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PRELIMINARY ERGONOMIC ANALYSIS OF A MICRO-COMPANY MANUFACTURING MARINE CABLES

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Abstract

Although they are responsible for 27% of Brazil's GDP and 52% of formal jobs in the country, microenterprises are not the basis for defining best practices in Occupational Health and Safety (OHS). Furthermore, the guidelines of OHS legislation are mainly aimed at the largest business conglomerates. Thus, this study aimed to perform a primary diagnosis of the ergonomic situation of a microenterprise in the nautical manufacturing sector, using the DeParis method to identify critical work situations. Three operators and one manager were interviewed. For each item analyzed and discussed, the resulting facial expressions were defined by consensus. This analysis made it possible to indicate situations where necessary actions were taken and classify them as satisfactory, unsatisfactory or potentially dangerous. Finally, the 5W1H tool was used to propose planning for improvement actions. As a result, six headings were critical to the work context: workplace, accident risks, repetitive work, handling/lifting of weight, noise and work relations between workers. The main problems identified were work postures, accident risks in equipment, handling of heavy loads and dispersion due to monotonous and repetitive work. It was concluded that the application of the method was essential for understanding the main problems related to the headings, and for the participation of the operators. It was possible to suggest more assertive and viable improvements for the company.

Keywords: AEP; Risks; Participatory ergonomics; DeParis.

1. INTRODUCTION

Microenterprise is a company with annual revenues of up to 360 thousand reais, employing up to 9 people in the trade and services sector or up to 19 people in the industrial sector (PORTAL DA INDÚSTRIA, 2019). The opening of this type of company in Brazil has increased over the years, and they are responsible for 27% of the Brazilian GDP and 52% of

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jobs with a formal contract (SEBRAE, 2021). On the other hand, this type of company does not have widespread foundations and practices in Occupational Health and Safety (OHS) (LEGG et al., 2015), being a challenge in its processes. The best OH&S practices are still based on the characteristics of large companies (LEGG et al., 2015), mainly to comply with the laws that regulate these largest business conglomerates as a priority (ZENG et al., 2014).

As a result, ergonomic and security interventions in OH&S in micro and small enterprises (MSEs) are strongly shaped by traditional and functional experiences and practices in the largest organizations, but they are not always adequate or adjusted to the reality of small businesses. This situation, combined with the recurrent scarcity of resources for investment (in human, financial or time resources), means that interventions in OHS are not so present in MSEs (LEGG et al., 2015). For Champoux and Brun (2001), the lack of education and training in smaller companies results in damage to health and safety actions, resulting in non-systematic approaches and the use of poorly designed control measures in the implementation of OH&S practices.

In Brazil, the OHS of companies is guided by the Regulatory Standards (NR) of the Federal Government. These rules have the weight of law and, if companies do not comply with their guidelines, fines and punishments may occur. The application of these NRs in the country is widely disseminated in large companies, mainly due to the activity of regulatory agencies and efficient occupational safety policies (VILAS BOAS; GASQUES, 2018). NR-1 determines that it is an obligation of all employers with workers under the CLT - Consolidation of Labor Laws regime (except Individual Microentrepreneurs, micro-enterprises and small businesses without occupational exposure to physical, chemical and biological agents, in accordance with NR 9) to prepare a Risk Management Program (PGR) in order to operationalize Occupational Risk Management (GRO), defining and promoting actions that provide healthy and safe working conditions and environments (BRASIL, 2022). In this sense, and together with the lack of knowledge of employers and employees, micro and small companies end up not evaluating their operations from the point of view of occupational risks (BRASIL, 2010). This context ends up generating a pretext for a series of issues that can hinder the development of companies, such as: work accidents, increased occupational risks, low quality of life at work, development of WMSDs (Work-Related Musculoskeletal Disorders), among others.

An ergonomic methodology widely used in risk management is SOBANE (*Screening*, *Observation*, *Analysis*, *Expertise*). This method is structured for the analysis of working conditions in companies, aiming to prevent risks quickly, efficiently and at low cost (DA SILVA; AMARAL, 2018). The Participatory Risk Diagnosis (DeParis) is a qualitative method

for risk analysis (MALCHAIRE, 2003), which is the first level of the preliminary diagnosis of the SOBANE strategy, which consists of a questionnaire with 18 rubrics related to different aspects of the work (DA SILVA; AMARAL, 2018). In the application of the method, the desired situation is described, and by a figurative system of colors and facial expressions that indicates the degree of urgency of intervention in the issue to be addressed (SCHREINER et al., 2008).

