Original Research Article

Evaluation of Ergonomic Risks in Workers of the Furniture Industry

ABSTRACT

This study evaluated ergonomically the workers of a furniture industry making sofa structures, located in the city of Visconde do Rio Branco,Minas Gerais State, between August 2016 and December 2016.It was evaluated a population of 66 workers, including assemblers of sofa structures and carpentry machine operators, both males. Initially, all of these were submitted to the WHOQOL-Bref (World Health Organization Quality of Life - Bref) questionnaire, which evaluates the perception of quality of life; After the kinesiological analysis of the work, observing the positions adopted and the assembly time of the structures of the sofa; The RULA method (Rapid Upper Limb Assessment), responsible for evaluate possible damage to limbs, such as the arm, forearm, wrist, neck, trunk and legs; and finally the biomechanical evaluation of static and postural forces, using 3DSSPP software (3D Static Strength Prediction Program). The resultsof WHOQOL-Bref questionnaire revealed that, in general, the perception of the sample about quality of life at work was classified as "very satisfactory" and the "physical environment" was the one with the lowest degree of satisfaction. The kinesiological and biomechanical analyzes showed that the factors most critical to the work routine are related to wrist flexion, ulnar deviation and flexion of the indicator. However, based on static and postural forces, this activity can be developed without health risks by 97% of the workers. The load on workers during the working day did not prove to be crucial for triggering musculoskeletal disorders, so most workers are able to develop their work activities without health risks.

Keywords: Assemblers; Quality of Life; Physical Environment; Postural Forces.

1. INTRODUCTION

The manufacture of furniture, especially made of wood, can be considered one of the most traditional activities of the transformation industry. The sector includes, among other things, high use of inputs of natural origin, intensive use of labor, reduced technological dynamism and high degree of informality. These factors, coupled with the ergonomic risks posed by machinery or workplaces, may compromise the health, well-being and safety of workers [1].

In general, the main risks related to ergonomics in the workplace are due to organizational aspects, such as the high production rate, inadequate postures of the worker and excessive overtime [2]. All these aspects make the worker adapt quickly to situations imposed by the workplace, supporting uncomfortable and inadequate positions throughout the work period [3].

Most of the injuries due to ergonomic risks are of the cumulative trauma type, the worker will only perceive their effects after some years exposed to a certain work situation. In this way, the importance of having the workplace adapted to the psychophysiological characteristics of the workers is emphasized, so as to provide maximum comfort, safety and efficient performance, as recommended in the Standard NR-17, which deals with ergonomics at work [4].

In the case of carpentry workers, one of the main problems faced is the handling and movement of loads, which can lead to chronic and acute problems related to the lumbar, thus affecting not only the health of the worker, but also their efficiency [3]. One way of minimizing these losses would be through a preventive intervention in work situations, involving a correct evaluation of the risks involved in the activity [5].

In this way, the ergonomic studies can base the realization of changes in the workplace, improving and adapting machines and equipment used in the execution of the tasks, according to the physical characteristics and psychological conditions of the worker, providing safety, health and comfort, reflecting in the efficiency of the work performed [4].

However, it is emphasized that ergonomic risks are not enough to verify the biomechanical and postural factors, it is also necessary to evaluate the Quality of Life (QL) of the worker, since health is defined as a state of well-being physical, mental and social, not simply the absence of illness or infirmity [6].

Given the importance of the work, this research aimed to analyze the quality of life; the ergonomic postural conditions and risk of damage to the musculoskeletal system in workers of a furniture industry.

2. MATERIAL AND METHODS

2.1 Study area and sampled population

The present study was developed in a furniture industry, located in the city of Visconde do Rio Branco, in the state of Minas Gerais, under coordinates 21º00'37" S and 42º50'26" W. The climate, according to the classification of Köppen is Cwa, characterized by dry winters and rainy summers. The average annual temperature is 24 °C.

From a pilot study of all the activities evaluated, a minimum number of data was required to provide a maximum sampling error of 5% by means of Equation 1 [7]:

$$n \geq \frac{t^2 \,.\, s^2}{\varepsilon^2}$$

At where:
n = number of workers;
t = coefficient table at 5% probability (Student distribution);
s = standard deviation of the sample;
ε = error admissible at 5% of the arithmetic mean of the data.

