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Assessing and improving work postures in the manufacturing industry to mitigate musculoskeletal disorders using rapid upper limb assessment (RULA)

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Abstract

Manufacturing industries often encounter issues related to Musculoskeletal Disorders due to non-ergonomic work postures. This condition leads to fatigue, long-term injuries, and decreased worker productivity. Addressing poor work postures is crucial for creating a healthier and more efficient work environment. The aim of this study is to evaluate the risks of musculoskeletal disorders caused by non-ergonomic work postures in manufacturing industries and to develop effective ergonomic solutions to mitigate these risks. This study applies the Rapid Upper Limb Assessment method to assess work postures. Data on worker postures were collected, analyzed, and scored using Rapid Upper Limb Assessment to identify ergonomic risk levels and provide recommendations for posture improvements. The analysis of worker positions and movements during material lifting in manufacturing industries using the Rapid Upper Limb Assessment method resulted in a score of 7 (red), indicating the need for immediate investigation and correction. After implementing assistive device design, the final score improved to 2 (green), demonstrating that the intervention was effective in reducing Musculoskeletal Disorders and making the workers movements acceptable. The findings of this study suggest that the use of assistive devices can significantly reduce the risk of musculoskeletal disorders in workers. Ergonomic design improvements not only enhance comfort and safety but also have the potential to increase productivity and work efficiency in manufacturing industries.

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Keywords

Work postures, MSDs, RULA, Biomechanics

Introduction

The manufacturing industry is currently one of the sectors with a high number of injuries resulting in significant lost work time [1], [2]. Workers in this field often face greater physical demands, such as excessive fatigue, repetitive movements, and uncomfortable postures. These physical demands frequently lead to work-related musculoskeletal

disorders (MSDs) [3], [4]. Additionally, repetitive tasks are a major contributor to the development of MSDs [5]. As the manufacturing industry continues to evolve, efforts are needed to minimize risk factors that contribute to musculoskeletal disorders in the workplace.

MSDs are injuries or disorders that affect the human musculoskeletal system. Common types of MSDs in the manufacturing industry include neck pain, lower back pain, shoulder pain, and tendon or ligament disorders in the wrists and elbows. Injuries and workplace accidents remain a significant safety issue worldwide [6]. According to the International Labour Organization, approximately 7,600 people die every day due to work-related illnesses or workplace accidents [7]. Unsafe behavior by humans, which occurs frequently, is a leading cause of workplace accidents. Safety accidents in various industries not only result in personal injuries but also incur high economic costs [8], [9], [10]. These workplace accidents are directly linked to human factors, particularly unsafe operator behavior.

Preventive measures are therefore essential to reduce the occurrence of injuries and workplace accidents. The level of perceived workplace hazards by operators acts as a barrier to performing their tasks effectively. Numerous studies have been conducted to identify and address the risk factors leading to musculoskeletal disorders. Some studies have employed ergonomic methods, such as Rapid Upper Limb Assessment (RULA) and Rapid Entire Body Assessment (REBA), to evaluate workers' postures and provide recommendations for improvement to reduce the risk of musculoskeletal disorders [11], [12], [13], [14]. The Rapid Upper Limb Assessment (RULA) index is one of the most widely cited tools for evaluating ergonomic risks [15], [16], [17]. This assessment method involves observing the postures of workers during specific tasks and generating biomechanical and postural load values for the entire body, with particular emphasis on the neck, trunk, and upper limbs. RULA provides a comprehensive analysis of posture-related risks and is crucial for identifying potential ergonomic issues that could lead to musculoskeletal disorders

To address these challenges, it is crucial for companies to analyze workers' postures during tasks and implement appropriate interventions to correct non-ergonomic postures. One method that can be used to assess ergonomic risks is the Rapid Upper Limb Assessment. This study aims to evaluate the application of RULA in assessing the working postures of manufacturing industry workers and provide recommendations for improvements to reduce the risk of musculoskeletal disorders.

Method

Subject

This study involved one subjects aged 50 years working in the assembly workstation. Each task in the assembly process was observed with 3 repetitions. Individuals with acute musculoskeletal system injuries (such as herniated discs or spondylolisthesis),

motion limitations and/or spinal deformities, a history of spinal fusion (spondyloses), and rheumatic diseases were excluded from the criteria.

The research was approved by the Ethics Committee of Universitas Ahmad Dahlan under approval number 012204026. All participants voluntarily took part in the study, and all procedures were conducted in accordance with relevant guidelines and regulations.

