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EFFECTIVENESS OF THE ROTATION IN THE PROCESS OF PACKAGING REAMS OF PAPER, AFTER THE IMPLEMENTATION OF ERGONOMIC IMPROVEMENTS

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Abstract

At the beginning of the 20th century, with the second industrial revolution, Ergonomics emerged, concerned with the interface between man and machine. In Brazil, Regulatory Standard 17 aims to adapt work to the characteristics of workers. In a pulp and paper company, ergonomics is essential due to the complexity of operations. The paper packaging process, despite some automation, still requires manual intervention, generating discomfort. Ergonomic work analysis (EWA) allows for the diagnosis and correction of work situations, while methods such as DUET and TOR-TOM assess ergonomic risks.

A study evaluated the effectiveness of task rotation in the company, using DUET and TOR-TOM. After the implementation of load handlers, rotation improved, but the primary task (feeding reams) still represents a high ergonomic risk. Workers' perception of rotation coincides with the results of TOR-TOM. The study concludes that the current rotation has improved working conditions, but improvements in the primary task are necessary to ensure the absence of musculoskeletal disorders in the upper limbs.

Keywords: DUET; TOR-TOM; Rotation; Musculoskeletal disorders in upper limbs; ergonomics.

1. INTRODUCTION

At the beginning of the twentieth century, with the advent of the second industrial revolution, when the methods of work organization were established, Ergonomics began to emerge and with it, the concern with the human-machine interface (Melo et al., 2011).

Transformations are manifested at work and Ergonomics comes to harmonize the impacts on the health of the worker, including bringing a more social aspect to the theme,

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permeating in a more genuine way the good practices of companies and promoting inclusion, since there is the feasibility of adapting the work to the needs of the worker.

In Brazil, the regulatory standard 17 (NR17), of the mystery of work and employment (MTE), aims to establish parameters that allow the adaptation of working conditions to the psychophysiological characteristics of workers, in order to provide maximum comfort, safety and efficient performance.

The pulp and paper company object of this study was founded in 1924, and its development followed the trends of the industrial revolution in Brazil, when the methods of work organization were established.

The pulp and paper production sector in Brazil contributes significantly to the economic and technological development in the country and its various stages of manufacture, from the planting of the eucalyptus seedling, the main tree used for pulp extraction, to the embossing of paper.

The term "reams of paper" is widely used in the paper industries, which consists of the formation of packaged sets of paper sheets, which is part of one of the final finishing processes, to later be palletized and sent to customers, which in this case, most of the time are composed of large companies in the printing industry, which require large format sheets.

The process of packaging reams of paper, the focus of this work, although it has some automated steps, part of them still requires manual intervention by the worker, generating discomfort, fatigue and pain in the upper limb region.

In this way, Iida (2005) analyzes the various factors that influence the performance of the production system and seeks to reduce its harmful consequences on the worker. Thus, this perspective seeks to reduce monotony, fatigue, repetitiveness, mental overload, errors and accidents, providing safety, satisfaction and health to workers, as well as cooperative and motivating environments.

The rotation of tasks in this sense is important because it makes it possible to reduce the duration of exposure to the risk factors imposed by the activity performed (Rocha, 2017). When there is job rotation, but the other tasks present the same biomechanical pattern, there will be no biomechanical advantage of rotation (Batiz et al., 2013).

Couto (2007) prescribes that during the rotation in tasks, the demands of the muscle groups alternate, providing a reduction in the existing overload of the musculoskeletal structures that were previously highly demanded.

These unfavorable conditions of environment and physical facilities have repercussions on the worker's body, especially on the most demanded musculoskeletal structures. The continuous movement of the upper limbs makes the viscosity within the natural sheaths and beds where tendons, vessels, and nerves slide critical, resulting in friction between several neighboring structures, consequent functional disturbances. Such unfavorable biomechanical aspects can be aggravated by other anti-ergonomic and environmental issues, as well as the nature of poor work organization (Scopel, 2010).

