LOW-COST ERGONOMIC INTERVENTIONS TO REDUCE RISK FACTORS FOR WORK-RELATED MUSCULOSKELETAL DISORDERS IN THE DENTURE FABRICATION WORKFORCE

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Abstract

To reduce risk factors for work-related musculoskeletal disorders (WMSDs) in the denture fabrication workforce, low-cost ergonomic interventions can be highly effective. This study aims to identify the risk of musculoskeletal disorders in the laboratory of PT X and reduce, enhancing worker comfort, productivity, and overall well-being. Using quantitative methods through RULA and REBA, as well as analysis of the ErgoFellow application, it was found that more than 50% of workers experienced musculoskeletal symptoms in the neck, shoulders, upper back, and wrists in the last 12 months. The Nordic Body Map questionnaire showed discomfort in most respondents due to their work. The results of the work posture analysis showed that the casting and sun-blasting workstations had a score of 4 with a moderate risk profile. In contrast, the night cooling workstation had the highest score of 6 with a moderate risk profile, indicating the need for further improvement. The night cooling station in particular requires investigation regarding the lowering of the stove position and adjustment of the pan position to reduce the risk to the arms and shoulders and improve safety. These recommendations are expected to improve working conditions and mitigate musculoskeletal risks at PT X.

Keywords: Ergonomic, Musculoskeletal Disorders, RULA, REBA

INTRODUCTION

Workers in various industries can be exposed to hazardous work factors that trigger the development of occupational diseases, negatively impact their ability to work, and reduce their quality of life (Karanikas et al., 2021); (Prayoga et al., 2024); (Suryadi & Islami, 2022). Work-related musculoskeletal disorders (WMSDs) are one of the most common occupational health problems, incurring significant costs to both workers and organizations (Govaerts et al., 2021);(Widjajati et al., 2021); (Dewi et al., 2023). By investing in preventive measures, organizations can reduce the incidence of WMSDs, improve worker health, and increase overall productivity. This, in turn, has a positive impact on the social and economic development of the community. Work-related musculoskeletal disorders (WMSDs) affect various tissues and structures in the body, causing pain and potential disability in various areas (Bonfiglioli et al., 2022); (Suryadi, Islami, & Suwardana, 2023). These disorders are usually caused by repetitive movements, uncomfortable postures, lifting heavy loads, or prolonged static positions that put stress on the body. Addressing WMSDs early and implementing workplace modifications can help prevent long-term injuries and disabilities, thereby protecting workers and organizational productivity (Asuquo et al., 2021); (Safirin, Islami, Sari, Panjaitan, et al., 2023).

The International Labor Organization (ILO) underlines the widespread prevalence of work-related diseases globally, with more than 160 million cases each year (Malta et al., 2024). Among them, Work-related musculoskeletal disorders (WMSDs) are one of the most common and widespread occupational health problems. This high prevalence reflects the significant impact of WMSDs on workers in various industries. One of the jobs that has the potential for workers to experience WMSDs is laboratory workers. Wet laboratories often require workers to be in positions that are not ergonomically ideal, which if left untreated for a long time, has the potential to cause health problems such as musculoskeletal disorders (Stegink-Jansen et al., 2021). This disorder, especially lower back pain, is one of the complaints that often arise among laboratory workers. Previous studies have shown a significant relationship between non-ergonomic work postures and low back pain complaints. Laboratory work involves various activities such as lifting heavy equipment, working in a sitting or standing position for a long time, and performing limited repetitive

movements (López-González et al., 2021); (Safirin et al., 2023); (Suryadi et al., 2021). All of these activities can increase the risk of musculoskeletal disorders, especially in the back, shoulders, and neck. Evaluation of the risk of musculoskeletal disorders in PT. X laboratory workers have never been carried out comprehensively using assessment methods such as RULA or REBA to identify jobs that are at high risk of musculoskeletal disorders. The main causative factors of musculoskeletal disorders in PT X's laboratory are also unknown whether they are caused by work posture, lifting load, or internal factors of workers such as age and length of service.