Procedure

The independent variables in this study include complaints related to the upper arms, lower arms, wrists, wrist rotation, neck, trunk, and legs. The dependent variable is the final RULA score, which determines the level of risk associated with a specific task.

The primary objective of this study is to identify postural scores that remain unchanged when input parameters are altered. The RULA scoring system is a discrete type, which may classify certain postures as insensitive meaning different postures are rated as having the same risk. To deliver the RULA questionnaire, the first step is to identify the task or activity to be assessed, focusing on those that are repetitive, involve awkward postures, or require significant physical effort. Observations are then made, either directly or through video recordings, to capture the worker's posture during the task. These observations are analyzed by breaking down the posture into components, including the upper arm, lower arm, wrist, neck, trunk, and legs, each of which is scored based on angles, movements, and positions. Adjustments are made to these scores to account for factors such as force, repetition, or static loading. The final scores are combined using the RULA scoring system, resulting in an overall score that indicates the level of ergonomic risk. The score of RULA can see in Table 1.

Table 1. RULA Score and implication

RULA Score	Implications and risk posture
1-2	Acceptable posture
3-4	Further investigation. Change may be needed
5-6	Further investigation. Change soon
7	Investigate and Implement Change

Results and Discussion

RULA score

The use of the RULA questionnaire aims to identify the body parts of operators that experience pain or discomfort compared to those without complaints. The questionnaire is completed by a single worker at the assembly workstation.

The RULA scoring is performed manually and subjectively using the RULA reference table to determine the final score. This process involves observing the worker's posture during the assembly process and matching it to the scores provided in the RULA table. The results of the RULA analysis can be found in Table 2. Additionally, the scores are accompanied by colors that serve as action analysis codes.

Table 3. Calculation Using the RULA Table Before Redesign

	Step	Note	Score
1	Locate Upper Arm Position	Arms Raised 52,6°	3
		Shoulders Pulled Back	1
		Total	**4**
2	Locate Lower Arm Position	Lifting from Mid to Overhead 125,8°	1
3	Locate Wrist Position	Arms Straight < 15°	2
		Arms Moving Sideways to the Right	1
		Total	**3**
4	Wrist Twist	The palms are not shaking hands or upright	2
5	Look - up posture score in table A		5
6		Dynamic Movement	0
7		Load Greater Than 22lbs	3
8	Find Raw in Tabel C		8
9	Locate Neck Position	Forming an Angle 16°	2
		No Rotation and No Tilt	0
10	Locate Trunk Position	Forming an Angle 95,5°	4
		Neither rotating nor tilting.	0
11	Legs	Not supported	2
12	Look up Posture Score in table B		5
13		The movement is dynamic	0
14		Load > 22lbs	3
15		**Find Column in table C**	**7**
		Final Score	**7**

Based on Table 3, the results are influenced by Table A RULA, which assesses arm and wrist postures. Table B evaluates neck and trunk postures, while Table C RULA combines neck and trunk positions with arm and wrist positions, resulting in a final RULA score of 7. This score indicates that an investigation and immediate changes are required.

In addition to the analysis using the RULA table calculations, posture analysis was also conducted using CATIA software. The worker's posture was modelled with a manikin to accurately represent the operator's working position. This posture was designed to closely resemble the worker's actual condition, as illustrated in Figure 1.

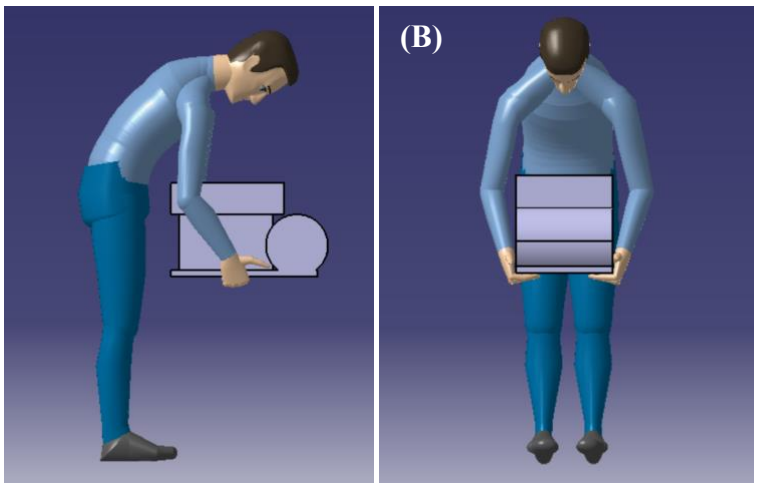

Figure 1. View of Working Posture

The movement shown in Figure 1 is performed repeatedly; this process is referred to as dynamic, as it is not in a static (stationary) state, and is conducted 20 times during a working day. In the RULA test, using CATIA software, intermittent movements

(repeated less than 4 times per minute) were selected. The results of the processing with CATIA software can be seen in Figure 2. Additionally, there are color codes used as an analysis action indicator.

