

ERGONOMIC ANALYSIS OF A WORKSTATION IN A MOBILITY AND ENERGY COMPANY

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ABSTRACT

Background: Cable preparation involves repetitive tasks, inappropriate postures, excessive noise and manual lifting of loads, factors associated with work-related musculoskeletal disorders (WRMD).

Objectives: To perform an ergonomic analysis in a Portuguese company, identifying the risk level of WRMD and propose improvement measures. **Methodology:** Initially, the Nordic Questionnaire and the Ergonomic Workplace Analysis (EWA) method were applied and to deepen the evaluation it was used the Rapid Upper Limb Assessment (RULA), Key Indicator Methods - Lifting, Holding, Carrying (KIM-LHC) and Key Indicator Methods - Manual Handling Operations (KIM-MHO), applied to reel placement, cable cutting and stripping. **Results:** The methods showed high repeatability, inadequate postures, excessive noise and heavy lifting. RULA revealed critical positions, especially in the lifting of reels and in the stripping. KIM-LHC classified the survey at the highest risk level, while KIM-MHO identified a slightly increased load in the cut. **Conclusions:** It was confirmed the presence of risk factors for WRMD and proposed the acquisition of an automatic stripping machine and a lifting cart, work gymnastics and a pamphlet for good postural practices. We conclude that these methods allowed a robust evaluation, contributing to the improvement of comfort, safety and efficiency of the workplace.

Keywords: Cable, Ergonomics, Prevention, Risk.

1. INTRODUCTION

Ergonomics plays a central role in improving working conditions and productivity, as well as adapting work to the worker (Iida & Buarque, 2021). Currently, quality of life, safety, and occupational health are fundamental topics related to human engineering (Iqbal *et al.*, 2025). Musculoskeletal problems remain among the most prevalent occupational diseases, being associated with repetitive movements, awkward postures, and prolonged manual tasks

(Nurhanisah *et al.*, 2025). Consequently, ergonomic assessments and studies are developed, to improve working conditions and reduce exposure to risk (Faust *et al.*, 2016).

The current understanding of human factors and ergonomics emphasizes the interaction of all stakeholders and work-oriented systems (Reiman *et al.*, 2021). In most companies, employees often perform their work based on the characteristics of the task and the working conditions. Thus, they sometimes adopt prolonged periods in certain postures, negatively influencing their health and leading to a reduction in their professional performance (Marková & Škurková, 2023).

Despite the growing number of publications exploring ergonomic assessment methodologies, there is still a gap in ergonomic case studies that link observational risk assessment methods to practical intervention measures.

Systematic reviews show that, although tools such as RULA (Rapid Upper Limb Assessment) is widely used in research, their application often lacks integrated analysis in more specific case contexts, restricting the understanding of their practical value in complex and specialized workstations (Kee, 2022). This limitation is particularly relevant in small or highly specific industrial environments, such as the one analysed in the present study.

Considering these scientific concerns, the present project, is framed as an exploratory ergonomic case study conducted in a Portuguese company linked to the mobility and energy sector. The aim is to carry out an ergonomic analysis of a specific workstation, following the approach adopted in other ergonomic studies by other authors (Gabriel *et al.*, 2023).

In this context, the cable preparation workstation of the partner company was selected due to the presence of repetitive manual activities, postural demands, and frequent handling of loads - conditions known to elevate WRMD risk (Nurhanisah *et al.*, 2025). Additionally, musculoskeletal complaints reported by workers reinforced the need to understand the risk factors associated with the tasks performed, as has already occurred in other studies (Baklouti *et al.*, 2024).

This study addresses three interrelated research gaps: (i) the systematic application of observational ergonomic assessment tools in a real industrial setting; (ii) the analysis of ergonomic risk factors beyond descriptive task characterization; and (iii) the development of evidence-based recommendations that can be transferred to similar workstations.

Given the exploratory nature of this research, the sample encompasses the entire accessible population of operators assigned to the workstation during the analysis period, in this case, only two workers. Although limited in number of individuals, the study is consistent with exploratory ergonomic case study design, in which analytical depth and contextual understanding are prioritized over statistical generalization. Similar methodological approach can be found in studies involving entire workstation populations in manufacturing contexts, where repetitive tasks and musculoskeletal complaints are prevalent (Kirci *et al.*, 2020).

