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ERGONOMIC ANALYSIS OF THE ACTIVITY OF A STOCK PREPARATION ASSISTANT IN A PAPER INDUSTRY

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Abstract

The paper industry generates a significant number of jobs within the manufacturing sector, but there are few national reports that analyze the ergonomics of workplaces in this type of industry in Brazil. The objective of this study is to analyze the postures of the pulp preparation assistant in a paper industry and propose improvements in the postural and ergonomic aspects of the workplace. This is a field study, in which the workers were observed without any interference. The Ergolândia software was used for the postural analysis, with the RULA (Rapid Upper Limb Assessment) and OWAS (Ovako Working Posture Analyzing System) methods. The results show a risk of developing musculoskeletal disorders for most of the activities performed by the pulp preparation assistant. Finally, training is suggested to improve postures at the workplace, so that the establishment provides better working conditions, respects the worker's psychobiophysiological characteristics, together with the worker's awareness of breaking up bales of shavings into smaller pieces and the use of mechanized systems for lifting and transporting loads, especially in activities involving cellulose bags.

Keywords: Ergonomics; Paper mill; RULA; OWAS.

1. Introduction

The pulp and paper manufacturing sector in Brazil has an important scale in the generation of income and jobs, but due to the lack of industrialization and mechanization of some activities in this sector, some workers are exposed to occupational safety risks, resulting from the lack of availability of resources for appropriate equipment and the adequacy of jobs within the work environment.

From July 2018 to June 2019, the National Institute of Social Security recorded more than 475,000 reports of occupational accidents – CAT. Of these, 1,074 occurred in paper mills throughout Brazil (Brasil, 2019). It is noted that in most cases the absence from work is related to musculoskeletal diseases (BD), resulting from biomechanical overloads and that could be

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avoided with the insertion of ergonomic solutions in the work environment and employee awareness.

ME injuries affect thousands of workers every year. These diseases are known by the acronyms LTC (consecutive trauma injuries) or RSI (repetitive strain injuries), and affect the muscles, bones, ligaments, menisci, joint capsules, axial skeleton, spine, and upper and lower limbs; which manifest as tendinitis, tenosynovitis, nerve compressions, and lumbar disorders (Iida & Guimarães, 2018).

According to Kroemer and Grandjean (2007), older workers are more likely to have persistent musculoskeletal problems, which are those that do not disappear even after work has been interrupted. These are inflammatory and degenerative processes in overloaded tissues that, if they last for many years, can lead to chronic inflammation and even deformation of the joints (Kroemer & Grandjean, 2007).

In their study of upper extremity musculoskeletal disorders in a pulp and paper mill, Silverstein and Hughes (1996) describe that 41% of respondents suffer from arthritis, 15% from tendinitis and 5% from carpal tunnel syndrome. The research also indicates that in the paper production sector, the parts of the upper extremity most affected are: the shoulders, hands and wrists, the carpal tunnel, the neck and the elbow.

Fassa, Facchini and Dall'Agnol (1996) point out that, although in developed countries many studies are produced on morbidities occurring in the pulp and paper sector, there are few publications on the subject in Brazil. The authors demonstrate in their article the most typical morbidities in the sector, among the main ones are nervousness, back pain and eye problems, with the most affected being the administrative, maintenance and production sectors. The study by Machado and Nascimento (2013), in an industry in the paper sector, suggests that it is necessary to evaluate several jobs for the application of an ergonomics program. As exposed by Nepomuceno, Alvarez, Araujo and Figueiredo (2017, p. 77) "Many experiences in Brazil and in other countries are not yet recorded, and can bring significant contributions to this debate."

Based on the above, aiming to contribute to ergonomic studies in pulp and paper mills, this study aims to analyze the postures of the activities performed by the dough preparation assistant in a paper industry located in the state of Santa Catarina, and, sequentially, to propose improvements in the postural and ergonomic aspects of the workplace, using renowned techniques for ergonomic and methodological assessments, such as RULA (Rapid Upper Limb Assessment) and OWAS (Ovako Working Posture Analysing System).

