



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

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ABSTRACT

Paper mill industries generate a significant number of jobs within the manufacturing sector, but few national reports analyze the ergonomics of jobs in this type of industry in Brazil. The aim of this study is to analyze the postures of the mass preparation assistant position in a paper mill and to propose improvements in the postural and ergonomic aspects of the job. This is a field study in which workers were observed without any interference. For the postural analysis, the Ergolândia software was used, using the Rapid Upper Limb Assessment (RULA) and Ovako Working Posture Analysis System (OWAS) methods. The results show a high risk to develop musculoskeletal disorders for most of the activities performed by the mass preparation assistant. Finally, training to improve posture in the workplace is suggested, also the establishment of working conditions respecting the worker's psychobiophysiological characteristics, together with the workers' awareness of fractioning the bales of shredded paper into smaller pieces, and finally the use of mechanized lifting systems and cargo transportation, especially in activities involving cellulose bags.

KEYWORDS: Ergonomics; Paper mill; RULA; OWAS.

1. Introduction

The manufacturing sector of the paper and cellulose industry in Brazil plays a significant role in generating income and employment. However, due to the lack of industrialization and mechanization of certain activities in this sector, some workers are exposed to occupational safety risks. These risks arise from the unavailability of resources for appropriate equipment and the inadequacy of workstations within the working environment.

From July 2018 to June 2019, the National Institute of Social Security recorded over 475,000 work accident reports (CAT). Of these, 1,074 occurred in paper factories throughout Brazil (Brazil, 2019). It is noteworthy that, in most cases, work absences are related to musculoskeletal disorders (MSDs) resulting from biomechanical overloads, which could be prevented with the implementation of ergonomic solutions in the workplace and employee awareness.

MSDs affect thousands of workers every year, known by acronyms such as CTDs (cumulative trauma disorders) or RSI (repetitive strain injuries), affecting muscles, bones, ligaments, menisci, joint capsules, the axial skeleton, vertebral column, and upper and lower limbs. These manifest as tendonitis, tenosynovitis, nerve compressions, and lumbar disorders (Iida & Guimarães, 2018).

According to Kroemer and Grandjean (2007), older workers are more prone to persistent musculoskeletal problems, which are those that do not disappear even after work has been discontinued. These are inflammatory and degenerative processes in overloaded tissues that, if prolonged for many years, can lead to chronic inflammation and joint deformity (Kroemer & Grandjean, 2007).

In their study on 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 most affected parts of the upper extremity are the shoulders, hands and wrists, carpal tunnel, neck, and elbow.

Fassa, Facchini, and Dall'Agnol (1996) point out that, although many studies on morbidities in the paper and cellulose sector are conducted in developed countries, there are few publications on the subject in Brazil. The authors demonstrate in their article the most typical morbidities in the sector, including nervousness, back pain, and eye problems, with the most affected being the administrative, maintenance, and production sectors. Machado and Nascimento's study (2013) in a paper industry suggests the need for evaluating various workstations for the implementation of an ergonomics program. As stated by Nepomuceno, Alvarez, Araujo, and Figueiredo (2017, p. 77), "Many experiences in Brazil and other countries are not yet documented and can bring significant contributions to this debate."

Based on the above, aiming to contribute to ergonomic studies in paper and cellulose factories, this study aims to analyze the postures of activities performed by dough preparation assistants in a paper industry located in the state of Santa Catarina. Subsequently, it proposes improvements in the postural and ergonomic aspects of the workstation, using established ergonomic and methodological techniques such as RULA (Rapid Upper Limb Assessment) and OWAS (Ovako Working Posture Analyzing System).

2. Literature Review

Ergonomics studies the relationships between human beings and other elements within the system in which they are involved. Its objective is to improve human well-being and performance (IEA, 2019). This science initially focused on the work environment, aiming to provide improvements in productive efficiency. Over time, it expanded to encompass areas such as safety, health, and comfort in various human activities.