The workstation integrates tasks such as coil placement, cable cutting and stripping; these activities are characterized by repetitive strain, demanding postures, and load lifting. The relevance of this analysis stems from the impact these activities can have on the development of work-related musculoskeletal disorders, directly affecting workers comfort, productivity, and health. To frame the present study, previous works that applied similar methodologies were analysed. Colim *et al.* (2020) carried out ergonomic evaluations in industrial contexts using diagnostic and observational methods comparable to those adopted here, while Rahman (2014) analysed work postures using the RULA method, demonstrating its applicability in identifying critical postures.

The main contribution of this work is threefold: (i) a systematic identification and quantification of WRMD risk factors in a cable preparation workstation using standardized observational

methods; (ii) a critical evaluation of these methods' applicability and sensitivity in an industrial field setting; and (iii) the formulation of well-founded ergonomic improvement proposals that are aligned with documented risk exposures and practical workplace constraints. Thus, the central goal is to evaluate the level of WRMD risk associated with manual cable preparation activities and to present evidence-based recommendations that contribute to a safer, more efficient, and ergonomically optimized workstation.

2. MATERIALS AND METHODS

The ergonomic assessment of the workplace aims to determine the risks to which workers are exposed, using methodologies that include observation of tasks, analysis of postures, efforts and environmental conditions. This section describes the methodological framework adopted to conduct the ergonomic assessment, detailing the study design, procedural stages, and data processing methods.

2.1 STUDY DESIGN

To select the workplace that would be the target of our ergonomic evaluation, we began by identifying indicators that justify the choice and the relevance of the analysis, starting by analysing jobs whose activity would be mostly manual. In the first contact with the workers of the cable preparation station, they reported recurrent muscle pain of the wrists, neck, shoulders and lumbar, with loss of strength during the activities. In addition, they reported recurring tingling sensation and sensitivity, especially after working hours. It is also added that activities present in the post are repetitive and are carried out during a shift of work (8h).

The tasks of the post consist in cutting and stripping cables with different diameters, and they are carried out manually using cutting pliers as main tool. In addition, the station contains a support for the placement of coils with cables, weighing between 30 and 50 kg, supplied by the workers themselves. For the performance of tasks in this post, it was verified that workers often adopt incorrect postures as shown in Figure 1. It should be noted that the workers are two women with 40 and 42 years of age, working in the post for about 10 years.



Figure 1: Tasks carried out by the workers at the cable station.

This methodological approach allows an in-depth and context-specific analysis of biomechanical and organizational risk factors.

Data collection was conducted during the morning shift over a two-week period. A mixed-method approach was adopted, combining self-reported instruments and observational ergonomic assessment tools to obtain a comprehensive evaluation of physical workload and musculoskeletal risk exposure.

As mentioned previously, the study involved two female workers, which correspond to the total number of workers allocated to this job position. Therefore, this research should be interpreted as an exploratory case study, and not as a generalizable study.

2.2 STUDY PROCEDURE

The ergonomic assessment was conducted in five sequential stages.

Stage 1 corresponded to preliminary observation with direct observation of the workplace for approximately 5 hours, distributed over different work periods. This allowed the collection of photographic records (left side view, front and back) to document postures and execution of tasks. The duration and frequency of each task were noted to assist in applying different methods.

Stage 2 incorporated the Nordic Questionnaire, which was self-administered. To make this possible, the workers received written instructions and clarifications on the pain scale, allowing the collection of information about musculoskeletal symptoms in the last 7 days and 12 months, in nine anatomical regions (Mesquita *et al.*, 2010). This method evaluates the intensity of pain, allowing for the compilation and descriptive summary by anatomical region and pain intensity. As mentioned, we did not have the opportunity to apply the questionnaire in person, that is, among the workers, however, it is not believed that the viability of the result will be affected since, according to the article evaluating the reliability of a self-administered musculoskeletal questionnaire (Dahl *et al.*, 2022), it presented moderate to good reliability for most pain sites.

In stage 3, the Ergonomic Analysis of the Work Environment (EWA) was applied, a diagnostic method that evaluates the conditions in the workplace through on-site evaluation, and the team assisted the workers in filling out the questionnaire, in order to clarify the pain scale and all other aspects necessary to ensure a correct assessment. This was chosen, since it is a method suitable for manual industrial activities and material handling tasks (Fernandes, 2011). Fourteen quantifiable items, that constitute determining factors for the safety, health and productivity of a workstation, were evaluated through a score assigned by the analyst (scale 1 to 4 or 5) and, also, a more subjective perception performed by the workers themselves (++ , + , - , --) (Costa, 2006). Each item was evaluated independently and subsequently compiled and compared for graphical representation.