2. THEORETICAL REVIEW

Ergonomics studies the relationships of human beings with other elements of the system in which they are inserted, aiming to improve human well-being and performance (IEA, 2019). This science is focused on the work environment, with the aim of providing improvements in production efficiency, and, over time, it has extended to the areas of safety, health and comfort in the various activities performed by man.

Also according to the International Ergonomics Association (2019), there are three main specialties within the study of this science, namely: physical ergonomics; cognitive ergonomics; and organizational ergonomics. In line with the objective of this study is physical ergonomics, which according to the Brazilian Association of Ergonomics (2019):

> It is related to the characteristics of human anatomy, anthropometry, physiology and biomechanics in their relation to physical activity. Relevant topics include the study of posture at work, material handling, repetitive movements, work-related musculoskeletal disorders, workplace design, safety and health.

Aiming at ergonomic aspects to ensure the health and physical integrity of workers, Regulatory Standard No. 12 – Occupational Safety in Machinery and Equipment (Brasil, 2019) establishes minimum requirements for the prevention of accidents and occupational diseases in the design and use phases of machinery and equipment of all types.

It is of great importance to emphasize that, in order to ensure ergonomics for the worker, the dimensions of the workstations must meet the anthropometric and biomechanical characteristics, as well as ensure adequate and comfortable posture and avoid bending and twisting of the operator's trunk during the execution of their tasks, as provided for in Regulatory Standard No. 12 (Brasil, 2018), before its last revision in 2019.

The analysis of workstations is of great importance to the study of biomechanical principles, which estimates the tensions that occur in muscles and joints, from the application of the physical laws of mechanics to the human body. Among the concepts of biomechanics, the most relevant for the study of ergonomics, injury prevention and performance improvement are: keeping the joints in a neutral position; keep weights close to the body; avoid bending forward; avoid torso twists; avoid sudden movements that cause voltage peaks; alternate postures and movements; restrict the duration of continuous muscle effort; prevent muscle exhaustion; and taking short, frequent breaks (Dul & Weerdmeester, 2012).

Ergonomics uses several techniques to assess postures at work, including the RULA (Rapid Uper-Limb Assessment) method and the OWAS (Ovako Working Posture Analysing System).

RULA was developed by McAtamney and Corlett (1993) as a screening tool for adult risk factors for work-related upper limb disorders. RULA takes into account the repetitive work and the force that may be required to accomplish a task. This method uses illustrations with different body postures. A numerical score is assigned for the most common conduct observed. In this method, the body is divided into 2 groups: Group A, which evaluates upper limbs (arm, forearm and hand); and Group B, which evaluates the body (neck, trunk and legs). Scores for static muscle and strength are also added, which are combined in a table to obtain the final score. The data resulting from the table are used to measure the level of action that indicates the intervention necessary for the posture observed, as can be seen in Table 1.

Table 1. RULA scores, action levels, and indications

Final score	Action level	Indications
1 or 2	1	The posture is acceptable, if not permanent.
3 or 4	2	Medium-term research is needed.
5 or 6	3	It is necessary to investigate and take action in the short term.
7 or higher	4	It is necessary to investigate and take immediate action.