According to the International Ergonomics Association (IEA, 2019), there are three main specialties within the study of this science: physical ergonomics, cognitive ergonomics, and organizational ergonomics. Aligned with the objective of this study is physical ergonomics, which, according to the Brazilian Ergonomics Association (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, workstation design, safety, and health.

In order to ensure the health and physical integrity of workers, Regulatory Standard No. 12 - Occupational Safety in Machinery and Equipment (Brazil, 2019) establishes minimum requirements for the prevention of accidents and occupational diseases in the design and use phases of all types of machinery and equipment.

It is crucial to emphasize that, to ensure ergonomics for the worker, the dimensions of workstations must meet anthropometric and biomechanical characteristics. They should also ensure proper and comfortable posture, avoiding flexion and torsion of the operator's trunk during the execution of tasks, as stipulated by Regulatory Standard No. 12 (Brazil, 2018), before its last revision in 2019.

The analysis of workstations is of great importance in the study of biomechanical principles, estimating the tensions that occur in muscles and joints by applying the physical laws of mechanics to the human body. Among the biomechanical concepts most relevant to the study of ergonomics, injury prevention, and performance improvement are: maintaining joints in a neutral position; keeping weights close to the body; avoiding leaning forward; avoiding trunk twists; avoiding sudden movements that cause tension peaks; alternating postures and movements; restricting the duration of continuous muscle effort; preventing muscle exhaustion; and taking short and frequent breaks (Dul & Weerdmeester, 2012).

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

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

Table 1. Scores, Action Levels, and Indications of the RULA Method

Final score	Action level	Indications
1 or 2	1	The posture is acceptable, if not permanent.
3 or 4	2	Medium-term investigations are necessary.
5 or 6	3	Investigation and necessary actions are required in the short term..
7 or higher	4	Investigation and immediate actions are required.

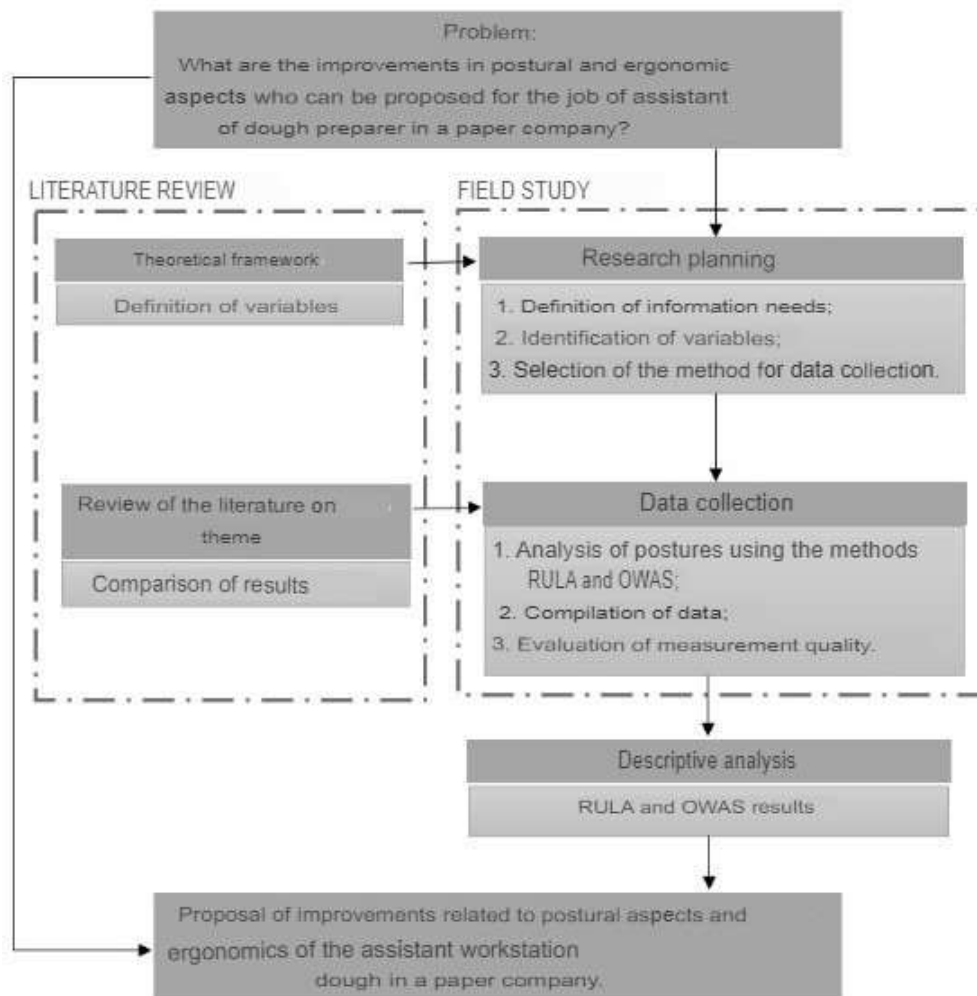
Source: Adapted from McAtamney and Nigel Corlett (1993)