Data on ergonomic analysis of the work were collected in a population of 66 workers, all males, ranging in age from 19 to 56 years. The workers worked on an 8-hour day, starting at 7:30 am and ending at 5:30 pm, with an interval of 1 hour for lunch. They acted in the functions of couch structure assembler and carpentry machine operator.

All the workers involved in this study were informed about the objectives and methodology that would be used, and about the acceptance of participation. All agreed and signed the Free and Informed Consent Form, based on Resolution 466/2012 of the National Health

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The evaluations included the stages of stapling of wooden parts, which serve to assemble the structures (crate, backrest and seat arm), with the use of compressed air pneumatic staplers; and manual loading of the assembled structure, which can be taken directly to the tank or to the subsequent board.

Workers were also filmed using a high resolution camera, model GoPRO Hero 4.0, with monitoring of movements and positions in each activity performed.

2.2 Analysis performed

In order to evaluate the ergonomic risks of furniture industry activities, variables related to workers quality of life, kinesiology of movements performed and biomechanics of limbs and static and postural forces were evaluated.

2.2.1 Quality of life

The quality of life of workers was measured using the WHOQOL-Bref (World Health Organization Quality of Life - Bref) questionnaire, developed by the World Health Organization.

It is a questionnaire with 26 questions, applied in the form of an interview in the workplace. During the WHOQOL-Bref application, the data collected covered four domains: physical, psychological, social relations and the environment.

For the purpose of classification, the evaluated parameters were classified as: very unsatisfactory; unsatisfactory; neutral; satisfactory; very satisfactory [8].

2.2.2 Kinesiological analysis

Kinesiological Analysis was used to evaluate the repetitiveness of hand movement and to identify the frequency of these movements. In this approach, the filming of the individuals was analyzed, observing the typical positions adopted of each of them and the assembly time of the structure to which each of them was responsible. The movements were classified as repetitive based on observations during the work cycle.

From these observations, the Latko Scale was used to evaluate the repeatability (Table 1). It uses a series of 0 to 10 analog-visual scales that reflect the dynamic aspect of movements and the time of pauses, classifying them into three levels of activity: low, medium and high [9].

Table 1. Levels of activities on the hands according to the Latko scale

Level		Hand activities
Low	0	Inert hands most of the time; without regular effort

	1	Consistent, long pauses visible; very slow movements
Middle	4	Constant slow motion; frequent short breaks
	6	Constant movement/effort; no frequent breaks
High	8	Fast and constant movement or continuous effort; no frequent breaks
	10	Fast and constant movement or continuous effort; difficulty maintaining/conserving

[9]

2.2.3 Biomechanical assessment of limbs

The biomechanical evaluation was performed using the RULA method (Rapid Upper Limb Assessment), method, which was used to evaluate the upper and lower limbs [10]. Through this observational method, the body segments were divided into two groups, A and B. Group A consists of the upper limbs (arms, forearms and wrists). Group B is represented by the neck, trunk and legs.

For each limb, different movements and respective ranges of amplitude were studied visually, where we observed the rotations, flexions and extensions of each body segment analyzed. Joint movements were assigned progressive scores in such a way that number 1 represents movement or posture with a lower risk of injury, while higher values, maximum of 7, represent greater risks of injury to the assessed body segment (Table 2).

Table 2. Progressive scores by the RULA method

Scores	Level of action	Action (providence)
1 or 2	1	Posture acceptable if not maintained or repeated for long periods.
3 or 4	2	More research is needed and possible need for change.
5 or 6	3	Necessary investigations and changes quickly.
7 or more	4	Necessary investigations and immediate changes.

[10]

2.2.4 Biomechanical evaluation of static and postural forces

For this evaluation, the angles of the body segments were measured by means of photos and filming of postures, as well as the data of height and weight of the workers.

