported by fifteen percent of workers in the last twelve months. Regarding the spine region, there was no removal. Figure 4 presents the data collected from the questionnaire.

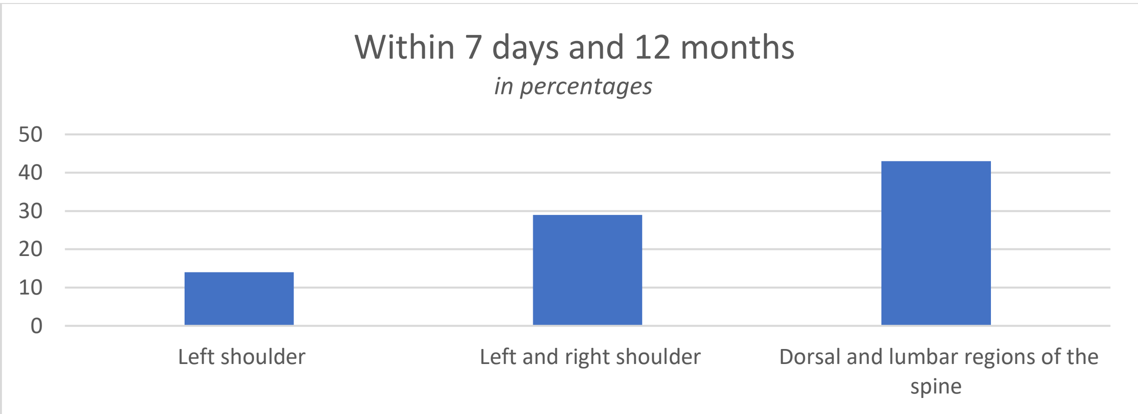

Figure 4: Result of applying the Nordic Questionnaire, within 7 days and 12 months.

Related to environmental conditions, operators stated that there is a lot of noise at the site. The noise comes from the workstation itself when the machines are running. As for the illuminance factor, everyone indicated that it is satisfactory for carrying out the activities. The lighting in this place comes from fluorescent lamps together with low natural light propagation.

Thermal comfort groups factors such as air temperature, exposure to heat, air humidity related to the physical effort performed by the worker. When asked about the thermal sensation at the workplace, everyone pointed to the high temperature as an environmental factor that generated greater discomfort. The place has a non-working fan and the air intake is close to the ceiling. The environmental data collected are presented in Table 1, with their respective regulatory standards.

Table 1: Environmental conditions in the cutting sector

Variables	Real value	Recommended value	Standard
Temperature (°C)	30,6	20-23	NR-17
Noise (dB)	78,6	85	NR-15 / NR-17
Illuminance (lux)	330	Not less than 500	NBR 5413/92
Moisture (%)	61	Not less than 40	NR-17
Average IBUTG (°C)	29.2	29.4	NHO-06

5 DISCUSSION

The results showed that the activities carried out at Tupia can generate risks to the health of workers, as they require a harmful attitude from the operator. Bringing discomfort and pain to the shoulder and trunk regions. Therefore, according to NR 17, for activities that require static or dynamic muscular overload of the neck, shoulders, back and upper and lower limbs, rest breaks must be included. The implementation of a workplace exercise program, developed and applied by a qualified professional, can bring short and long-term benefits to both workers and their productivity levels.

The implementation of workplace gymnastics promotes several benefits such as: improving social integration and organizational climate; decreased unnecessary muscle tension, increased willingness and concentration at work; assistance with disposition and concentration at work; improves muscle oxygenation and blood oxygenation; reduction in absenteeism, sick leave and the risk of accidents at work due to human error (OLIVEIRA, 2007).

Based on Dul (2004) for the manual transport of loads that have a limit of twenty-three kilograms; the load is kept close to the body to reduce tension in the muscles and consume less energy; avoid carrying loads with one hand and using transport equipment, such as carts. Carts for transporting loads, according to NR 11, must be resistant, maintained, and present their maximum load in a visible place.

The temperature observed in the cutting sector was diagnosed above the NR17 recommendation, which establishes values between 20° and 23°. In activities exposed to values above 24°C, they are subject to a drop in performance and an increase in errors. Adjustments that provide greater airflow are recommended, preferably with the installation of windows that provide natural ventilation. And exhaust fans that also provide the removal of dust suspended in the air, caused by the execution of cuts in the machines.

The noise level found was 78.6 dB and complies with the regulatory standard that recommends a limit of 85 db. It is worth highlighting the importance of properly using ear protectors to avoid possible hearing damage.

The cutting sector presented an average of 330 lx, being below the lower limit proposed by NBR 5413/92. It is recommended that the illuminance in the location be improved by enhancing the combination of natural luminosity with the implementation of bulb and tubular LED lamps that have luminous efficiency in the range of 50 to 110 lm/W. The investment is rewarded by a longer lifespan than other lamps and savings in energy consumption, which can reach 95% of the power. According to NR-17, the relative humidity of the air must not be less than 40%. Humidity of 61% was analyzed in the workplace, so the air quality is in line with recommendations.

The Globe Thermometer Wet Bulb Index represents the rate of heat exposure during work. Identifying this rate makes it possible to assess whether the environment to which the worker is exposed is thermally unhealthy or suitable for working conditions. According to NHO-06, the recommendation for the average metabolic rate of workers in the sector is an average IBUTG of 29.4 °C. Based on the real value found in the environment, 29.2°C, it is possible to conclude that there is no thermal overload at the workstation. It is recommended that control measures be taken such as increasing air speed, the use of uniforms with lighter fabrics and workers drinking 150ml of water every 20 minutes.

6 CONCLUSION

From the data it can be concluded that ergonomic intervention is necessary at the points where constraints were found in cutting activities. Therefore, the changes to be made must include: use of adequate lighting to enable the execution of activities; changes that allow for greater ventilation in the environment and the implementation of workplace gymnastics. Therefore, the results made it possible to guide the changes necessary to maintain the good health and comfort of workers. In this study, the analysis of the behavior of active operators became observable through the grouping of a succession of methodological precepts with the intention of developing an operating model.

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