Regarding stage 4, this was stuck with the application of RULA, since it is suitable for repetitive manual tasks, in particular those that cause repetitive upper-body strain, considering the trunk, neck and upper extremities (McAtamney & Nigel Corlett, 1993). The choice of this method was since the activities of the station are mostly focused on the use of upper limbs requiring high manual precision. In addition, it is noteworthy that for the selection of postures to be evaluated, we performed several observations of the activities on the factory floor, to identify and select the most critical postures. Based on the preliminary observation, three postures were selected for evaluation, these being the placement of the coils, cable cutting and cable stripping. These same postures were selected based on the frequency of occurrence, reported discomfort and, obviously, visual identification of deviations in relation to the correct postures to adopt. For each of these postures, three independent observations were made where, in each one, straight segments were drawn that enhance the visualization of deviations and assist the measurement of angles. The final scores of RULA were obtained according to the original scoring tables. Since not all tasks take

the same time to complete, a weighted RULA score was calculated considering the proportion of time spent on each task during the work shift.

Finally, in stage 5, two Key Indicator Methods (KIM) forms were applied, with the aim of complementing the analysis and making it more substantiated. The KIM are a risk assessment methodology that aims to document key indicators (in terms of physical demand for work), make correlations between the activity developed and the physical effort, as well as calculating the probability of overload and possible repercussions on workers' health (Klussmann *et al.*, 2010). In this way, the KIM-LHC (Lifting, Holding, Carrying) was used for the manual coil lifting sub activity, of a level practically corresponding to ground level. This application was motivated by the reading of an article that, although applying the Key Indicator Methods – Pushing and Pulling (KIM-PP) sheet in a task of pushing coils (Veronesi Junior *et al.*, n.d.), led the team to identify the convenience of using the KIM-LHC to evaluate lifting sub activity of electrical cable coils. On the other hand, combined with the fact that the workers had some complaints (having to exercise a high force to cut and also the cutting tool's cable being very straight), KIM-MHO (Manual Handling Operations) was applied to the electrical cable cutting sub-activity, since it is characterized by repetitive work, the use of hand tools while standing (BAuA, n.d.).

2.3 DATA PROCESSING AND ETHICAL CONSIDERATIONS

It should be noted that all scores were manually calculated and followed the original guidelines of each assessment method.

On the other hand, although the company authorized the study, the participation of the workers was voluntary. They gave their prior consent to the collection of any type of data, with the group committing to ensure the anonymity and confidentiality of both.

3. RESULTS

This chapter presents the results obtained from the application of different ergonomic assessment methodologies at the company's cable preparation station. The results are organized by method, allowing an objective reading of the identified risk levels.

3.1 NORDIC QUESTIONNAIRE

The results of the Nordic Questionnaire show the presence of relevant musculoskeletal complaints among the workers, covering various anatomical regions. The most affected regions are the neck, shoulders, wrists/hands and lumbar region, all directly involved in the tasks performed at the workplace.

For the last 12 months, both workers reported symptoms in these regions and indicated that these problems led them to avoid or limit the performance of their normal activities. Regarding the last 7 days, active complaints remain, at the level of the neck, wrists/hands and lumbar region, which demonstrates that the symptoms are not only historical, but persistent.

The pain levels reported are between moderate and high (5 to 8), with emphasis on the lumbar region, where the highest value was recorded. The bilaterality of several complaints, namely in the shoulders and wrists/hands, suggests a symmetrical exposure to biomechanical requirements, associated with the repetitive and manual nature of the tasks performed throughout the work shift.

3.2 ERGONOMIC WORKPLACE ANALYSIS

The results of the EWA method reveal several unfavourable evaluations in physical, organizational and environmental factors of the workplace. Lifting tasks, postures and movements, work repetitiveness, and noise stand out, all presenting high scores from the analyst and negative evaluations from the workers.

The item Lifting Tasks stand out as one of the most critical aspects, reflecting the manual handling of reels, an activity that implies high physical load and increased risk for the lumbar region and upper limbs.

The Postures and Movements were also evaluated, both by the analyst and the workers, being associated with forced positions, trunk inclinations and repetitive use of the upper limbs. The Repetitiveness of the work also obtained an unfavourable classification, showing the continuous execution of similar movements throughout the shift, with reduced alternation of tasks and limited breaks, which contributes to increased fatigue and risk of WRMD.