Evaluation of work posture in the PT X laboratory needs to be done using RULA and REBA assessment methods to identify jobs that are at high risk of musculoskeletal disorders. The evaluation results are expected to be used as a basis for recommending changes in work posture through redesigning jobs to comply with ergonomic standards to prevent musculoskeletal disorders in workers in the future. This study aims to reveal the risk factors for musculoskeletal disorders in PT. X laboratory so that appropriate preventive measures can be designed to improve workers' occupational safety and health. Our previous study results using RULA and REBA showed that the risk factors for developing WMSDs in most tasks in the wet lab of denture manufacturing produced medium to high values. The results showed that the risk levels of WMSDs were unacceptable in tasks at the grinding workstation, casting workstation, sun-blasting workstation, polishing workstation, and night cooling workstation. A systematic approach to implementing ergonomic interventions is essential to effectively reduce the risk levels associated with specific tasks. Therefore, the current study, in line with previous studies, was conducted to evaluate the effects of ergonomic design interventions on postural risk in certain high and very high tasks in laboratory work.

REVIEW OF LITERATURE

Ergonomic Interventions

Ergonomic interventions aimed at improving work posture are designed to reduce strain on the body, particularly the muscles, joints, and tendons, while enhancing comfort and efficiency. These interventions can help mitigate the risks of developing work-related musculoskeletal disorders (WMSDs) by encouraging neutral postures and reducing awkward

or static positions (Odebiyi & Okafor, 2023). These ergonomic interventions help foster healthier work postures by reducing the strain on the body and encouraging neutral positions during tasks. Proper workstation setup, training, and regular posture breaks are essential to maintaining comfort and preventing work-related musculoskeletal disorders.

Work-Related Musculoskeletal Disorders (WMSDs)

Work-related musculoskeletal disorders (WMSDs) refer to injuries or disorders of the muscles, nerves, tendons, joints, cartilage, or spinal discs that are caused or exacerbated by work activities (Bispo et al., 2022). These conditions typically develop over time due to repetitive motions, forceful exertions, awkward postures, or prolonged static positions in the workplace. Ergonomic interventions are essential for reducing the risk of work-related musculoskeletal disorders (WMSDs) by optimizing the design of workstations, tools, and tasks to fit the needs and abilities of workers (Choobineh et al., 2021). These interventions can improve comfort, efficiency, and safety, which leads to a reduction in strain on muscles, tendons, and joints (M. Islami & Sudiarno, 2023).

RULA (Rapid Upper Limb Assessment) and REBA (Rapid Entire Body Assessment)

RULA (Rapid Upper Limb Assessment) and REBA (Rapid Entire Body Assessment) are ergonomic assessment tools designed to evaluate the risk of musculoskeletal disorders in the workplace by analyzing postures, movements, and forces applied during tasks (Gür & Yeşilnar, 2024). REBA assesses the entire body, not just the upper limbs, and is used to evaluate awkward postures, forceful exertions, and static postures in a wider range of jobs, including manual labor, healthcare, and industrial tasks. REBA is broader in scope and can be applied to a variety of work tasks, particularly in environments where the whole body is engaged in physical work, such as lifting, pushing, pulling, and carrying. Both RULA and REBA are valuable tools for identifying and mitigating the risk of musculoskeletal disorders. By using these assessments, organizations can make informed decisions to improve ergonomic conditions in the workplace and protect workers from potential injuries.

RESEARCH METHOD

This study is a quantitative study by applying the RULA and REBA methods which aim to determine the posture conditions of wet lab workers, as well as the Nordic Body Map

questionnaire. Then the data that will be used in this study is in the form of photos when workers are doing their work. The photos captured are the positions on the side of the worker so that researchers can easily calculate and the results of the calculations have high accuracy and consistency. The Nordic Body Map, RULA (Rapid Upper Limb Assessment), and REBA (Rapid Entire Body Assessment) are ergonomic assessment tools used to evaluate the risk of musculoskeletal disorders (MSDs) in the workplace by analyzing postures, movements, and strain on the body. Each tool serves different purposes and targets specific parts of the body.

RESULTS AND DISCUSSION

The results from the Nordic Body Map (NBM) questionnaire administered to 16 workers provide insight into the prevalence and distribution of musculoskeletal disorders (MSDs) within the group. This analysis is crucial for identifying areas of concern related to workplace ergonomics and employee well-being. The findings highlight the importance of proactive ergonomic interventions to reduce the risk of MSDs in the workplace. By identifying the most affected body regions and associated tasks, targeted interventions can be implemented to improve worker comfort and productivity. Regular follow-up assessments using the NBM or other ergonomic tools such as RULA and REBA can further refine these interventions.

