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Effectiveness of Ergonomic Implementation on Working Postures in Denture Fabrication to Minimizing Musculoskeletal Disorder (MSDS) Complaints

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ABSTRACT

The dental laboratory has 2 denture manufacturing labs called wet and dry laboratories. In the wet laboratory, workers are required to be in non-ergonomic positions such as standing for too long, which if left untreated for a long period, can potentially cause health problems such as musculoskeletal disorders (MSDs). The main cause of musculoskeletal disorders in Dental Laboratory X is also unknown, whether caused by work posture, lifting load, or internal factors of workers such as age and length of service. Evaluation of work posture in Dental Laboratory X must be carried out using the RULA and REBA assessment methods to identify jobs that have a high risk of musculoskeletal disorders. The results of the assessment are expected to be used as a basis for proposing changes in work posture through rearranging jobs to comply with ergonomic standards to avoid musculoskeletal disorders for workers in the future. This consideration aims to reveal the risk variables for musculoskeletal disorders in Dental Laboratory X so that appropriate preventive measures can be planned to improve the safety and well-being of specialists. This consideration can be in the form of quantitative considerations using the RULA and REBA strategies that aim to determine the condition of the moist lab worker pose. The results of RULA and REBA scores at five different workstations show that calculations using the RULA strategy at the casting, crushing, and wax coating workstations scored 3, and sun exposure and cleaning scored 4. The RULA scores obtained indicate the level of immediate risk so that changes in position may be important but do not change the overall body position.

Keywords: Ergonomics, work posture, musculoskeletal disorder

Introduction

Occupational health and safety is a primary concern across industrial activities, including dental laboratorysettings (Bai et al., 2022; Sari et al., 2024; Suryadi, Islami, & Ramadhan, 2023; Prayoga et al.,2024; Islami & Sari, 2022). Manual tasks in wet laboratories often require non-ergonomic working postures, which, if sustained over the long term, can lead to health issues such as musculoskeletal disorders (MSDs) (Suryadi, Islami, & Suwardana, 2023; Widjajati et al., 2021a). Lower back pain is a common complaint among laboratory workers. Improving ergonomics in the laboratory helps reduce the risk of MSDs and enhances overall productivity by ensuring workers can perform tasks without distress or fatigue (Safirin et al., 2023); Bazaluk et al., 2023). Non-ergonomic working postures are related to complaints about low back pain in laboratory workers. In laboratory settings, workers often take uncomfortable or persistent postures, especially for tasks that require accuracy and fine motor skills, suchas pipetting, microscopy, or operational

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laboratory devices (Bazaluk et al., 2023). These postures can lead to stress, especially in the lower back's musculoskeletal system. Activities such as lifting heavy devices, prolonged sitting or standing, and repetitive movements increase the risk of musculoskeletal disorders, particularly affecting the back, shoulder, and neck.

A comprehensive evaluation of musculoskeletal risk in dental laboratory X was not performed using assessment methods such as RULA or REBA. The main factors that cause musculoskeletal problems in dental laboratory X remain unclear whether they result from working posture, lifting loads, or internal factors such as age and tenure (Suryadi et al., 2021a). Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA) are measurement methods that assess the risk of MSD complaints by determining worker's risk levels and categories (Kakaraparthi et al., 2022). Rapid Entire Body Assessment (REBA) and Rapid Upper Limb Assessment (RULA) are widely used based on ergonomic tools to assess the risk of developing musculoskeletal disorders (MSDs) by analyzing workers' postures, forces, and movements. Both methods can help identify high-risk tasks in various work environments, including laboratories, and guide improvements to reduce the risk of injury (Widjajati et al., 2021b). Both REBA and RULA provide insight into the ergonomic dangers workers face in laboratory settings, identify areas that need improvement, and areas where MSD complaints need to be prevented. These assessments allow prioritization of tasks that require immediate ergonomic intervention and serve as the basis for ergonomically robust work design. RULA and REBA methods can evaluate working postures at dental laboratory X.

