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

Denise Napolitano Alegrette, Suzano S.A, denialegrette@hotmail.com
Regiane Maria Martins, Suzano S.A, regiane.martins00@gmail.com
Rita Caroline de Castro Caetano, Suzano S.A, ritacastro.caetano1986@gmail.com
Sarita Geraldo Rosa Barros, Suzano S.A, sarita_orl@yahoo.com.br

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 (AET) allows you to diagnose and correct work situations, while methods such as DUET and TOR-TOM evaluate ergonomic risks.

A study evaluated the effectiveness of job rotation in the company, using DUET and TOR-TOM. After the implementation of load handlers, the rotation improved, but the primary task (feeding reams) still represents a high ergonomic risk. Workers' perception of rotation coincides with the results of the TOR-TOM. The study concludes that the current rotation 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 the upper limbs; ergonomics.

Introduction

At the beginning of the 20th century, with the advent of the second industrial revolution, when work organization methods were established, Ergonomics began to emerge and with it, the concern with the human-machine interface (Melo et al., 2011) .

The transformations are manifested at work and Ergonomics comes to harmonize the impacts on the worker's health, including bringing a more social aspect to the topic, permeating in a more genuine way the good practices of companies and promoting inclusion, since there is the viability of adaptation of work to the worker’s needs.

In Brazil, 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 performance efficient.

The company in the cellulose and paper segment that is the subject of this study was founded in 1924, and its development followed the trends of the industrial revolution in Brazil, when work organization methods were established.

The paper and cellulose production sector in Brazil contributes significantly to the economic and technological development of the country and its various stages of manufacturing, from the planting of eucalyptus seedlings, the main tree used for cellulose extraction, to the squeezing 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 are part of one of the final finishing processes, to later be palletized and sent to customers, who in this case, in the most often 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, some of them still require manual intervention from 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.

Task rotation, in this sense, is important because it allows for a reduction in the duration of exposure to risk factors imposed by the activity performed (Rocha, 2017). When there is job rotation, but the other tasks have the same biomechanical pattern, there will be no biomechanical advantage of rotation (Batiz et al., 2013).

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

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

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

The DUET method is a new ergonomic risk assessment tool, 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 involving the

upper extremity: 1) an assessment of the intensity of effort for each task; 2) the number of task repetitions during the workday (Gallagher et al., 2017).

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

The TOR-TOM method is an ergonomic risk assessment instrument, applied in different work scenarios, however, it has been used more in activities that require manual work. It provides a relationship between the worker's Actual Occupancy Rate (TOR) in a given activity throughout their journey and the Maximum Occupancy Rate (TOM) that should exist in the activity, establishing safe limits and helping to guide the management of solutions (Nogueira, 2012).

Couto (2014) explains that the TOR-TOM method evaluates the ergonomic requirements established in the different tasks and activities, as well as evaluating the effectiveness or not of the regulatory mechanisms applicable to them, allowing to define the existence or not of ergonomic risk and safe limits for labor demand.

TOR is thus compared with 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, that is, TOR=TOM, 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 impairment due to overload, that is, TOR>TOM, an ergonomic risk.

Therefore, it is also observed in the studies by Oliveira (2005), that ergonomics has an eminently interdisciplinary character. Its practice consists partly of organizational aspects and

at the same time relates 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 manufacturing 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. Handlers are also solutions, which, when well planned, contribute positively to ergonomic aspects in a given workplace (Seman, 2019).

These two approaches, organizational and technological aspects complement each other and should not coexist separately. It is currently part of a global vision of the worker's relationship with their work. However, the biggest motivation for this study was to anticipate solutions that will be effectively capable of minimizing ergonomic risk, to the point of reducing risks to acceptable levels, in a way that does not cause harm to worker health and safety.

Objective

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

Secondary objectives

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

Method

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

A second ergonomic assessment was then 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 (CDT) was also carried out, where CDT 1 considers how it was done and CDT 2 considers how it is currently done, with the implementation of improvements.