Regarding Noise, it was classified as high, having been recorded a value of 88.7 dB(A), which, combined with the need for verbal communication in the station, represents a factor of discomfort and potential additional risk. In addition, the item related to the difficulty in making decisions presented an unfavourable evaluation, associated with the malfunction of the display monitor of Manufacturing Orders, which makes it difficult to access the information necessary for the execution of tasks, conditioning the autonomy of workers and the normal flow of work. On the other hand, the lighting and thermal environment parameters are within the recommended values, according to the data provided by the company and the calculations made. The analyst's and worker's scores are shown graphically in Figure 2.

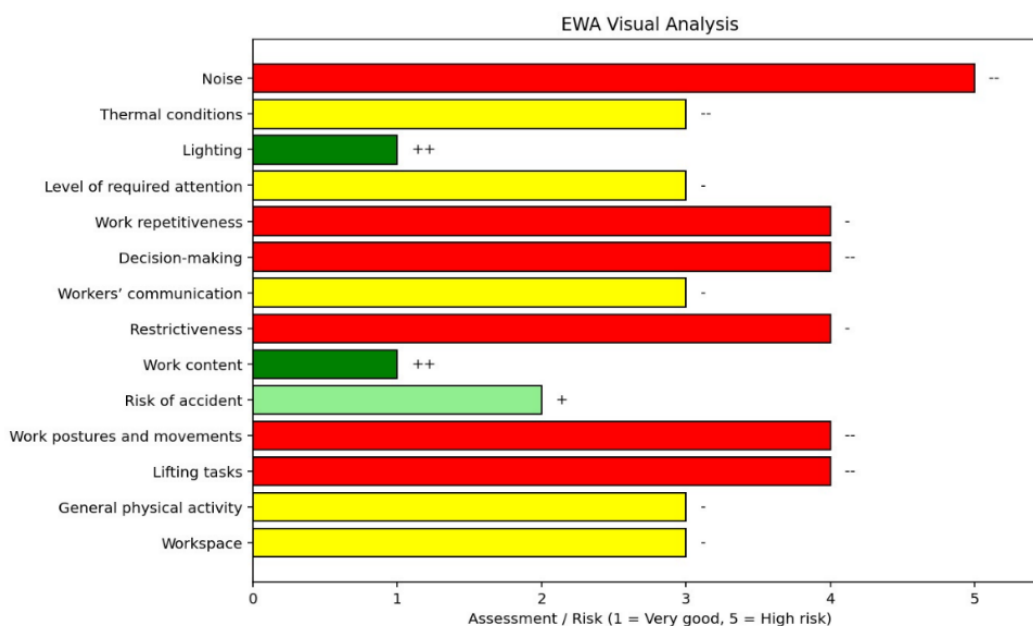


Figure 2: Chart of EWA results.

3.3 RAPID UPPER LIMB ASSESSMENT

The application of the RULA method focused on three positions considered critical, associated with the main tasks of the workplace: placement of coils, cutting and stripping cables.

In the posture corresponding to the lifting of the coils, a RULA score of 7 was obtained, indicating the need for immediate intervention. This score results from the combination of pronounced flexions of the trunk and neck, inadequate support of the lower limbs and application of high force due to the weight of the coils.

Regarding the posture adopted in the cable cutting task, the RULA score was 4, reflecting an intermediate risk level. Although the manipulated loads are reduced, the repetitiveness of the movements, the static position and the flexion of the neck contribute to the need for continuous observation and eventual introduction of improvements.

In the cable stripping task, the RULA score reached 7 again, showing a high ergonomic risk. This score is associated with accentuated arm flexion, wrist deflections, significant applied force and repetitive movements.

The weighting of RULA scores according to the time spent on each task resulted in a weighted RULA of 6 for the workplace, indicating the need to introduce changes in the short term.

3.4 KEY INDICATOR METHODS – LIFTING, HOLDING, CARRYING

The KIM-LHC was applied to the subactivity of manual lifting of coils. The final score obtained was 114,5, corresponding to risk level 4, the highest on the scale. This result indicates a high load intensity and a high probability of physical overload.

The main factors that contributed to this score were the weight of the load, the body postures adopted during the lifting, the unfavorable handling conditions and some aspects of the working conditions, such as the available space and the positioning of the load. The result highlights the need for reassessment of the post and implementation of priority preventive measures.