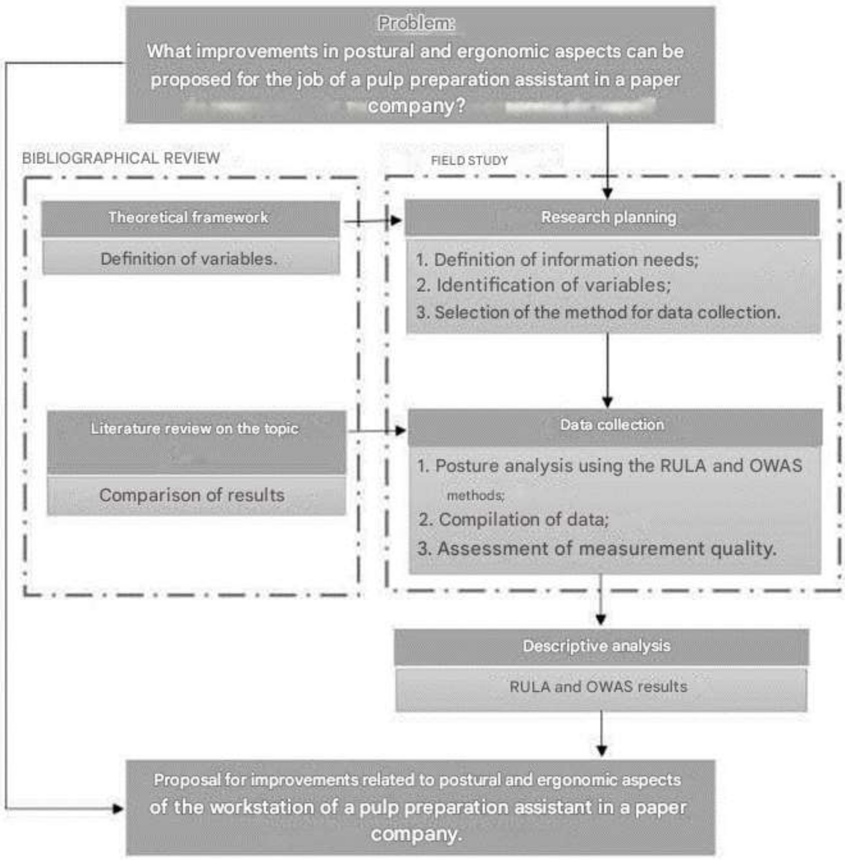
Source: Adapted from McAtamney and Nigel Corlett (1993)

The OWAS method was developed by three Finnish researchers working at a steel company. From the search for improvements in the place where they worked, they began the photographic survey for the analysis of the main postures found in heavy work industries. They resulted in 72 typical postures from the combinations of back, arms, legs, and the load supported or in the use of force (Iida & Guimarães, 2018).

3. Methodology

The classification of the study in terms of its nature is a qualitative research, as it aims to analyze the particularities of the postural and ergonomic aspects of the job of dough preparer's assistant in a paper company. In order to perform the Ergonomic Work Analysis, the study went through several stages that are illustrated in Figure 1.

Figure 1 – Methodological stages of the study



Source: The authors (2019)

To answer the research problem, the theoretical framework was started so that it would be possible to plan the research, foreseeing: the definition of information needs, the identification of variables that would have an impact on the processes carried out in the field and the definition of the selection of the method for data collection.

Then, data collection was carried out, with the analysis of postures using the RULA and OWAS methods, compiling the data and evaluating the quality of the measurement, for this purpose the parallel was made again with the literature review on the subject to compare the results.

In the last stage, a descriptive analysis of the results obtained by the RULA and OWAS methods was elaborated, and proposals for improvements related to the postural and ergonomic aspects of the analyzed workstation were made.

Therefore, it can be classified as exploratory in its stages of bibliographic review, which aims at familiarization with the content and expansion of knowledge. Having understood the subject, it was possible to define the problems of the research more clearly and structure it.

The data are predominantly descriptive. It is a material with descriptions of the company, with the activities performed in the workplaces, the characteristics of the workers and other variables relevant to the study. For this purpose, the methods of field study and case study were used.

3.1. Variables relevant to the study

It was found relevant for the research the survey of the data described with the bibliographic research.

The factory involved in the study is located in the southern region of Brazil, and produces about 20 tons of paper per day, operating 24 hours a day, in 3 shifts. Among its main products are: toilet paper rolls, napkins, paper towels and hospital sheets.

The existing processes in the industry consist of: receiving shavings and pulp; dough preparation; dough refining; paper production; reel formatting; and product shipment. Of these, the analyzed workstation is inserted in the dough preparation process.

The job of the dough preparation assistant consists of disposing of the raw materials, bale of shavings or bag of cellulose, which will feed the hydrapulper[1].

For the disposal of bales of shavings, the activities have the following sequence:

1. Receive the bales of shavings on a table;
2. Fractionate and weigh the shavings;
3. Fill the conveyor belt that feeds the hydrapulper.

For pulp bags, the sequence of activities is:

1. Receive the bag on the scale and weigh it;
2. Proceed to open the bag so that the pulp is poured onto the conveyor belt;
3. Fill the conveyor belt that feeds the hydrapulper, distributing the cellulose in it.