The OWAS method was developed by three Finnish researchers working in a steel company. In their quest for improvements in their working environment, they began a photographic survey to analyze the main postures found in heavy-duty industrial work. This effort resulted in 72 typical postures arising from combinations of the back, arms, legs, and the load supported or the use of force (Iida & Guimarães, 2018).

3. Methodology

The classification of the study regarding its nature is qualitative research, as it aims to analyze the particularities of the postural and ergonomic aspects of the work station of a pulp preparer assistant in a paper company. With the purpose of conducting the Ergonomic Work Analysis, the study went through several stages illustrated in Figure 1.

Figure 1 – Methodological stages of the study



Source: The authors (2019)

To address the research problem, the process began with a theoretical framework to facilitate research planning, including: defining information needs, identifying variables that would impact field processes, and selecting the data collection method.

Subsequently, data collection was carried out, involving posture analysis using the RULA and OWAS methods. The data was compiled, and measurement quality was assessed by comparing the results with the literature review on the topic.

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

Therefore, the research can be classified as exploratory in its literature review stages, aiming to familiarize with the content and expand knowledge. With a better understanding of the subject, the research problems were more clearly defined and structured.

The data is predominantly descriptive, consisting of descriptions of the company, job activities, worker characteristics, and other relevant study variables. Field study and case study methods were employed for this purpose

3.1. Variables Relevant to the Study

The collection of data described in the literature review was found to be relevant for the research.

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

The processes in the industry include: receiving waste and pulp; pulp preparation; refining of pulp; paper production; reel formatting; and product dispatch. The analyzed workstation is part of the pulp preparation process.

The job of the pulp preparer assistant involves handling raw materials, either bales of waste paper or cellulose bags, which will feed the hydropulper.

For the disposal of waste paper bales, the activities follow the sequence:

1. Receive the waste paper bales on a table;
2. Divide and weigh the waste paper;
3. Feed the conveyor belt that supplies the hydropulper.

For cellulose bags, the sequence of activities is:

4. Receive the cellulose bag on the scale and weigh it;
5. Open the bag to pour the cellulose onto the conveyor belt;
6. Feed the conveyor belt that supplies the hydropulper, distributing the cellulose.

The postures at the pulp preparer assistant workstation were analyzed for 4 employees, with a daily workload of 8 hours (including a 1-hour break in the middle of the shift for rest). All employees in this position are men with average height.