The evaluation results are the basis of recommendations for posture modifications with new work designs to match ergonomic standards and prevent future musculoskeletal disorders among workers. Therefore, it is expected that RULA and REBA methods will affect future measures of the business group to address worker's well-being. Efforts to redesign jobs using REBA and RULA results as a foundation will significantly reduce the risk of MSDs, improve worker comfort and overall productivity, and create a healthier, safer working environment. Through continuous evaluation and appropriate changes in tasks based on REBA and RULA outcomes, businesses can support worker health and operational efficiency, creating an environment that leads to healthier, safer, and more productive workplaces.

Material and Methods

In this ergonomic posture evaluation study, the RULA (Rapid Upper Limb Assessment) and REBA(Rapid Entire Body Assessment) methods were applied to evaluate the working postures of laboratory workers in the wet laboratory environment. These environments involve repetitive, static, or unpleasant postures that can increase the risk of musculoskeletal disorders (MSDs). This study aims to identify high-risk body postures and recommend ergonomic interventions to improve worker's health, safety, and overall productivity (Islami et al., 2023). This study showed that laboratory workers in wet environments are at risk for MSDs due to non-ergonomic postures. By using RULA and REBA, the study provided a clear method for ergonomic improvements that reduce the risk of injury, improve comfort, and promote a safer productive work environment. Regular monitoring and re-evaluation were recommended to ensure that the ergonomic interventions continue to meet worker needs over time. Data were collected by photographs of performing their tasks between workers. The photo captured a side view of the worker and allowed for the evaluation of joint angles by considering the positions of the arms, shoulders, neck, and other body parts contributing to musculoskeletal risk. The research process involved the following stages:

1. Getting started: This initial step indicates that research has commenced.
2. Literature review: This stage involves gathering necessary information related to the research, both from fieldwork and existing literature.

3. Problem Formulation: This stage plays a crucial role in guiding the research. The purpose here is to identify and articulate the research problem, addressing issues that arise in the field.
4. Data collection: Researchers collect data that is directly relevant to the study, ensuring the accuracy and validity of the research. In your case, this includes photographing workers/ postures.
5. Data processing: Once collected, data needs to be organized and prepared for analysis.
6. Analysis and discussion: researchers analyze the processed data, draw conclusions, and discuss findings.
7. Conclusion: The research study concludes by summarizing results and suggesting future directions.

Nordic body map

The Nordic Body Map (NBM) questionnaire is commonly used in research to assess the prevalenceof musculoskeletal disorders (Adiyanto et al., 2022). It helps identify the specific body regions where workers experience distress, pain, or other symptoms that could be related to their working conditions. The Nordic Body Map (NBM) questionnaire is an invaluable tool for assessing the prevalence of musculoskeletal disorders in the workplace. Its application in research provides direct insights into worker distress, making it easier to implement ergonomic improvements that reduce therisk of MSDs, enhance worker health, and improve overall productivity (Suryadi et al., 2021b). By combining the NBM with objective assessments like REBA and RULA, researchers and ergonomists can develop comprehensive strategies to prevent MSDs and improve workplace safety.

Rapid Upper Limb Assessment (RULA)

The RULA method focuses on observing workers' upper body postures during their tasks. By observing work positions, postures, and movements related to upper limb use, RULA helps workers with the risks they face (Gajšek et al., 2022). This method aims to analyze and design precautions, particularly to improve upper body health and safety. The RULA method is a highly effective approach to analyzing upper body postures and analyze the identification of ergonomic risksthat can lead to musculoskeletal disorders (MSDs). By focusing RULA on the postures, using worker's upper limbs, RULA guides the development of preventive actions to enhance occupational safety and health, reduce the risk of injury, and promote a healthier, more productive workforce.