According to the understanding of Guérin et al. (2001), the ergonomic analysis of work (AET) will allow diagnosing and correcting a real work situation, enabling its transformation. It will also analyze the activities of a given task, surveying the data regarding the objectives, the expected results of the work, understanding the work as it is actually performed, the difficulties encountered and the strategies used to overcome them. Finally, the data collected allow the formulation of working hypotheses that guide the directions to be followed.

The DUET method is a new tool for assessing ergonomic risk, associated with tasks involving the distal upper limbs, validated by the scientific community in 2017. It is based on the theory that evaluates the cumulative damage to these musculoskeletal structures, subjected to repetitive stress. This requires only two pieces of information about each task that involves the upper extremity: 1) an evaluation of the intensity of effort for each task; 2) the number of repetitions of tasks during the working day (Gallagher et al., 2017).

The classification of the intensity of effort can be obtained in different ways, however, in the DUET method the subjective classification of effort of the OMNI-RES scale is used, which according to Robertson et al. (2003) should instruct the worker to quantify the intensity of effort, tension, discomfort and/or fatigue that, in view of his perception during the execution of this task, guided by the 0 to 10-point scale, provided by the evaluator, with 0 being extremely easy and 10 being extremely difficult.

The TOR-TOM method is an ergonomic risk assessment instrument, applied in various work scenarios, however, it has been more used in activities with manual requirements. It brings a relationship between the Actual Occupancy Rate (TOR) of the worker in a given activity throughout his or her working day and the Maximum Occupancy Rate (TOM) that should exist in the activity, establishing safe limits and contributing to guide the management of solutions (Nogueira, 2012).

Couto (2014) explains that the TOR-TOM method evaluates the ergonomic requirements instituted in the various tasks and activities, as well as evaluates the effectiveness or not of the regulation mechanisms applicable to them, allowing the definition of the existence or not of ergonomic risk and safe limits for the work demand.

The TOR is thus compared with the TOM, according to Couto (2014), interpreting the result as follows:

- When the TOR is lower than the TOM, we have a safe working situation, that is, TOR<TOM, without ergonomic risk.
- When TOR is equal to TOM, it indicates that complaints are likely in susceptible people, i.e. TOR=TONE, at the limit, but still without ergonomic risk.
- When the TOR is well above the TOM, it is very likely that the worker already has some involvement due to overload, that is, TOR>TOM, an ergonomic risk.

Therefore, it is also observed in the studies of Oliveira (2005) that ergonomics has an eminently interdisciplinary character. Its practice is partly constituted by organizational aspects and at the same time is related to various technologies, where its result translates into technical devices (design of tools, machines, spaces and equipment), which can be used with maximum comfort, safety and effectiveness, as well as mechanization and automation.

In the case of equipment called load handlers, they were developed to assist in the manufacture and handling of materials in general. Its numerous models are manufactured to perform their functions according to the type of product to be moved. They are handled without unnecessary effort and depend on the worker's performance, manipulators are also solutions, which when well planned, contribute positively to ergonomic aspects in a given workstation (Seman, 2019).

These two approaches, organizational and technological aspects, complement each other and should not coexist separately. It is currently part of a global view of the relationship between workers and their work. However, the main motivation of this study was to anticipate solutions that will be effectively capable of minimizing ergonomic risk, to the point of reducing risks to acceptable levels, so that they do not cause harm to the health and safety of workers.

2. GOAL

Evaluate two rotation systems, one previous and the current, seeking to verify that the job rotation, as currently practiced, is, in fact, ensuring that there is no ergonomic risk.

3. SECONDARY OBJECTIVES

Study the previous rotation system for which there was no certainty as to effectiveness; study the rotation currently practiced, considering that solutions capable of reducing effort have been instituted when not performing the primary activity; and test the effectiveness of the caster using two ergonomic tools.

4. METHOD

Primarily, this work began with an ergonomic analysis of the paper ream packaging process, before the improvements implemented in the secondary activities of this process.

Next, a second ergonomic evaluation was carried out, now considering the implementation of load handlers in secondary activities, including calculating the TOM in the rotation tasks, currently practiced with the handlers.