The postures at the workstation of dough preparation assistants of 4 employees, with a daily load of 8 hours (with 1 hour break in the middle of the shift for rest), were analyzed. All employees in this position are men of average height.

[1] Equipment that works on the same principle as a blender and is capable of separating and disaggregating all the fibers of the paper. Together with the addition of water, it transforms the paper into a homogeneous pulp.

3.2. Data collection

Data collection occurred by observing the activities performed by the workers at their workstations. The observations lasted 12 days, with 3 days of follow-up for each of the four employees, from different shifts.

The receipt of both bales of shavings (Figure 2a) and bags of cellulose (Figure 2b) were observed. It was noted that there are differences in the attitudes of the workers when receiving these two raw materials, since the block of shavings is fractionated by the employee to supply the conveyor belt that feeds the hydrapulper, while the receipt of the bags, which weigh from half to one ton, occurs with a forklift, and the assistant needs to cut the bag so that the pulp is dumped directly on the conveyor belt.

Figure 2 – Bale of shavings (a) and *bag* of pulp (b)

(a)

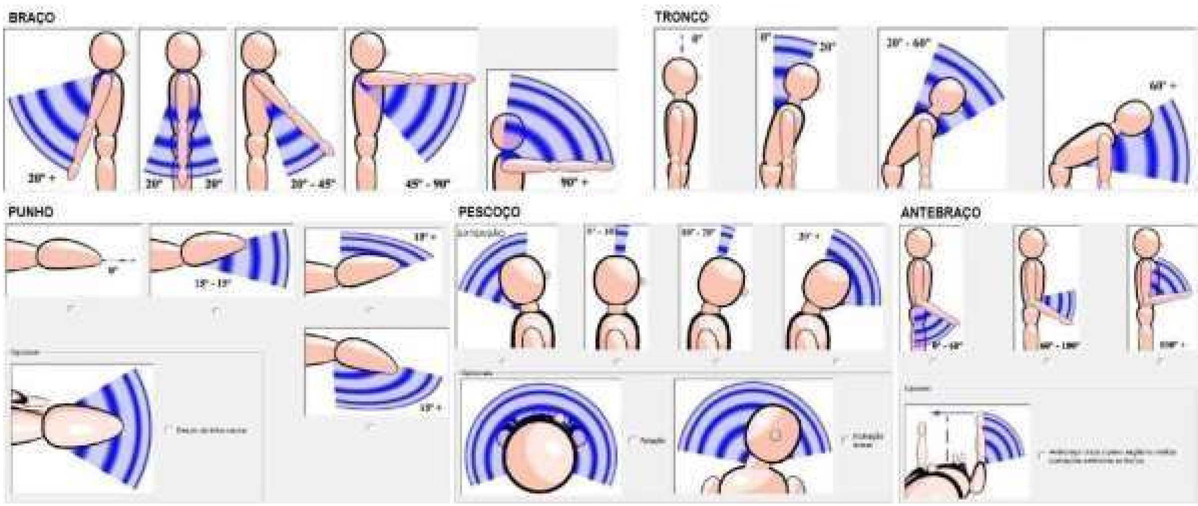
(b)

Source: The authors (2019)

Therefore, observations and analyses were carried out for the two distinct situations, in view of the differences in posture and load loading by the employees in both.

Upon observing the workers, ergonomic posture analyses were performed using the Ergolândia software, which provides several methods of ergonomic analysis, including: RULA (Rapid Uper-Limb Assessment) and OWAS (Ovako Working Posture Analysing System). The methods were used in a complementary way, since the RULA (Figure 3) presents a complete analysis of the upper limbs and the OWAS method (Figure 4) makes it an accurate analysis of the lower limbs.