Table 1. RULA Score Table

Score	Risk Level	Explanation
1 – 2	Acceptable Posture	The category is good and ergonomic, so it does not require repair
2 – 3	Further investigation may be needed	Changes in some positions may be necessary
4 – 7	Further investigation, change soon	The need for further examination and changes is needed immediately
8 – 10	Investigate and implement change	High risk requires inspection and correction of position

Rapid Entire Body Assessment (REBA)

REBA method is an essential tool for evaluating the entire body posture of workers and identifying risks associated with the neck, back, arms, wrists, legs, and other body parts (Vachinska-Aleksandrova et al., 2022). By pinpointing high-risk postures, REBA provides a basis for designing preventive measures that enhance occupational safety and health, promote worker comfort, and prevent musculoskeletal disorders (MSDs). Its holistic approach makes it applicable

across various industries, ensuring that workers' health and well-being are protected through ergonomic interventions and improved work environments.

Table 2 REBA score table

Score	Risk Level	Explanation
1	Negligible	No correction required
2 – 3	Low risk	Changes in some positions may be required
4 – 7	Medium risk	Further inspection and immediate correction are required
8 – 10	High risk	Working position inspection and immediate correction are required
>11	Very high risk	Worker's posture should be changed as it is highly risky

Results and Discussion

Based on the results of the Nordic Body Map (NBM) questionnaire administered to 16 workers, we can analyze the prevalence and distribution of musculoskeletal disorders (MSDs) among the participants. By presenting the findings in this structured manner, you can effectively communicate the results of the Nordic Body Map (NBM) questionnaire and highlight the importance of addressing musculoskeletal health in the workplace.

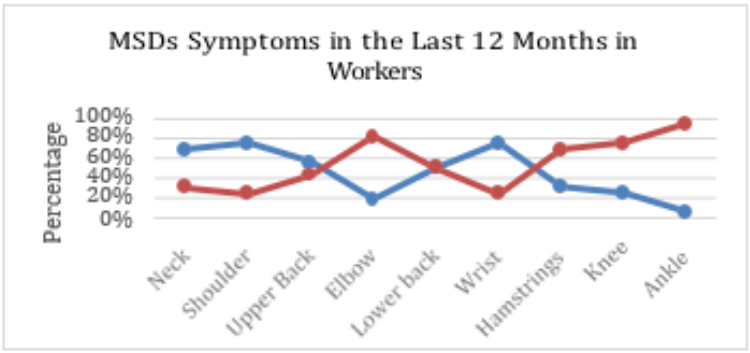

Figure 1. Symptoms of MSD in the last 12 months in workers

Based on Figure 1 above, evaluation of the questionnaire results shows variations in symptoms of musculoskeletal disorders (MSDs). Most workers experience neck, shoulders, upper back, and wrists symptoms. However, for the lower back, the number of workers who experience symptoms is equal to those who do not. A minority of workers reported symptoms in the elbows, buttocks/groin, knees, and ankles.

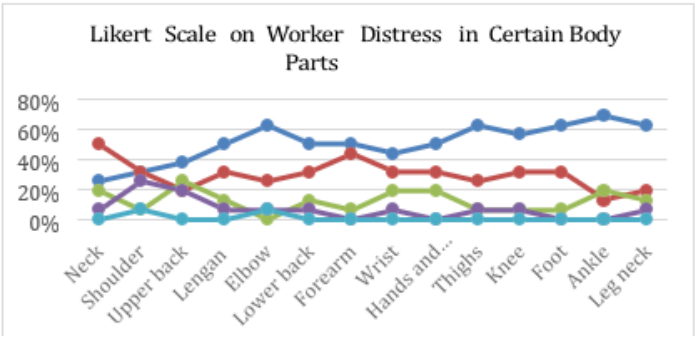

Figure 2. Graph of distress among workers in working on specific body parts

Based on the chart over, illustrates the levels of workers' distress in various body parts amid work. Very extreme distress (scale 4 & 5) is felt by 6% of workers within the neck, arms, elbows, lower back, wrists, thighs, knees, and ankles. Furthermore, 19% and 25% of workers feel extreme