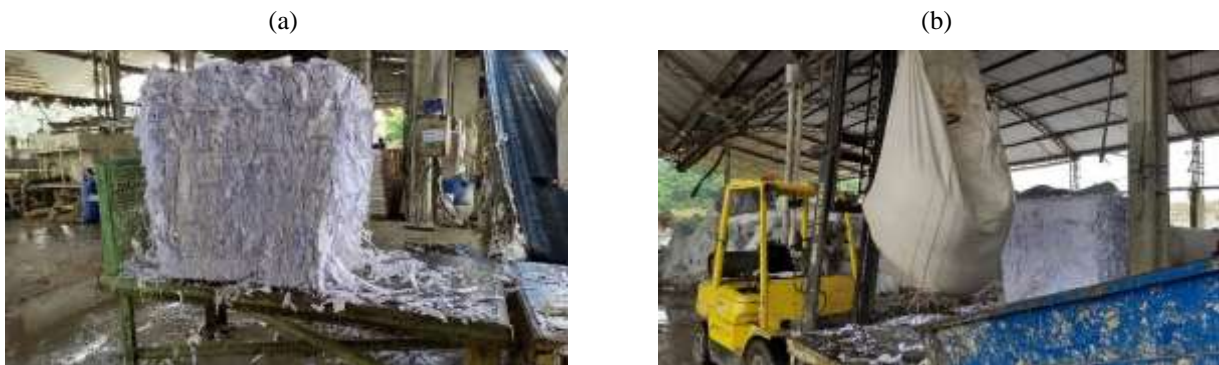
¹Equipment that operates on the same principle as a blender and is capable of separating and disaggregating all paper fibers. Along with the addition of water, it transforms the paper into a homogeneous pulp.

3.2. Data Collection

The data collection involved observing the activities performed by the workers at their workstations. The observations lasted for 12 days, with 3 days of monitoring for each of the four employees, covering different shifts.

Both the receipt of waste paper bales (Figure 2a) and cellulose bags (Figure 2b) were observed. It was noted that there are differences in the postures of the workers when receiving these two raw materials. The waste paper bale is manually divided by the employee to feed the conveyor belt supplying the hydropulper. In contrast, the reception of bags, weighing from half to one ton, is done with a forklift. The assistant needs to cut the bag for the cellulose to be poured directly onto the conveyor belt.

Figure 2 – Waste paper bale (a) and cellulose bag (b)

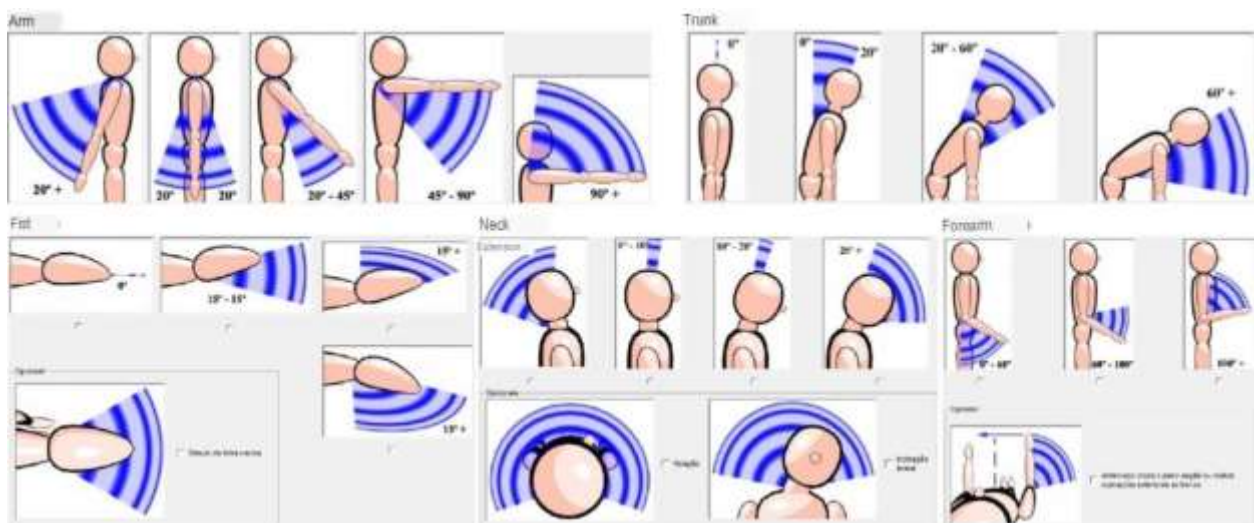


Source: The authors (2019)

for the two distinct situations, considering the differences in posture and load handling by the employees in both.