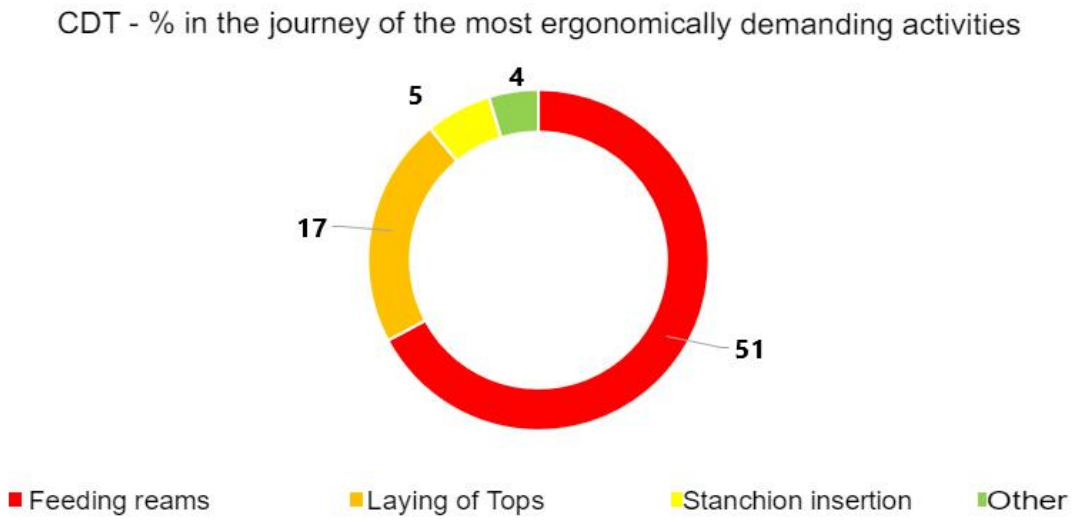
The present work concludes whether or not task rotation is effective, considering the TOR-TOM method and the DUET method.

Development

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

The activity of feeding reams was considered primary and of greater ergonomic demand, whereas the activities of placing wooden tops and inserting the stagna shaft into the kraft packaging coil were considered secondary.

The following graph represents the activities mentioned above during the timing of a typical day:



Graph 1: Typical day timing.

Considering the DUET method in relation to CDT1, before implementing the

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.

Of which: task 1: Feeding of reams; task 2: Placing tops; task 3: Stang 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.

Additionally, note that task "1", feeding reams, is responsible for approximately 97.4% of the total workday damage.

Still in relation to the DUET method, now considering CDT2, after implementing the manipulators in 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	2	1e-05	0.0

Total Cumulative Damage:	2.27659
Probability of Distal Upper Extremity Outcome (%):	69.8

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

Of which: task 1: Feeding of reams; task 2: Placing tops; task 3: Stang insertion.

After deploying 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 high risk, according to the DUET method, however, it is observed that secondary activities no longer pose a risk to the physical integrity of workers.

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

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

During the analysis together with the workers, we imagined a hypothetical situation, however, possible to make viable, where we simulated reducing the effort to “a little easy” on the OMNI subjective strength scale. 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 maintenance and compressed air regulation problems, was no longer used. This action plan will not be the target and object of this study, but will make up 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 to CDT1 (before implementing the improvements), we found the following results:

TOR (Actual occupancy rate)	TOM I (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 in the type of production.

When observing CDT2 (after implementing the improvements), using the TOR-TOM method, we found the following results:

TOR (Actual 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, the occurrence of discomfort, difficulty or fatigue is unlikely. Activity with low ergonomic risk, but with the likelihood of complaints at certain production peaks.

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

Discussion

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

Work-related musculoskeletal disorders (WMSDs) are characterized by the occurrence of several symptoms, whether concomitant or not, such as pain, paresthesia, sensation of heaviness and fatigue, which, according to Scopel (2010), normally have an insidious appearance and mainly affect the upper limbs. and may have a neuro-orthopedic connotation, in these cases, defined as tenosynovitis, synovitis, compression of peripheral nerves, which 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 work already completed show a significant relationship and success in identifying dangerous work for upper limbs.

In this sense, the TOR-TOM index provides professionals interested in ergonomics with a strategic vision with a bias towards correcting workplace mismatches, which in

successful cases increases the TOM related to productivity, or in cases of technical unfeasibility of With more robust actions in the field of engineering, professionals will be able to spend time on tasks with low ergonomic demands and enable appropriate regulation mechanisms (Couto, 2012).

Conclusion

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

However, according to the DUET method, the primary activity of feeding reams 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.

The TOR-TOM method, which in addition to encompassing the criteria evaluated in the DUET, also considers the activity regulation mechanisms, showed a different result in terms of 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 state that rotation as currently practiced has improved working conditions from an ergonomic point of view, but that other improvement actions in the primary activity cannot be neglected, since, in line with the premises of the management hierarchy, risks, the elimination of the strength and repetitiveness factor will sustainably guarantee the absence of musculoskeletal disorders in the upper limbs.

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