distress, with 25% reporting it within the upper back and 19% within the neck, wrists, hands, and fingers. The chart shows that 50% of respondents feel mellow neck inconvenience (scale 2), 44% torment within the lower arms, and 31% encounter it within 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 wax cooling. The five workstations showed results in the form of feet with a side view of the worker who was doing his work and was utilized to conduct RULA and REBA analysis. The worker's posture and upper body work position were calculated utilizing the RULA method, and the overall body posture of the worker was calculated utilizing 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 starts by assessing the focus of the whole body and observing the values of certain angles within the required work posture. The data that has been obtained is at that point handled utilizing 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 shows that the work posture is surveyed within the category of Changes in a few positions that will be required.

The somewhat bowed back position that cannot be upheld by the chair backrest legitimately will possibly cause a bowed work position. This causes specialists to end up tired rapidly. In expansion, the workers' arms are not upheld appropriately, so an interesting base with a pad that fits the position of the workers' arms is required.

Figure 3. REBA analysis for grinding workstation

RULA analysis for the 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

This causes workers to have to twist their wrists down more than 15˚ to be able to do their work. In addition, the neck is in a downward-facing position, which can cause a hunched posture, making it uncomfortable if it is in that position for a long time.

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 shows that the work posture requires advanced examination and quick advancement.

Figure 5. REBA analysis for sun-blasting workstation

The lower arm that's also bowed upwards is assessed in an unergonomic position, which can cause fatigue. This causes workers to have to twist their wrists down more than 15˚ to be able to do their work. In expansion, the worker's legs seem somewhat bowed, which in the case as well as long in an inactive position, will cause fatigue. By altering the environment and providing proper ergonomic support, the worker's comfort and productivity can improve significantly, minimizing the risk of fatigue and long-term injuries.

RULA analysis for sun-blasting workstation

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

Figure 6. REBA analysis for sun-blasting workstation

The neck position is considered as well bowed. This can be because the table's tallness does not match the worker's tallness, so it ought to be balanced. Altering the table tallness and actualizing ergonomic arrangements will offer assistance to lighten the over-the-top neck bowing watched by laborers. These changes are crucial in preventing distress and potential musculoskeletal disorders, eventually driving a more beneficial and more profitable work environment. Regular evaluations should be conducted to ensure the effectiveness of these interventions and to make further adjustments as required.

RULA analysis for sun-blasting workstation

Based on the REBA analysis of the Wax Cooling worker's posture, the work posture produces a value 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 wax cooling workstation

It sounds like the stove and table height are not ergonomically designed for the worker, which can cause distress and inefficiency, especially when dealing with large pans. In this case, adjusting the work surface to fit the worker's height is crucial to reduce strain on the arms and shoulders. The table height should allow the worker to maintain a neutral posture, with arms bent at a comfortable angle (around 90 degrees) when handling the pan or other cooking tools. Making these ergonomic improvements will enhance worker comfort and productivity while reducing the risk of musculoskeletal issues.

Conclusion

Results of assessment analysis using RULA and REBA using the Ergofellow ergonomics application achieved the following results in casting and sun-blasting workstation, receiving a score of 4 which is a moderate risk profile, so improvements need to be made even though it can be tolerated. The wax cooling workstation received a score of 6 and it had a moderate risk profile but had the highest score among other workstations, which required further testing and observation. Improvements included lowering the stove position. The stove was too high, causing workers to be exposed to their arms and shoulders, and brought the pan too close to their faces, making it less safe. Addressing ergonomic issues at wax cooling workstations is important to reduce the risk of musculoskeletal symptoms and improve worker safety. Reducing the height of the stove and improving the placement of the pan creates a more comfortable and safe working environment. Continuous monitoring and commitment with employees ensure that changes made are effective and sustainable.

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