For the analysis in question, two postures were selected: typical and critical, defined after the evaluation of the filming performed, observing the time the worker was in each position (determination of the typical posture) and evaluation of the difficulty in performing the movement (critical posture).

The typical posture was defined as that the worker stands facing the bench with the erect body, handling the pneumatic stapler, joining pieces of wood to make a more robust structure. The critical posture was characterized by loading the already ready structure to a specific location.

From the definition of the two postures, "pieces" of the videos with the images of the postures were collected, which were submitted to the evaluation by the 3DSSPP software (3D Static Strength Prediction Program) of the University of Michigan [11]. The software evaluated the commitment of the worker's body to the force exerted on the L_5-S_1 disc of the spine, and damage to the wrists, elbows, shoulders, back, hip, knees and ankles in relation to the load the worker was carrying.

3. RESULTS AND DISCUSSION

3.1 Quality of life

Regarding the worker's perception of his quality of life and his satisfaction with health, the average response was 80%, which was classified as very satisfactory.

Considering the physical domain of the facets: "willingness to suffer" (56%), "non-dependence on medical treatments" (76%), "energy for the day" (80%), "locomotion" (70%), "sleep" (80%), "ability to perform activities" (90%) and "ability to work" (84%), the final result was classified as very satisfactory, except for the first facet that obtained a satisfactory classification.

The results of the physical domain demonstrate that, although the work requires physical effort, the activities performed were compatible with the capacity of the employees evaluated. The parameter "pain and discomfort" was considered below the ideal limit, corroborating with complaints of pain reported by workers.

In analyzing the social relations domain composed of the facets: "personal relationships" (94%), "sexual life" (84%) and "social support" (96%), it was perceived that these presented similar results, being classified as very satisfactory.

In the social relations domain, the evaluated parameters were classified as very satisfactory. From this, it can be seen that workers present a healthy relationship and good interpersonal practices. Other authors reported a similar result, where they observed the behavior of workers in the timber sector, emphasizing that harmonious coexistence keeps the team motivated, generating, consequently, an increase in the quality of the service [12].

The psychological domain was composed of the following facets: "taking advantage of his life" (80%), "personal beliefs" (86%), "concentration" (84%), "acceptance of physical appearance" (86%), "self-confidence" (76%) and "absence of negative feelings" (64%). In this, the last facet obtained a lower score, being classified as satisfactory, while the others were classified as very satisfactory.

Regarding the psychological domain, the parameter evaluated as satisfactory raises concern, since this may be an indication of a greater propensity of the workers to develop secondary pathologies, such as depression, anxiety and distress, if they are affected by some occupational disease [13].

Finally, the environmental domain covered the facets: "security of their attitudes" (84%), "physical environment" (66%), "financial resources" (90%), "opportunity for new information", "Leisure activities" (96%), "housing conditions" (94%), "access to health services" (76%) and "transportation" (74%). It was observed that the "physical environment" facet obtained a lower score and was classified as satisfactory. The other facets were classified as very satisfactory.

For the environment domain, it was observed that the parameter "physical environment" presented the lowest score within this domain. This index is related to the unhealthy conditions of workplaces mentioned by workers, such as thermal discomfort and noise levels. When it comes to loud noise, these tend to impair mental concentration in performing certain tasks that require attention, speed or precision of movement [4].

The average index of the evaluated domains [8] presented a very satisfactory classification, with the exception of the "willingness to suffer", "absence of negative feelings" and "physical environment" facets that were classified as satisfactory only.

3.2 Kinesiological analysis

It was observed in this analysis that the employees produce, on average, 266 pieces per day, in the average time of 136 seconds for assembly of the structure. According to the observations made locally, the movements classified as repetitive were palmar prehension, flexion of the index finger, ulnar deviation of the right wrist and flexion of the right wrist, all of which were performed during the work of fabricating structures sofas (Figure 1).