Typical day timing (DTC) was also carried out, where DTC 1 considers how it was done and DTC 2 considers how it is done today, with the implementation of improvements.

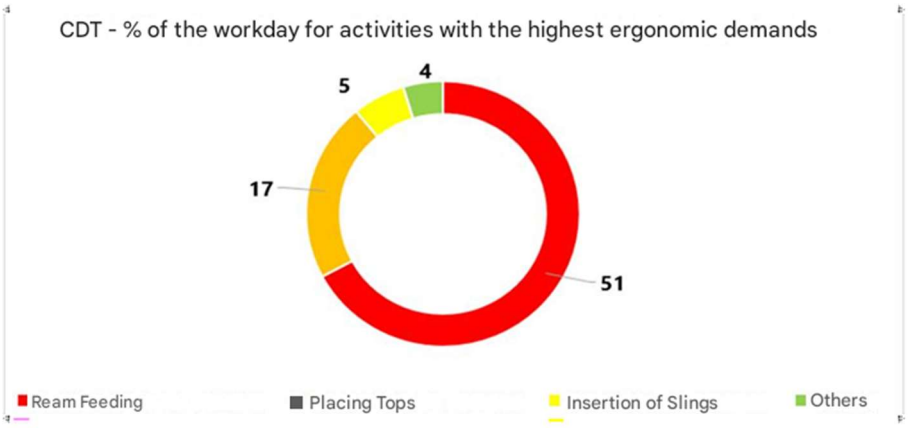
The present study concludes whether there is effectiveness of the rotation in the tasks, or not, considering the TOR-TOM method and the DUET method.

5. DEVELOPMENT

The typical day timing (DTC) before and after the implementation of the load handlers did not change.

The activity of feeding reams was considered primary and with greater ergonomic demand, while the activities of placing wooden tops and inserting the tanga shaft in the kraft packaging coil were considered secondary.

The following chart represents the above-mentioned activities during typical day timing:



Graph 1: Timing of the typical day.

Considering the DUET method in relation to CDT1, before the implementation of the manipulators, we obtained the results shown in the following table:

The Distal Upper Extremity Tool

Task #	OMNI-RES Scale	Repetitions (per work day)	Damage (cumulative)	% Total (damage)
1	8: Hard	2160	2.27608	97.4
2	8: Hard	40	0.04215	1.8
3	10: Extremely Hard	2	0.01942	0.8
			Total Cumulative Damage:	**2.33765**
			Probability of Distal Upper Extremity Outcome (%):	**70.0**

Table 1: Results of the DUET method, considering CDT1.

Being: task 1: Ream feeding; task 2: Placement of tops; task 3: Tin insertion.

The combination of these three tasks leads to a combined probability of 70% for musculoskeletal disorders of the distal upper extremity. High-risk activity.

Also, note that task "1", ream feeding, accounts for approximately 97.4% of the total workday damage.

Still in relation to the DUET method, now considering CDT2, after the implementation of the manipulators in the secondary activities, we obtained the results presented below:

The Distal Upper Extremity Tool

Task #	OMNI-RES Scale	Repetitions (per work day)	Damage (cumulative)	% Total (damage)
1	8: Hard	2160	2.27608	100.0
2	4: Somewhat Easy	40	0.0005	0.0
3	3			
			Total Cumulative Damage:	**2.27659**
			Probability of Distal Upper Extremity Outcome (%):	**69.8**

Table 2: Results of the DUET method, considering CDT2.

Being: task 1: Ream feeding; task 2: Placement of tops; task 3: Tin insertion.

After the implantation of the manipulators in secondary activities, the combination of these three tasks leads to a combined probability of 69.8% for musculoskeletal disorders of the distal upper extremity. The activity continues to be of high risk, according to the DUET method, however, it is observed that secondary activities no longer represent a risk to the physical integrity of workers.

Task "1", feeding reams, is responsible for 100% of the total damage of the working day.

However, the DUET method clearly indicates that the primary task (ream feeding) represents a high risk of injury to the upper limbs of the distal extremity and that it deserves attention in the direction of action plans, in addition to the rotation already implemented and the load handlers in secondary activities.