While observing the workers, ergonomic posture analyses were performed using the Ergolândia software, which provides various ergonomic analysis methods, including the RULA (Rapid Upper-Limb Assessment) and OWAS (Ovako Working Posture Analysis System). The methods were used complementarily, as RULA (Figure 3) provides a comprehensive analysis of the upper limbs, and the OWAS method (Figure 4) complements it with an accurate analysis of the lower limbs.

Figure 3 – Selection options in RULA



Source: Adapted from FBF Sistemas - Ergolândia (2019)

Figure 4 – Selection options in OWAS



Source: Adapted from FBF Sistemas - Ergolândia (2019)

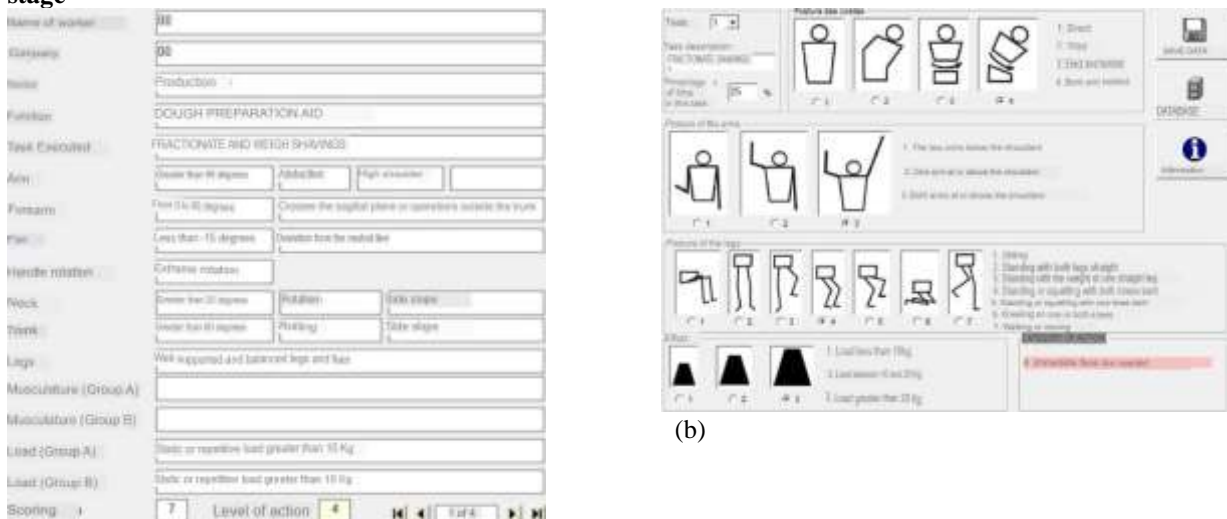
4. Results And Discussion

As reported in the methods, the analyses were conducted for two situations at this workstation: for the waste paper bale raw material and for cellulose bags.

4.1 Analysis With Raw Material From Baled Waste

The transportation of the waste paper bale, weighing between 1,000 and 1,200 kg, to the receiving table is done with the assistance of a forklift. The employee's activities at this stage involve only assisting the forklift operator with signaling instructions, with no direct interaction with the product or activities that require physical effort. Therefore, this activity was excluded from the analysis. After receiving the bale on the table, the employee divides it by hand and then positions the portions on the conveyor belt that feeds the hydropulper.