The method involves the active participation of workers and managers in the identification of aspects related to safety, health and well-being, consequently impacting productivity (MALCHAIRE, 2003). Thus, it is a participatory method that instigates workers to discuss and determine which are the most applicable practices in the company's routine in terms of health, safety and ergonomics. Thus, the objective of this research was to carry out a primary diagnosis of the ergonomic situation of a manufacturing microenterprise in the nautical sector, mapping the existing risks of the current operation and proposing improvement solutions.

2. METHOD

The company object of the study operates in the field of nautical cables and, during the application of the research, had been operating for approximately one year. The sector in question was in the initial phase of development in Brazil, and most of the products sold at the time were imported. The main customers were stores that sold equipment for the practice of sailing and yachting.

Producing a wide variety of types of nautical cables on demand, the company was allocated in a wide area and operating with 12 machines, each of which constituted a workstation. The work was divided into three shifts with rotation among the 6 operators who were formally hired, under the CLT regime. It was not necessary for all the items produced to go through all the workstations; This was determined by the specification of the item demanded. Ear protectors and gloves were made available as PPE. The use of closed shoes was considered mandatory, although a standard model was not available.

2.1. Application of the DeParis Method

The application of the DeParis Method began with a visit to the company, in which it was possible to better understand the processing flow, understand the physical space, equipment and furniture available, observe and catalog the first focuses demanding analysis and interview

some of the participants in the process. During the visit, the 18 headings of the method were discussed during a guided interview with three of the operators and the manager of the processes analyzed.

With the intention of complementing the application of the tool, questions were used to assist in the discussion of each rubric, as exemplified in Chart 1. The questions were discussed and answered by the working group formed, with the help of the researchers of this work in agendas of approximately 20 minutes each.

Chart 1 – Fragment of the questions to encourage and complement the discussion of the rubrics

HEADING: Workplaces
- Is the work performed in a comfortable and stable chair sitting position, with enough legroom under the work surface or is it standing with no impediments to movement? - Are the work planes of adequate height, arranged in such a way as to allow the shoulders to be relaxed, the arms at the sides of the body and with the feet resting freely on the ground or on a comfortable foot support? - Does the work require kneeling, squatting, torso twisting, arms elevated?
HEADING: Accident risks
- Ask about each of the following risks and their severity: shock, falling people, falling from objects, crushing, fracture, cuts, stings, abrasion, burns, electricity, projection, fire, explosion, hits, among others; - Are PPE such as gloves, helmets and goggles used?
RUBRIC: Repetitive work
- Does the work require continuous repetition in the same positions and efforts? - If repetitive, was the work organized taking into account optimal anthropometric positions?; - What is the cycle time and the number of repetitions of the movement throughout this cycle?;
RUBRIC: Handling/Weightlifting
- Are the loads light or heavy?; - Is torso twisted when handling these loads?; - Is mechanical help required to handle the load?; - Are the distances and heights to pick up and deposit loads comfortable?; - Are the loads easy and comfortable to hold? - What is the height at which the loads are removed and placed in relation to the waist reference point?; - Are gloves used as PPE?
RUBRIC: Noise
- Is it possible to talk normally at a distance of 1 meter?; - If there is noise, what is the origin and state of the machines or facilities from which this noise comes?; - Is there a noise control mechanism?;
RUBRIC: Labour relations between workers
- Is there organization and division of labor?; - Are there breaks, rotations, breaks and substitutions?; - Are there workers who are isolated or excluded from the group?; - What is the autonomy of the group in the management of
Tasks?; - Do workers know and respect hierarchical relationships, responsibilities and delegations?

Source: Adapted from MALCHAIRE, 2003.

The working group took place in the form of a meeting, where the questions discussed were recorded by the researchers in order to formulate a table of answers. In this chart, the situation of each item was determined by indicating facial expressions and color: green color and positive facial expression meant satisfactory situation; yellow color and neutral facial expression meant a median situation that could be improved; and red color and negative facial expression meant an unsatisfactory situation, susceptible to danger and in need of improvement. For each point discussed in each rubric, it was agreed that the expressions and colors that the

group considered consistent with the situation would be determined, so that at the end of the agenda a general expression would be chosen to define the rubric based on the consensus among the participants, taking into account the discussions previously held.