During the analysis together with the workers, we imagined a hypothetical situation, but one that could be made viable, where we simulated reducing the effort to "a little easy" on the subjective scale of strength of OMNI. In this case, the risk of the primary activity would be considered moderate.

After these observations and simulation, the workers themselves rescued a previously used resource, a **pneumatic "gun",** which for many years, due to problems of maintenance and regulation of compressed air, was no longer used. This action plan will not be the target and object of this study, but will compose the list of action plans as something that can be improved and adjusted, with the potential to be a low-complexity action.

When we applied the TOR-TOM method in CDT1 (before the implementation of the improvements), we found the following results:

TOR (Real Occupancy Rate)	**TOM** (Maximum Occupancy Rate)	**TOR-TOM**
75%	72.7%	+2.3%

Table 3: Results of the TOR-TOM method, considering CDT1.

In this case, discomfort, difficulty and fatigue, especially in more susceptible people or in a variation of type of production.

In the observation of CDT2 (after implementation of the improvements), still using the TOR-TOM method, we found the following results:

TOR (Real Occupancy Rate)	TOM (Maximum Occupancy Rate)	TOR-TOM
75%	75.5%	-0.5%

Table 4: Results of the TOR-TOM method, considering CDT2.

Where in this condition, discomfort, difficulty or fatigue is unlikely to occur. Activity with low ergonomic risk, but with a probability of complaints at certain production peaks.

In an interview with employees, the perception of rotation, as currently practiced, coincides with the result of TOR-TOM. The complaints are no longer related to the tasks, but to occasional episodes of demands for reams with greater weight (between 25 and 30kg).

6. Discussion

It is important to pay attention to some precautions so that the rotation works properly in all its interface aspects. Couto (2014) points out some of them: equal pay among workers; anticipate the possibility of quality problems; The rotation must have alternation of muscle groups and with tasks from high to low ergonomic demand, even in cases of high mental load.

Work-related musculoskeletal disorders (WMSD) are characterized by the occurrence of several concomitant or non-concomitant symptoms, such as pain, paresthesia, feeling of heaviness and fatigue, which according to Scopel (2010), are usually of insidious appearance and mainly affect the upper limbs and can have a neuroorthopedic connotation, in these cases, defined as tenosynovitis, synovitis, peripheral nerve compressions, may cause temporary or permanent work incapacity.

We know that musculoskeletal disorders have multifactorial causes, which go far beyond the two pieces of information requested in the DUET method (intensity of effort and repetition), however, even though it is a recently validated tool, the studies and studies already completed show a significant relationship and success in the identification of dangerous jobs for the upper limbs.

In this sense, the TOR-TOM index provides professionals interested in ergonomics with a strategic view with a bias in the correction of job maladjustments, which in cases of success increases the TOM related to productivity, or in cases of technical infeasibility of more robust

actions in the field of engineering, professionals will be able to size the time in tasks of low ergonomic demand and enable adequate regulation mechanisms (Couto, 2012).

7. Conclusion

Both methods, DUET and TOR-TOM, indicate that rotation as currently practiced, using load handlers in secondary activities, has improved the working condition, making it biomechanically favorable.

However, according to the DUET method, the primary activity of ream feeding is still characterized as a task of high ergonomic risk, and therefore, indicates the need to direct efforts to improve the aspects of repetition and strength, in an attempt to reduce them.

On the other hand, the TOR-TOM method, which in addition to encompassing the criteria evaluated in the DUET, also considers the mechanisms for regulating the activity, showed a different result regarding ergonomic risk, classifying it as low. In this sense, the occurrence of discomfort, difficulty or fatigue is unlikely, except in occasional episodes of production peaks.

However, we can affirm that the rotation as currently practiced has improved the working condition from an ergonomic point of view, but that other actions to improve the primary activity cannot be neglected, since, in line with the premises of the risk management hierarchy, the elimination of the force and repetitiveness factor will sustainably ensure the absence of musculoskeletal disorders in the upper limbs.

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