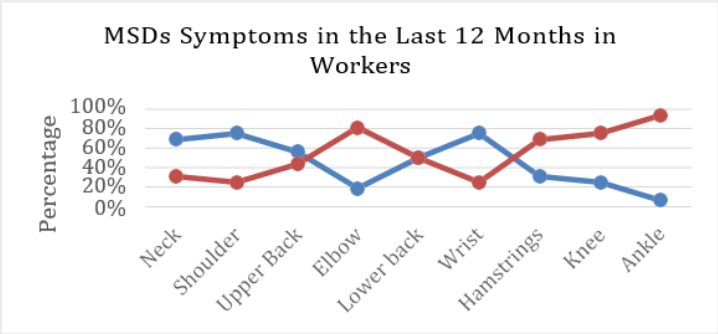

Figure 1
Symptoms of MSD in the last 12 months in workers

Based on Figure 1, the evaluation of the questionnaire results reveals notable variations in the symptoms of musculoskeletal disorders (MSDs) across different body regions. The results suggest that addressing MSD symptoms requires a tailored ergonomic approach, focusing on the most commonly affected areas like the neck, shoulders, upper

back, and wrists. While some regions (e.g., lower back) require selective intervention, others (like the elbows, buttocks, and knees) may benefit from targeted modifications to prevent long-term strain.

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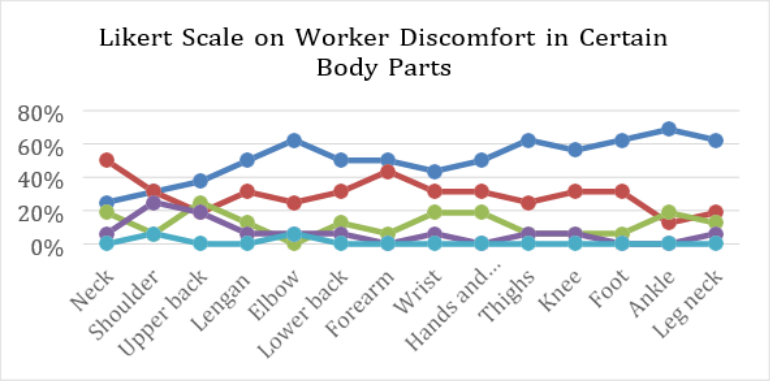

Figure 2
Graph of Discomfort Among Workers in Working on Specific Body Par

Based on the graph above, illustrates the levels of worker discomfort in various body parts during work. Very severe discomfort (scale 4 & 5) is felt by 6% of workers in the neck, arms, elbows, lower back, wrists, thighs, knees, and ankles. Additionally, 19% and 25% of workers feel severe discomfort, with 25% reporting it in the upper back and 19% in the neck, wrists, hands, and fingers. The graph indicates that 50% of respondents feel mild neck discomfort (scale 2), 44% feel pain in the lower arms, and 31% experience it in the shoulders, arms, lower back, wrists, hands, fingers, knees, and feet.

Further observations were made at five different workstations: casting, sun blasting, grinding, polishing, and night cooling. The five workstations showed results in the form of feet with a side view of the worker who was doing his job and was used to conduct RULA and REBA analysis. The worker's posture and upper body work position were calculated using the RULA method, and the overall body posture of the worker was calculated using the REBA method. The calculation was carried out when the workers carried out their duties according to the actual posture and body position, as in Figure 3. The RULA and REBA calculation method begins by estimating the points of the entire body and observing the values of certain angles in the required work posture. The data that has been obtained is then

processed using the ErgoFellow application so that the RULA REBA assessment results are obtained.

RULA Analysis for Grinding Workstation

Based on the RULA analysis of the Grinding worker's posture, the work posture produces a value of 3. This value indicates that the work posture is assessed in the category of Changes in some positions that may be needed.

Figure 3
REBA Analysis for Grinding Workstation

The slightly bent back position that cannot be supported by the chair backrest properly will potentially cause a bent work position. When the back is unsupported, the muscles of the back and core must work harder to maintain an upright position, leading to muscle fatigue and discomfort.

RULA Analysis for Casting Workstation

Based on the REBA analysis of the casting worker's posture, the work posture produces a value of 4. This value indicates that the work posture requires further examination and immediate improvement. The depth of the sink at the workstation with the casting machine needs to be held carefully.

Figure 4
REBA Analysis for Casting Workstation

A neck that is consistently bent downward contributes to a hunched posture, which places additional strain on the cervical spine, shoulders, and upper back. Prolonged periods in this position can lead to muscle fatigue, discomfort, and pain in the neck and upper back, affecting the worker's overall well-being.