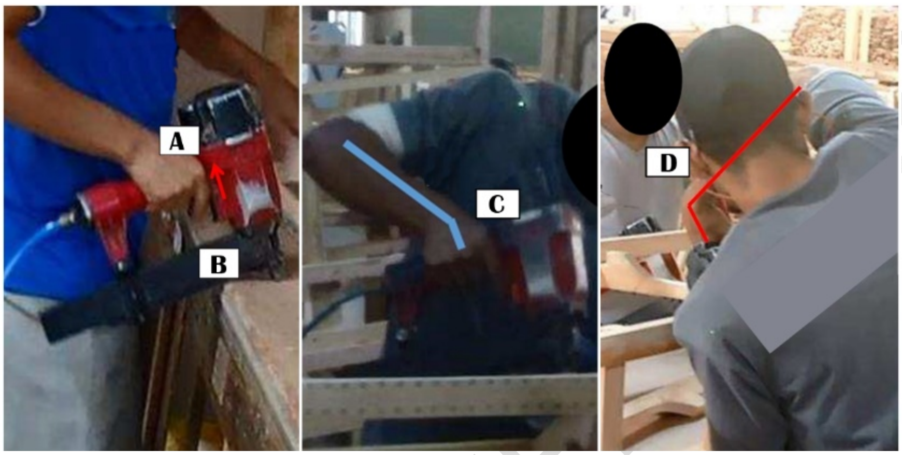

Fig. 1. Palmar prehension (A); flexion of the index finger (B); ulnar deviation of the right wrist (C); flexion of the right wrist (D).

The activities mentioned above were classified as level 8 (considered high level) because they require the workers to move quickly and constantly over time, generating continuous effort and with uncommon pauses. This classification was made following the scale proposed by Latko [9].

Based on the values obtained from the production of each worker per day, it is evident the repetitiveness to which the workers are exposed due to the quantity of wood structures made in a day of work. From the kinesiological point of view, the critical work stage was the staple phase of the wood pieces, where the worker was submitted to critical positions, flexing and extending mainly the wrist, reaching maximum amplitudes of the movement during the making of the structure because to the use of the pneumatic stapler.

From the observations by image, the movements classified as repetitive were obtained. Among these, palmar prehension is defined as the prehension of the palm of the crowded hand that is exerted to hold voluminous objects [14]. This movement causes intense superficial muscular activity that, from a continuous flexion of the wrist, generate points of tension in the muscles and nerves that could result in osteomuscular disorders [15].

The second classified movement was the flexion of the index finger, which is associated with palmar prehension. This is characterized by the approximation of the thumb and forefinger and if performed in a prolonged and repetitive manner may result in the occupational lesion called stenosing tenosynovitis, characterized by the formation of nodules in the flexor tendons of the fingers [14,15].

Another movement classified as repetitive was the ulnar deviation of the right wrist, characterized by the deviation of the nerve that covers the ulna bone [16]. This movement is considered as a risk factor for the development of musculoskeletal injuries related to work on the hands and wrists, which may result in inflammations of the tendons of the forearm muscles in the wrist region [17].

The last classified movement was the right wrist flexion. In this movement the operator flexes the wrist by manipulating the stapler in the assembly of the furniture structures. This occurs in the radiocarpal joint and its repeated execution may result in musculoskeletal dysfunctions, such as lateral epicondylitis [16, 18]. According to the Latko scale, worker hands activity was classified as level 8, indicating that the results predispose workers to a very significant risk of developing Repetitive Strain Injuries and Work Related Musculoskeletal Disorders. Not being repeatability the only risk factor, but it is the main one in the origin of the disturbances of the superior members [19].

3.3 Biomechanical assessment of limbs

In the biomechanical evaluation of the limbs (RULA method), the postures and amplitudes of the limbs of the workers were analyzed according to the groups in which they were subdivided and the description of each one was obtained (Table 3). From this, it was identified the movement that each member realized, its amplitude and the weight of the load.