3.5 KEY INDICATOR METHODS – MANUAL HANDLING OPERATIONS

The KIM-MHO was applied to the cable cutting task, whose average duration is about 3 hours per shift. The final score obtained was 45, corresponding to a risk level 2, which indicates a slightly increased load intensity.

The factors that most contributed to this score were the high frequency of movements (about 30 cuts per minute), the force applied during the cut, the absence of adequate handles on the tool and the occasional adoption of joint positions close to the limit of the range of movement. Although the risk level is lower than identified in other tasks, these results indicate the possibility of physical overload, especially for less resilient workers.

4. DISCUSSION

In this chapter the results obtained for each of the methods are discussed, as well as the improvement proposals elaborated by the team.

4.1 ANALYSIS OF THE RESULTS

The integrated analysis of the results obtained through the different methodologies shows the consistent presence of ergonomic risk factors in the company's cable preparation station. The convergence of the results of the Nordic Questionnaire, EWA, RULA, KIM-LHC and KIM-MHO reinforces the robustness of the diagnosis performed and confirms the need for ergonomic intervention.

The musculoskeletal complaints reported by the workers in the Nordic Questionnaire, especially at the level of the upper limbs and the lumbar region, find direct correspondence in the results of

the observational and diagnostic methods. The repetitiveness of the tasks, combined with the application of force and the adoption of forced postures, appears as a determining factor for the development and maintenance of the identified symptoms. The most affected regions coincide with the most requested areas in the analysed tasks.

Although this tool was administered without researcher supervision, the results are consistent with the other tools used. The individuals surveyed received clear instructions on how to complete the questionnaire and did so correctly. Furthermore, evidence shows that this questionnaire, even when self-administered, can produce reliable results.

The EWA method allowed to identify not only physical factors, but also organizational and environmental aspects that contribute to the overall workplace risk. The repetitiveness of the work, the restriction of the tasks and the high noise create an unfavourable context that enhances the physical and mental fatigue of the workers. These factors, when combined with high loads and inadequate postures, enhance the development of WRMD.

The results of RULA and KIM-LHC clearly show that manual lifting of coils is the most critical situation in the workplace, requiring priority interventions. The high score obtained in both methods demonstrates that this task represents a significant risk for the lumbar region and for the upper limbs, being essential to act at the level of elimination or reduction of manual load. The task of detaching cables also appears as a high-risk activity, mainly due to the force applied, the postures adopted and the repetitiveness of the movements.

In addition, the results obtained with the KIM-MHO method reinforce the findings of the RULA analysis for the cable cutting task. Although the overall risk level was classified as moderate, the method highlights relevant contributing factors, namely the high frequency of movements, the significant force applied during cutting, and the inadequate tool grip. These aspects indicate that, despite not being the most critical task at the workstation, cable cutting still represents a potential source of physical overload.

Although the present study analyzed only a small sample, evidence from significantly larger samples indicates that the risk factors identified are strongly associated with musculoskeletal injuries, reinforcing the need for ergonomic corrective actions (Yang *et al.*, 2023).

4.2 IMPROVEMENT PROPOSALS

Given this context, several proposals for improvement were defined with a focus on eliminating or reducing the identified risk factors.

The acquisition of an automatic cutting and stripping machine emerges as a structural solution directly linked to the risks identified through the RULA method, which classified the skinning and cutting cables as one of the most critical postures. Evidence shows that automating repetitive and force-intensive tasks significantly reduces biomechanical load and exposure to repetitive movements (EU-OSHA, n.d.), supporting the relevance of this intervention. With this machine, the skinning and cutting process would be carried out entirely automatically, with workers only responsible for supervising and grouping the prepared cables. Its acquisition cost would be approximately €40,000.00. Although it represents a high investment, the feasibility analysis, demonstrates benefits in the medium term, both at an ergonomic and productive level.

Additionally, the introduction of a lifting cart aims to reduce the critical risk factor identified by the KIM-LHC. Scientific literature indicates that mechanical lifting aids reduce the required force and the risk of lumbar injuries (van der Beek & Frings-Dresen, 1998), reinforcing the suitability of this measure. With a cost of €823, this solution combined with the automatic stripping machine

would positively impact workers' daily activities, as the force required for both lifting coils and stripping cables would be lower, consequently reducing physical fatigue, risk postures, and task repetitiveness.