RULA Analysis for Sun-Blasting Workstation

Based on the REBA analysis of the sun-blasting worker's posture, the work posture produces a value of 4. This value indicates that the work posture requires further examination and immediate improvement.

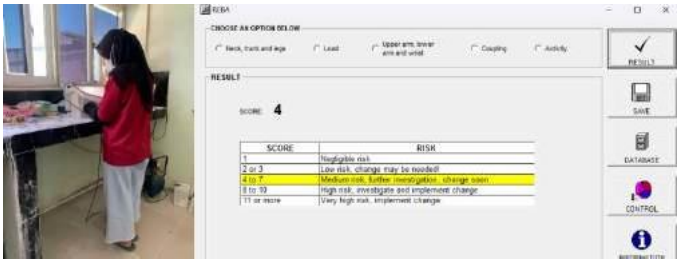

Figure 5
REBA Analysis for Sun-Blasting Workstation

The lower arm that is too bent upwards is evaluated in an unergonomic position, which can cause fatigue. This causes workers to need to bend their wrists down more than 15˚ to be able to do theirwork. In addition, the worker's legs look slightly bent, which if too long in a static position, will cause fatigue.

RULA Analysis for Sun-Blasting Workstation

Based on the REBA analysis of the Polishing worker's posture, the work posture produces a value of 2. This value indicates that the work posture is assessed in the category of Changes in some positions that may be needed.

Figure 6
REBA Analysis for Sun-Blasting Workstation

This is because the table height does not match the worker's height, so it needs to be adjusted. Prolonged periods in a bent neck position can contribute to musculoskeletal disorders, including cervical spine issues, chronic neck pain, and tension headaches.

RULA Analysis for Night Cooling Workstation

Based on the REBA analysis of the Night Cooling worker's posture, the work posture produces avalue of 6. This value indicates that the work posture is assessed as requiring work position inspection and repair as soon as possible.

Figure 7
REBA Analysis for Night Cooling Workstation

It sounds like the stove and table height are not ergonomically designed for the worker, which can cause discomfort and inefficiency, especially when dealing with large pans. When the stove and table heights are not suitable for the worker, it can lead to excessive bending, stretching, or reaching, causing discomfort and fatigue in the arms, shoulders, and back.

Low-Cost Ergonomic Interventions

Low-cost ergonomic interventions are practical solutions that can help improve comfort and reduce the risk of work-related musculoskeletal disorders (WMSDs) without requiring significant financial investment (M. C. P. A. Islami et al., 2023); (de Souza et al., 2021).

Table 1
Low-Cost Ergonomic Interventions

Workstation	Interventions
Grinding	Consider using lumbar support cushions or rolls that can be placed on existing chairs to encourage better posture
Casting	Use stacks of books, small boxes, or adjustable stands to elevate monitors to eye level, ensuring that the top of the screen is at or slightly below eye level. This encourages a neutral neck position.

Sun-Blasting	Raise or lower the work surface to ensure that workers can keep their arms bent at a more comfortable angle (ideally around 90 degrees). This will minimize wrist bending and improve overall posture.
Night Cooling	Provide footrests or stable platforms for workers to shift their weight while standing. This helps alleviate fatigue from prolonged standing

CONCLUSION

The results of the assessment analysis using RULA and REBA by utilizing the ErgoFellow ergonomics application obtained the following results: the casting workstation got a score of 4 and a moderate risk profile, so improvements need to be made even though it can be tolerated, the sun-blasting workstation got a score of 4 and a moderate risk profile, so enhancements need to be made even though it can be tolerated, and the night cooling workstation got a score of 6 and a moderate risk profile, so improvements need to be made. The night cooling workstation received a moderate risk profile but had the highest score of 6 among the other workstations, so further investigation and observation were needed. Improvements included lowering the stove's position, which was too high, putting workers at risk of experiencing musculoskeletal symptoms in the arms and shoulders, and placing the pan too close to the face, making it less safe. Addressing the ergonomic issues at the night cooling workstation is critical for reducing the risk of musculoskeletal symptoms and enhancing worker safety (Suryadi et al., 2023). Lowering the stove height and improving the placement of the pan will create a more comfortable and safer work environment. Continued monitoring and engagement with workers will ensure that the changes made are effective and sustainable.

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