Table 3. Description of the movements by the RULA method

Groups	Limbs	Moviment	Amplitude	Weight of the load
A	Arm	Flexion and Extension	45 to 90º	20 to 100 N
		Abduction	-	
	Forearm	Flexion and Extension	60 to 100º	
		It crosses the sagittal plane or performs operations outside the trunk	-	
	Wrist	Flexion and Extension	-15 and +15º	
		Neutral line deviation	-	
		Extreme rotation	-	
B	Neck	Flexion and Extension	> 20º	> 100 N
		Rotation	-	
		Lateral inclination	-	
	Trunk	Flexion and Extension	20 to 60º	
		Rotation	-	
		Lateral inclination	-	
	Legs	Well supported and balanced legs and feet	-	

Based on these results, we can identify that the postures adopted mainly for flexion and extension of the arm, forearm, wrist, neck and trunk are inadequate for the activity, based on the amplitude adopted. Thus, for these members, a score of 7 was adopted, which is equivalent to a level of action 4, indicating changes to the job immediately.

The limb postures are a major cause of productivity deficit problems and increased risk of injury. Incorrect postures can be corrected through modifications to the work method and specific trainings for the purpose of adopting safer, healthier and more comfortable postures. The results obtained regarding the posture of the limbs corroborate with those of the kinesiological analysis, indicating the wrist and forearm as areas prone to repetitive strain injuries.

When the worker adopts a forced posture for prolonged periods, there is an imminent risk of a mechanical overload, which can trigger pain and imbalances of force, thus putting at risk his or her physical integrity [20].

Other functions that require repetitive bending movements associated with trunk rotation and static and asymmetrical work postures, are important risk factors for joint and spine injuries. Certain movements of trunk flexion in large amplitudes may constitute a risk factor for the worker's spine [21].

3.4 Biomechanical evaluation of static and postural forces

The biomechanical analysis was obtained based on photographs angles of postures considered more typical (93% of the work time spent in this posture) and the most critical (7% of the working time in this posture), for the structure assembly function of sofa. The results of the analysis were provided by the 3DSSPP software (Table 4).

Table 4. Biomechanical evaluation for workers in a furniture industry

Posture	Graphic representation	Time in posture (%)	Compression force on disk L_5-S_1 (N)	Articulation	Able percentile in articulation (%)
Typical		93%	1.504 (SRL)	Wrist	99
				Elbow	99
				Shoulder	99
				Trunk	98
				Coxofemoral	96
				knee	98
				Ankle	96
Critical		7%	2.366 (SRL)	Wrist	97
				Elbow	99
				Shoulder	99
				Trunk	92
				Coxofemoral	84
				knee	74
				Ankle	66

In the typical posture of the operator the compression force on the L_5-S_1 lumbar disc was 1.504 N, and in the critical posture was 2.366 N. For the articulations of the critical posture, significant risks of injury to the ankles were verified, being these the ones more overloaded. Identifying then that 34% of adults and healthy people are not able to perform this task without risk of ankle injuries.

The compression force at the L_5-S_1 lumbar disc for the typical and critical postures presented values that did not exceed the limit load of 3.426 N recommended by the University of Michigan [11]. This result indicates that in these conditions the postures adopted did not impose risks of injury to the workers' spine. This result is due to the low weight of the load handled, mainly for the typical posture in which they are wielded of a stapler weighing 3.0 kg.

Regarding the critical posture joints, the values found indicated a significant risk of injury to the ankles of the operators. This result may be related to trunk inclination and stretched arms repeatedly, where the center of gravity is moved out of the body. Thus, it requires more strength of the support members, mainly affecting the ankles, which provide support base for the entire body of the worker [21].

4. CONCLUSION

Overall, workers were very satisfied with the quality of life at work. However, the "work environment" was the parameter with the lowest level of satisfaction, with the greatest complaints related to thermal overload and excessive noise, which directly affect the willingness to work and compromise the physical and psychological aspects of the work environment.

The kinesiological evaluation indicated the stapling of wood pieces as a critical activity of the function, where four movements considered as repetitive were observed that, if executed continuously, can result in occupational diseases.

Both the kinesiological evaluation and the biomechanics of the limbs indicated that the wrist is extremely affected by the posture adopted, however based on static and postural forces, this activity can be developed without health risks by 97% of the workers.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

ETHICAL APPROVAL

All authors hereby declare that all experiments have been examined and approved by the appropriate ethics committee **(Human Research Ethics Committee of the integrated Federal University of Viçosa)** and have therefore been performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki.

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