Figure 3 – Selection options in RULA



Source: Adapted from FBF Sistemas - Egolândia (2019)

Figure 4 – Selection options in OWAS

Source: Adapted from FBF Sistemas - Ergolândia (2019)

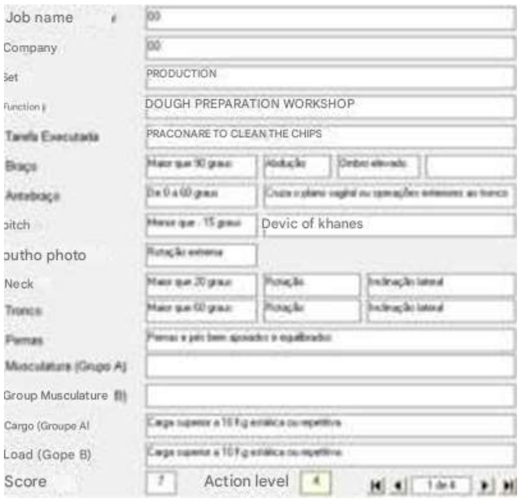
4. Results and Discussion

As reported in the methods, the analyses occurred for two situations in this workstation: for the raw material of shavings bales and for pulp bags.

4.1. Analysis of Raw Material of Chip Bales

The transport of the bale of shavings, which weighs between 1,000 and 1,200 kg, to the receiving table is carried out with the help of a forklift. The employee's activities at this stage are only to assist the forklift operator with marking instructions, and there is no direct interaction with the product or activity that requires effort, so this activity was discarded from the analysis. After receiving the bale on the table, the employee fractionates it, separating it with his hands, to later position the portions on the conveyor belt that feeds the hydrapulper.

Figure 5 – Results of the ergonomic analyses (a) RULA and (b) OWAS for the fractionation and weighing of the chips



(a)

(b)

Source: The authors (2019)

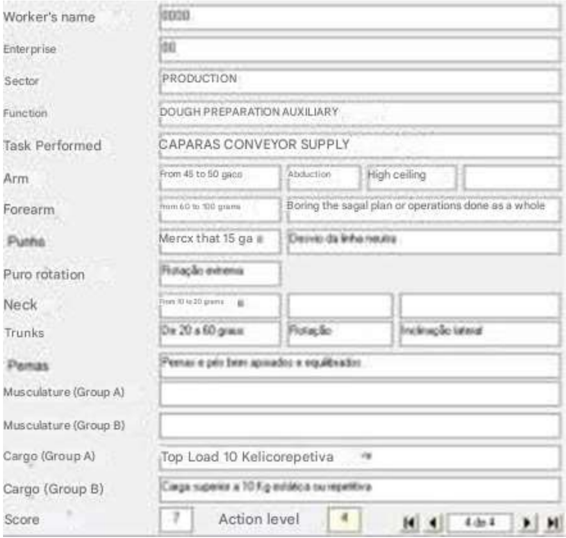
Figure 5 shows the posture analysis of the dough preparation assistant during the fractionation and weighing of the shavings.

In both analyses (RULA and OWAS) the score obtained suggests a very high risk, and it is necessary to investigate and take immediate action.

Figure 6 shows the ergonomic analyses of the workstation when filling the conveyor belt that feeds the hydrapulper with the chip fractions.

Figure 6 – Results of the ergonomic analyses (a) RULA and (b) OWAS for the belt filling stage with chips

(a) (b)



Source: The authors (2019)

Again, the scores obtained through the application of the RULA and OWAS methods suggest a very high risk for the occurrence of musculoskeletal disorders, and it is necessary to investigate and take immediate action.