In view of the information collected and the analysis by the DeParis method, proposals for improvements were made. The 5W1H tool was used as planning for the application of these improvements, and thus a summary table of the action plans for the main improvements indicated was built. Such a tool, in addition to prioritizing the most critical situations, would also allow a greater glimpse of how actions should be carried out.

3. FINDINGS

In this study, the work environment was fully evaluated considering all workstations due to the lack of physical delimitation and exclusive collaborators in each workstation. During the discussion, there was active participation of all those present. The meeting took place smoothly and the time stipulated for each agenda was considered adequate.

Within the delimited scope of the study, we chose to present and analyze in depth the results only of the items that were considered most relevant during the application of the DeParis method and that, consequently, were pointed out as those that most demanded attention in the factory or that represented a greater potential for a thorough study. The items selected for the presentation of the results were the following: 'Workplaces', 'Accident risks', 'Repetitive work', 'Heavy handling/lifting', 'Noise' and 'Work relations between workers'.

In the section 'Workplaces', the most critical issue raised was related to work postures – mostly performed while standing, sometimes requiring squatting and torso twisting (Figure 1a). Two intermediate priority issues were mentioned, the lack of delineation of areas for each operator during operation (Figure 1) and inefficient waste management (Figure 1b and Figure 1c). In addition, the place was characterized by the employees as easily accessible and in good condition for the activities to be well executed.

Figure 1 – (a) Torsion of the trunk and absence of area delimitation; (b) and (c) Packaging of waste

(a) **(b)** **(c)**

Source: Authors, 2023.

The item 'Accident risks' had the largest number of issues that needed urgent changes, with the maximum level of criticality: (i) lack of protective devices to prevent accidents related to the speed of operation of the machines (which worked within reach of the operators' limbs); (ii) drying oven developed by the operators themselves, without specific characteristics and functions; and (iii) the cable cutting stage, carried out without the appropriate equipment to prevent accidents. The availability of PPE was characterized as an intermediate level of criticality, some of which were made available by the company, but without standardization, use inspection or awareness policy. Finally, the machines were characterized as new, in good condition, and with light and sound signals during operation.

The rubric 'Repetitive work' brought notes of critical priority due to being characterized as monotonous and repetitive, generating dispersion. The postural issue generated discomfort, with flexion of limbs and head. With an intermediate level of urgency, it was found that workers ended up getting involved in each other's activities without planning and control. In addition, all operators knew all the activities and were able to work in any workstation.

Regarding 'Handling/weightlifting', only the process of weighing and packing the reels was characterized as of utmost urgency. In this step, operators handled products ranging from 0.5 kg to 22 kg, involving positioning them at waist and floor level (Figure 2). The same situation was reported during the raw material allocation stage, but because it involves less effort (masses from 0.5 kg to 12 kg) it was characterized as intermediate priority. Another point classified as intermediate was the transport of cables between operational posts, carried out with the dragging of boxes made with arms or legs.

Figure 2 – Lifting of the spool to move to the scale

Source: Authors, 2023.

As for the heading 'Noise', the topics were classified at the intermediate level of urgency. During the meeting, it was informed that a previous study was carried out by an audiometrist professional to evaluate the noise conditions during the operation. The noise was evaluated as intense, but acceptable, within the established standards, considering the mandatory use of hearing protectors to prevent long-term damage. Despite the determination and availability of ear protectors for all employees, there was no adherence to their use. It was also observed that both noise and ear protectors hindered oral communication between operators and, consequently, the operation.

The item 'Labor relations between workers' presented a point with intermediate priority: the exchange of jobs between workers in idle moments, without the manager's knowledge. In addition, it was evident that the employees were cooperative, teaching and learning together in harmony. The manager of the operation was respected and his instructions were complied with and complemented. Table 2 summarizes the main results of the 6 items presented, together with the criticality rating determined and the proposals for improvement raised.

Using the DeParis tool, it became evident that the activities were carried out empirically, with no alignment with the prescribed activity – which was still structured in a rudimentary way in the company. This fact could be due to the excellent working relationship between the operators who were constantly helping each other and seeking to make the activities more fluid due to their repetitiveness.