Figure 5 – Results of ergonomic analyses (a) RULA and (b) OWAS for the waste paper cutting and weighing stage



(a)

Source: The authors (2019)

Figure 5 displays the posture analyses of the pulp preparer assistant during the stage of cutting and weighing waste paper.

In both analyses (RULA and OWAS), the obtained scores suggest a very high risk, necessitating immediate investigation and action.

Figure 6 depicts the ergonomic analyses of the workstation when feeding the conveyor belt that supplies the hydropulper with the waste paper fractions.

Figure 6 – Results of ergonomic analyses (a) RULA and (b) OWAS for the stage of feeding the conveyor belt with waste paper.

(a)

Source: The authors (2019)

(b)



Once again, the scores obtained through the application of the RULA and OWAS methods suggest a very high risk of musculoskeletal disorders, necessitating immediate investigation and action.

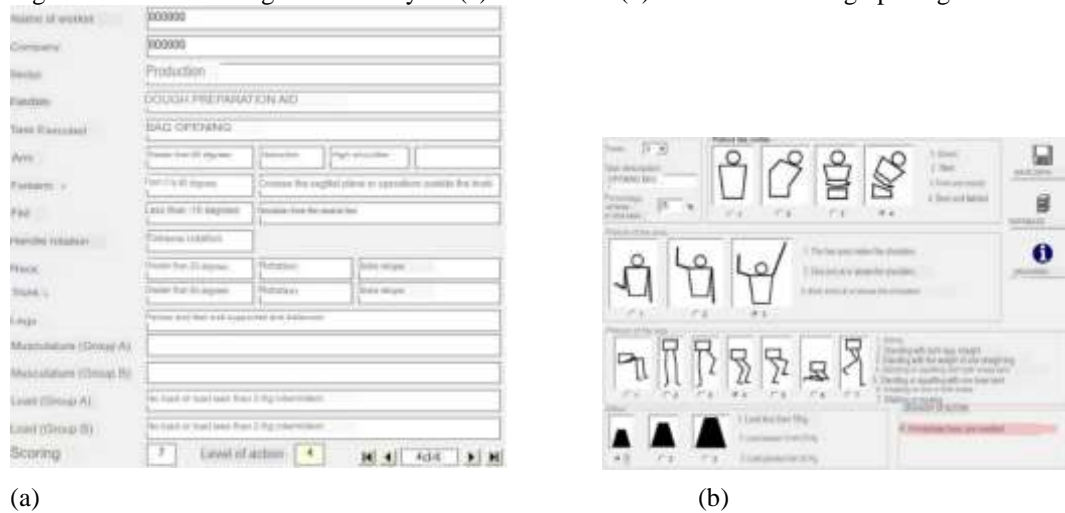
4.2 Analysis With Raw Material From Baled Cellulose Bags

The movement of the cellulose bag from the stock to the weighing scale is done with a forklift. The employee assists the forklift operator by providing guidance for positioning the bag onto the scale, requiring no muscular effort at this stage. Once weighed, the bag is lifted again by the forklift operator, allowing the assistant to open it with a knife, enabling the cellulose to fall onto the conveyor belt. After the cellulose falls onto the belt, the pulp preparer assistant spreads it to prevent overloading, using either a hoe or their hands.

The results of both the RULA and OWAS methods suggest the need for immediate investigation and action, given the very high risk of musculoskeletal disorders for the worker.

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

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



Source: The authors (2019)

Figure 8 depicts the analyses and results of feeding the conveyor belt with cellulose after opening the bag.

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



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. Investigations are recommended, and immediate actions should be taken.

4.3 Discussion Of Results

Ergonomics aims at adapting work to humans through its strategies and methodologies. It can contribute to reducing 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 day-to-day challenges. It is necessary to have good working conditions to maintain efficiency throughout the workday, including appropriate levels of noise, lighting, climatic conditions, ergonomic equipment, among other factors to handle activities more efficiently or with less accumulated fatigue throughout the day.