4.2. Analysis with raw material of bales of pulp bags

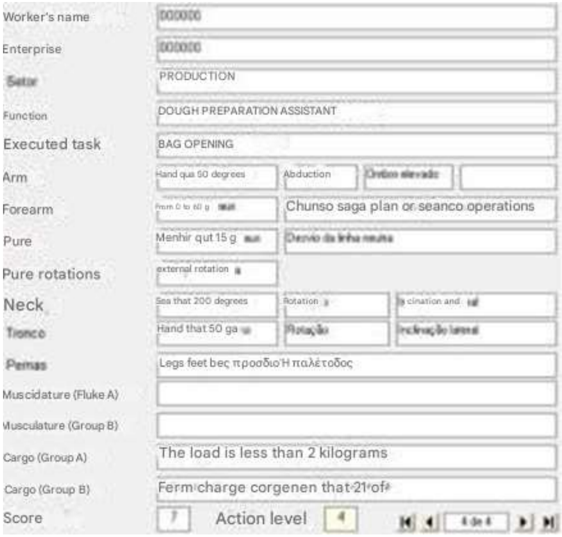
The movement of the pulp bag from the stock to the weighing scale is carried out with a forklift. The employee assists the forklift operator with instructions on how to mark the bag to the scale, requiring no muscle effort at this stage. Once weighed, the bag is again suspended by the forklift operator so that the assistant can open it with a knife, allowing the pulp to fall on the conveyor. After the pulp falls on the conveyor, the dough preparation assistant mirrors it so as not to overload it with a hoe or with his hands.

The results of both the RULA and OWAS methods suggest that immediate measures should be investigated and taken in view of the very high risk of musculoskeletal disorders occurring in workers.

Figure 7 shows the results of the analysis of the bag opening performed by the assistant.

Figure 7 – Results of the ergonomic analyses (a) RULA and (b) OWAS for the bag opening stage

(a) (b)

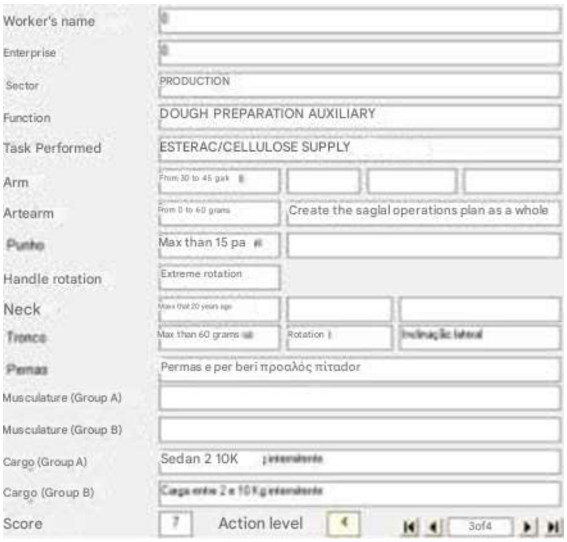


Source: The authors (2019)

Figure 8 shows the analyses and results of the conveyor belt filling with pulp after opening the bag.

Figure 8 – Results of the ergonomic analyses (a) RULA and (b) OWAS for the conveyor belt filling stage with pulp

(a) (b)



Source: The authors (2019)

For this stage, the results also indicate a very high risk of the worker developing musculoskeletal disorders while performing this activity. It is suggested that investigations be carried out and that immediate measures be taken.

4.3. Discussion of the results

Ergonomics aims at the adaptation of work to man with its strategies and methodologies, it can contribute to reducing the psychophysiological overloads present in many work situations (Rothstein, Berndt, Moraes & Lanferdini, 2013; Carvalho, Souza, Tinôco, Vieira & Minette, 2011)

The worker needs to have adequate leisure and sleep conditions to recover and face the day to day. It is necessary to have good working conditions to continue efficiency during the day, and it is necessary to have adequate levels of noise, lighting, weather conditions, ergonomics in the equipment, among other factors to face the activities more efficiently or with less wear and tear that accumulates throughout the day.

According to Batiz, Galo and Souza (2006), posture is the position that the individual adopts to perform daily functions, it can be static or dynamic, using the musculoskeletal system for activities at the workplace, and that alternating the sitting and standing position is the most suitable way to keep the body healthy.

An important factor to predict musculoskeletal disorders is to maintain the correct posture in daily activities, establishing appropriate measures, adapting the heights of equipment and processes to the psychophysiological characteristics of the factory employees and with adequate postural education.

If the machines that the worker uses for the development of an activity are adequate, but he does not have the correct postural education, the results will not be satisfactory. It is necessary to combine both factors for the benefit of the employee's health.

According to Silva (2019, p.74):

> It is necessary to work on behavioral management, on creating conscious habits of behavior at each of the levels, in order to facilitate the understanding of the need to establish Ergonomics as a science that helps to understand the behavior of the human body in the face of the conditions in which it is involved.