Employees appreciated the workplace, but some points related to waste management and operational *layout* were cited as aspects to improve. There were also reports regarding the inappropriate postures performed during the operations. The possibility of a postural and

anthropometric study of the workstations was viewed with positivity by both operators and managers.

Both the manager and the operators recognized the risks of accidents, especially during the operation with the machines and in their surroundings. The manager addressed that due to the specificity of the machinery there were no other safer models at the time of acquisition. It was mentioned that a question could be asked to the manufacturer about some update of parts (such as a security camera) that would protect operators. The need for a reformulation of the PPE policy in the company was also raised, combined with a policy and awareness about its use.

All participants agreed that the tasks were repetitive, but considered it positive that they could exchange operative positions with their colleagues. The production manager pointed out that this change was not recommended due to the specifications and exclusive responsibilities of each position, but that he was not opposed to the internal organization of employees as long as it did not interfere with productivity.

At specific points in the process, issues related to cargo handling were identified. Operators cited the packing stage more strongly, which involves trunk bending and lifting loads of up to 22 kg. Other steps mentioned were replacement of raw materials and transportation between stations.

Another important issue was related to the heading 'Noise'. The manager informed that there was a noise assessment carried out by an external professional hired shortly before this study. The evaluation classified the noise emitted during production as within the acceptable range, considering the mandatory use of hearing protection equipment. Even so, the operators indicated the difficulty of communication with the other operators and with the manager with the use of the protector, pointing out that, for them, this fact justified the non-use of PPE on a daily basis.

The work relationships between workers were described in a positive way, with mutual help between the operators and respect and contributions to the figure of the manager. The only issue that was indicated for possible intervention was related to the workflow at the stations, resulting in idleness and confusion of tasks between operators. The solution proposals based on the diagnosis obtained with the application of the DeParis method were listed using the 5W1H tool, as shown in Chart 3.

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Table 2 – Main results of the practical application of the DeParis method

Rubric	Answers	Proposals for improvement	Classification		
Workplaces	The work is done standing and sometimes squats and torso twists are performed.	Perform a postural and anthropometric study. General study of the workstation to check the arrangement of machines and tools.			☹
	There is room to carry out all the necessary movements, but without delineation of the areas of each operator.	Physical delimitation well marked (with positioning stickers) at workstations.		😐	
	The place is easy to access and in good condition so that the activities are well executed.		☺		
	There is no waste management, with accumulation and lack of definition of the place for packaging the waste.	Implement a Solid Waste Management Plan.		😐	
The risks of accidents	Ear protectors and gloves are available as PPE. The use of closed shoes is mandatory, but they are not available.	Formulate a kit with all the necessary PPE and encourage correct use through internal awareness programs.		😐	
	The machines are new and have an audible and light signal.		☺		
	The speed of the machines is high and there is no exclusive protection.	Search for safety devices that prevent contact with the machine in operation. Set minimum distance from the machine in operation.			☹
	The drying oven was developed by the operators themselves, and is not specific to the use it is given.	Acquisition of a dryer.			☹
	Risk of accident during the cable cutting stage, carried out with a box cutter.	Provide for the use of a tool without an exposed blade (cutting pliers). Create a specific workstation for the use of the thermal cutting machine.			☹
Repetitive work	Monotonous and repetitive work, there is dispersion.	Determine rotation between workstations. Create scale for breaks during shifts.			☹
	Workers engage in each other's activities during longer cycle times	Plan interchange between workstations during longer cycle times.		😐	

	There is flexion of the limbs and head.	Perform postural and anthropometric study.			☹
	All operators know and are able to work in any workplace.	Program scale with rotation of operating stations.	☺		
Handling/Weight Lifting	The reels are loaded manually from one station to another (approximate distance of 2m). Masses range from 0.5 kg to 22 kg.	Unify activities in just one workstation. It is proposed that the scale and the place for packaging be placed at the same level as the machine that forms the spools.			☹
	The allocation of raw materials in the dispensing machine involves manual transport from the stock sector (approximate distance of 2m). Masses range from 0.5 kg to 12 kg.			😐	
	Displacement of boxes with ready-made ropes occurs by dragging without standardization.	A wheelbarrow can be used to move the ropes between the stations.		😐	
The noise	Ear protectors are made available to all employees, but there is no adherence in use.	Implement a policy to raise awareness of the use of PPE. Elect one employee per month to be the PPE inspector.		😐	
	Noises disrupt oral communication between operators.	Participation in non-verbal language courses. Deploy more light signals on machines.		😐	
Labor relations between workers	Employees help each other, teach and learn together. There is a harmony among the team.		☺		
	Excessive autonomy in changing jobs.	Avoid interfering with the activity of another post during its performance, except when actually requested and possible.		😐	
	The manager of the operation is respected and his instructions are complied with. Employees question and complement the manager, helping to optimize activities.		☺		