Organizational and behavioural measures, such as work gymnastics (Magalhães *et al.*, 2021) and the provision of a pamphlet to raise awareness for good postural practices, as can be seen in Figure 2, also respond directly to the risks associated with repetitiveness and prolonged postures. Evidence shows that these actions promote ergonomic awareness and contribute to the mitigation of the effects of repetitiveness and prolonged postures (Abdullah *et al.*, 2017), reinforcing the adoption of safer behaviours in the workplace.

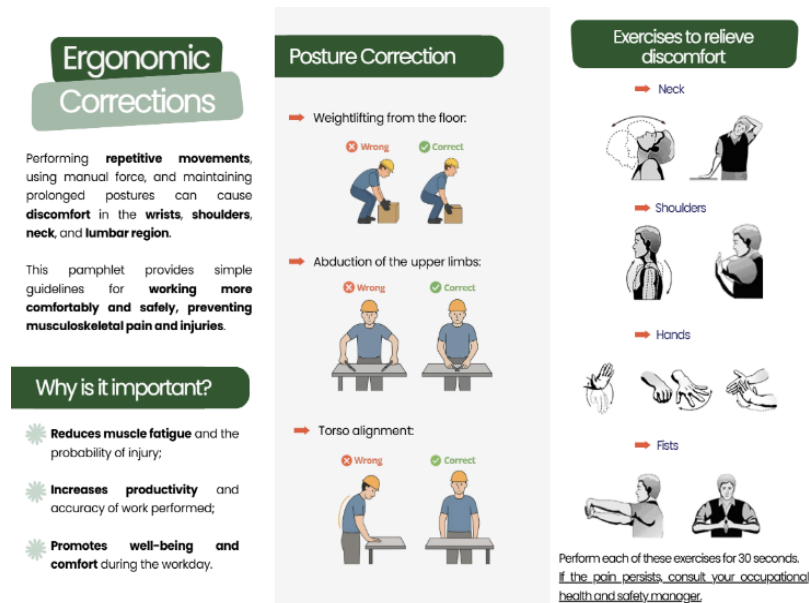


Figure 2: Pamphlet raising awareness about good posture practices.

In summary, the results obtained fully justify the implementation of the proposals presented, showing that an integrated approach (combining technical, organizational and training solutions) is essential to improve the ergonomic conditions of the cable preparation station.

5. CONCLUSIONS

The results obtained highlight high risk factors in several parameters, mainly due to the repetitiveness of tasks, inadequate postures, and lifting loads, increasing the likelihood of work-related musculoskeletal disorders and reinforcing the need to implement corrective measures to ergonomically improve the workstation.

During the study, limitations were encountered the tasks inherent to the workstation were performed exclusively in the morning shift and there were delays in production, which made it difficult to contact the workers and collect information. In addition, in terms of space, the workplace is narrow and rectangular. This makes loading and unloading materials difficult, and it is often disorganized, which increases risks, for example, due to the presence of cables scattered on the floor, compromising safety and the fluidity of activities. It is also important to acknowledge that this study presents significant limitations, mainly due to the very small sample size involved in the analysed tasks. This considerably restricts the external validity and generalisation of the

findings. Given this fact, future studies should involve larger and more representative samples to strengthen the robustness and applicability.

Thus, more time would be needed to sensitize the workers and deepen the analysis, including a more detailed assessment of noise, since the measured level would justify the use of Personal Protective Equipment, which is currently only recommended. Therefore, although high noise levels were identified, the study does not explore in depth the control and mitigation measures that should be implemented.

Among the proposals, the pamphlet and workplace gymnastics are already being implemented, with a positive impact. Even so, other actions remain pending, such as repairing the workstation monitor and acquiring the automatic blasting machine. Additionally, the lifting cart is already on site, although it has not yet been used.

That said, for a workstation with ergonomic problems, the diagnostic (Nordic Questionnaire and EWA) and evaluation (RULA, KIM-LHC and KIM-MHO) methods used proved effective, promoting an in-depth study and the achievement of well-founded proposals aimed at the well-being of the surroundings.

In addition to the results obtained, it becomes evident that further research is needed to deepen the understanding of the phenomena analysed. Future work should include longitudinal validation, allowing the monitoring of exposure and its effects over time, as well as the integration of an assessment of psychosocial impacts, particularly fatigue. Furthermore, potential intervention strategies regarding noise should be examined in detail, evaluating their effectiveness and feasibility.

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