The activities performed by these employees who work directly in the handling of materials for the production of paper through bags, sometimes involve the use of physical efforts generated by the body levers of the different body segments. These actions demand productivity, and sometimes employees act at a fast pace and perform in unfavorable body positions. It is necessary to promote comfortable adaptation to be productive within the work environment.

Manual lifting of loads always represents a great ergonomic challenge, especially when analyzing morbidity data in relation to occupational health. They must understand a mode of action that provides maximum safety, without compromising the health of the individual. Manual cargo transport is understood as any transport in which the weight of the load is borne entirely by a single worker, including the lifting and unloading of the load (Ormelez & Ulbricht, 2010; Caetano, Cruz, Silva & Leite, 2012).

The work functions of these employees that are related to lifting, transporting and deposition loads must always comply with the rules that define the conditions, infrastructure and appropriate equipment for this type of work, and it is necessary that the employer and the worker are aware of the regulatory standards in force. For the manual transport of loads, it is important to pay close attention to safety rules, such as the maximum weight for manual transport of loads.

The Consolidation of Labor Laws (CLT) established 60 kilos as the maximum weight that a worker can remove individually. It is forbidden for women and young people under 18 years of age to be assigned to services that require muscle strength in continuous work greater than 20 kilos, or 25 kilos for functions that occasionally require the manual transport of loads.

The conditions of the factory workers analyzed with the RULA and OWAS methods are not ergonomic, and the result suggests a reduction in the weight handled, which can be achieved by dividing the raw material into smaller portions, so that the weight increase is considered acceptable, respecting the maximum limit for manual and individual cargo transport.

Biomechanical factors such as heavy lifting, maintenance of improper postures and inadequate grip throughout the workday, significantly increase the ergonomic risk and consequently the appearance of painful symptoms and the decrease in functional capacity (Batiz et al., 2013; Barbosa, Assunção & Araújo, 2012).

The results found in this study corroborate the need for orientation of employees, as they make inappropriate movements that put their physical integrity at risk at the time of activities. Negative results in the context of the workday are a consequence of repeated inadequate gestural and postural performance.

The working conditions present in the daily life of the factory demonstrate the difficulties of handling loads without many alternatives to facilitate the tasks. Some suggestions in this regard would be the use of ergonomic solutions, such as better adaptation of biomechanical variables, rationalization of the frequency and intensity of actions and time, enabling the reduction of ergonomic risk (Carvalho et al., 2011; Ormelez & Ulbricht, 2010).

After the analyses, this study suggests that the worker should be instructed to handle the raw material in smaller fractions (up to 20 kg). Other suggestions are: the division of loads between two or more workers; keeping the load close to the body; avoid trunk rotations; lifting objects with the spine upright and bending the knees; explore the use of auxiliary devices such as forklifts, which is already widely used; the exploration of physiological alternatives such as recovery with breaks and rotation of functions (Ramos, Siqueira & Aita, 2011; Leme, Papini, Vieira & Luchini, 2014).

5. Final considerations

The results and analyses show that a good part of the activities performed by the dough preparation assistant require investigations and immediate measures because they demonstrate a very high risk for musculoskeletal disorders.

In their study, Pinto and Casarin (2019, p. 108) argue that "The entire scope of Quality of Life at Work, combined with the role of ergonomics in organizations, portrays the importance of inserting health practices within the work environment." From this point of view, the following suggestions were made with a view to improving the quality of life at work for the position analyzed:

- Postural training;
- Training and awareness for the assistant to perform the partitioning of smaller fractions of the bale of shavings, so that the amount of kilos reduces during the action;
- Use mechanized systems for lifting and transporting loads;
- Establish working conditions that respect the psycho-biophysiological characteristics of the worker;

Like other studies (Fassa et al., 1996; Nepomuceno et al., 2017; Machado & Nascimento, 2013) have already found that studies that present analyses of ergonomics in the workplace need to be reported more frequently, suggesting reviews where risks to the worker are found. Especially those related to the pulp and paper industries, which have little national publication, so that they can contribute progressively to the ergonomic quality of work.

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