According to Batiz, Galo, and Souza (2006), posture is the position that an individual adopts to perform daily functions. It can be static or dynamic, using the musculoskeletal system for activities at the workstation. Alternating between sitting and standing is the most recommended way to keep the body healthy.

An important factor in predicting musculoskeletal disorders is maintaining the correct posture in daily activities, establishing appropriate measures, adapting equipment and processes to the psychophysiological characteristics of factory employees, and providing proper postural education.

If the machines used by the worker for a particular activity are suitable but they do 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, creating conscious behavior habits at each level, in order to facilitate the understanding of the need for the establishment of Ergonomics as a science that helps comprehend the behavior of the human body in the conditions it is involved in.

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

Manual handling of loads always poses a significant ergonomic challenge, especially when considering morbidity data related to occupational health. Approaches should be designed to provide maximum safety without compromising the individual's health. Manual handling of loads includes lifting and depositing the load entirely supported by a single worker (Ormelez & Ulbricht, 2010; Caetano, Cruz, Silva & Leite, 2012).

The work functions of employees related to lifting, transporting, and depositing loads must always comply with rules defining conditions, infrastructure, and suitable equipment for such tasks. Employers and workers must be attentive to current regulatory standards. For manual handling of loads, strict adherence to safety regulations is crucial, such as observing the maximum weight for manual load transport.

The Consolidation of Labor Laws (CLT) established 60 kilograms as the maximum weight an individual worker can handle. It is prohibited to assign women and individuals under 18 years of age to tasks requiring continuous muscular effort exceeding 20 kilograms or 25 kilograms for functions occasionally requiring manual load transport.

The conditions of factory workers analyzed with RULA and OWAS methods are not ergonomic, and the results suggest a reduction in the manipulated weight. This reduction can be achieved by dividing raw materials into smaller portions so that the weight lifting is considered acceptable, respecting the maximum limit for individual manual load transport.

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

The results of this study underscore the need for employee guidance as they engage in improper movements that jeopardize their physical integrity during activities. Negative outcomes during the workday result from repeatedly adopting improper gestures and postures.

The working conditions in the factory's daily routine highlight the challenges of load handling without many task-facilitating alternatives. Some suggestions in this regard include the implementation of ergonomic solutions, better adaptation of biomechanical variables, rationalization of action frequency and intensity, and time management, allowing for a reduction in ergonomic risk (Carvalho et al., 2011; Ormelez & Ulbricht, 2010).

After the analyses, this study suggests instructing workers to handle raw materials in smaller fractions (up to 20 kg). Other suggestions include dividing loads among two or more workers, keeping the load close to the body, avoiding trunk rotations, lifting objects with an upright spine and bent knees, exploring the use of auxiliary devices such as forklifts, and considering

physiological alternatives like recovery through breaks and role rotation (Ramos, Siqueira & Aita, 2011; Leme, Papini, Vieira & Luchini, 2014).

5. Final Considerations

The results and analyses indicate that a significant portion of the activities performed by the dough preparation assistant requires immediate investigation and action as 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, illustrates the importance of incorporating health practices into the work environment." With this perspective in mind, the following suggestions were made to improve the quality of work life for the analyzed position:

- Postural training;
- Training and awareness for the assistant to divide the load of scraps into smaller fractions, reducing the weight during the action;
- Use of mechanized systems for lifting and transporting loads;
- Establishment of working conditions that respect the psychobiophysiological characteristics of the worker.

Like other studies (Fassa et al., 1996; Nepomuceno et al., 2017; Machado & Nascimento, 2013) have already found, research presenting ergonomic analyses in the workplace needs to be reported more frequently, suggesting reviews where risks to workers are identified. This is especially important for industries such as paper and pulp, which have limited national publications, so they can progressively contribute to the ergonomic quality of work.

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