Source: Authors, 2023

Chart 3 – Breakdown of the improvement proposals in 5W1H

What will be done?	Who will do it?	When will it be done?	Why will it be done?	Where will it be done?	How will it be done?
Postural and anthropometric study	Outsourced company	Second half of 2023	To analyze and verify the postures and workstations, also optimizing the arrangement of machines and tools, in addition to physically delimiting the workstations.	In the company itself	Ergonomic methods will be applied to define the optimal configuration of the *company* 's layout and its workstations.
Solid Waste Management Plan	Third-party environmental management company	First half of 2023	To regularize waste management by providing an exact definition of the waste management conduct in the routine of the operation.	In the company itself	A study of the site will be carried out, with analysis of the space for waste allocation. The waste will be classified and it will be studied if there is a need for special disposal.
PPE kit	Outsourced Company + OH&S Lead Employee	Immediately	To ensure the use of PPE.	In the company itself	PPE will be purchased as recommended. The kits will be personalized, containing name and instructions for use. They will be renewed periodically as instructed.
Acquisition of dryer machine	Manager	Immediately	To regulate the drying process in a machine suitable for this function.	On a specific vendor	Contact will be made with dryer machine supplier companies. The most cost-effective machine will be purchased.
Search for safety devices that avoid direct contact with machines in operation	Manager	Immediately	So that a survey is made of the existence of these devices on the market, safely, and that they can be used in machines.	Internet and telephone contact	Contact will be made with the companies supplying the machines asking if there is a device that meets the demand.

Creating a new cutting workstation with the use of the thermal cutting tool	Workers	Immediately	To enable the use of the tool already available, but not used on a daily basis because it is not prepared in an accessible place.	In the company itself	The thermal cutting machine will be allocated next to one of the machines that generates the highest demand and will be placed in condition for immediate use.
Acquisition of cable cutting pliers to replace the cutter in the cutting stage	Manager	Immediately	To replace the cutting tool with an exposed blade with a safer one.	On a specific vendor	Specialized cutting pliers that do not damage the handles and do not pose the risk of accident will be purchased from specialized tool stores.
Change of location of the scale	Workers	Immediately	So that the spools can be weighed without the need for displacement.	In the company itself	The location of the scale will be changed. This displacement will be manual, since it is a light scale.
Election of OH&S Contributor	Manager	Monthly	So that a culture of occupational safety is created.	In the company itself	A meeting will be held on the first business day of each month. Employees, with the manager's encouragement, must start an open vote to define the OH&S leader.

Source: Adapted from MALCHAIRE, 2003.

4. CONCLUSIONS

The proposed objective of carrying out a primary diagnosis of the ergonomic situation of a micro-manufacturing company in the nautical sector was achieved. The application of the DeParis method contributed to the identification of critical work situations, enabling a mapping of the existing risks in the operation and the proposition of immediate improvements to increase comfort, safety and productivity. Both the results presented, especially with the action plan for the implementation of the proposed improvements, as well as the discussion itself and the dynamics of applying the methodology were considered relevant and of high contribution potential by the company's representatives, motivating other actions and subsequent internal discussions.

Another concern present during the study was the use of methods aimed mainly at large companies to be applied to the context of a micro-enterprise. However, with the observation of small adaptations easily identifiable during the application, it was considered that all the tools used were adequate to provide the performance of the action in a methodological way, even in the unstable environment of small businesses. They were also fundamental in guiding accessible intervention proposals with potentially significant results. Even so, the possibility of creating a standard protocol for the implementation of the preliminary ergonomic analysis aimed at MSEs, which would take into account their distinct characteristics during the elaboration, to the detriment of treating them as exceptions, was seen as interesting by the work team, and remains as a suggestion for future work.

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