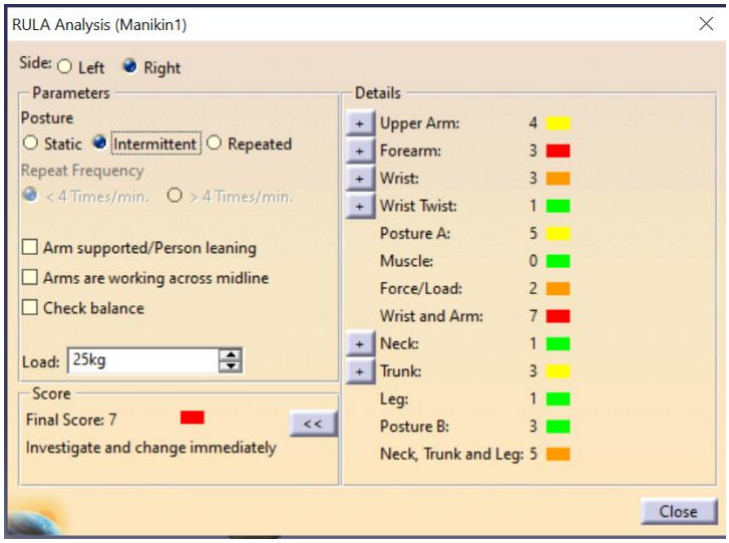

Figure 2. The RULA Analysis Results Before the Redesign

The RULA analysis results in Figure 2 show that the upper arm and trunk received scores of 4 and 3, with yellow coloring, indicating that these body parts have medium safety or require further investigation. The forearm and wrist and arm received red coloring, indicating that these body parts are hazardous or need immediate investigation and modification. The wrist section received an orange color, meaning this area has low comfort and requires investigation and immediate change. Meanwhile, the muscle, neck, and leg sections received green, indicating that these body parts are safe or acceptable. The final score of the RULA analysis for the worker's body posture is 7, with a red color. This indicates that immediate investigation and modification are necessary as this posture is unsafe.

Proposed Solution

The Assembly Table is a facility already available in the company, used to support the assembly of the machines that will be assembled. The table has ergonomic dimensions, with a height of 860mm, length of 1100mm, and width of 600mm. A hydraulic lift is designed as an assistive tool for workers in the final assembly process, which is packaging. The hydraulic lift measures 1500x1500mm, which is adjusted to the size of the pallet. The height of the hydraulic lift can be manually adjusted to the desired height by the worker, but it has a maximum height of 1000mm, which allows it to accommodate the 5th, 50th, and 95th percentiles. The design of the assistive tool can be seen in Figure 3.

The worker's working position after the design is evaluated according to the RULA guidelines in CATIA software. The design used in the RULA analysis in CATIA is based on the 50th percentile. This percentile is selected to match the worker's body dimensions

and serves as a reference, as the 50th percentile can be used by the majority of people. Figure 4 shows the RULA analysis using CATIA software.

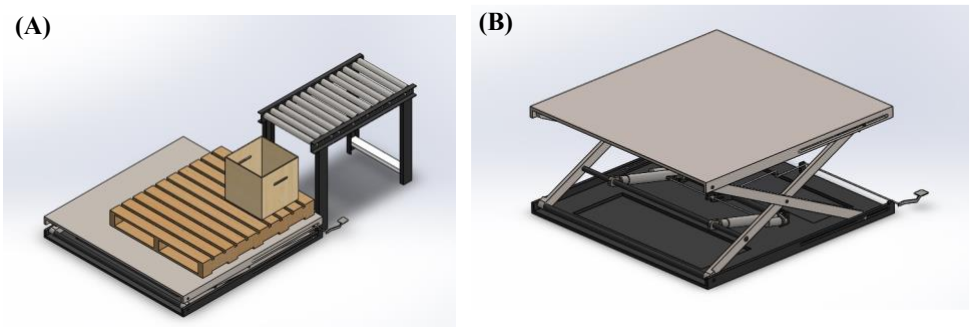

Figure 3. The complete assistive facility

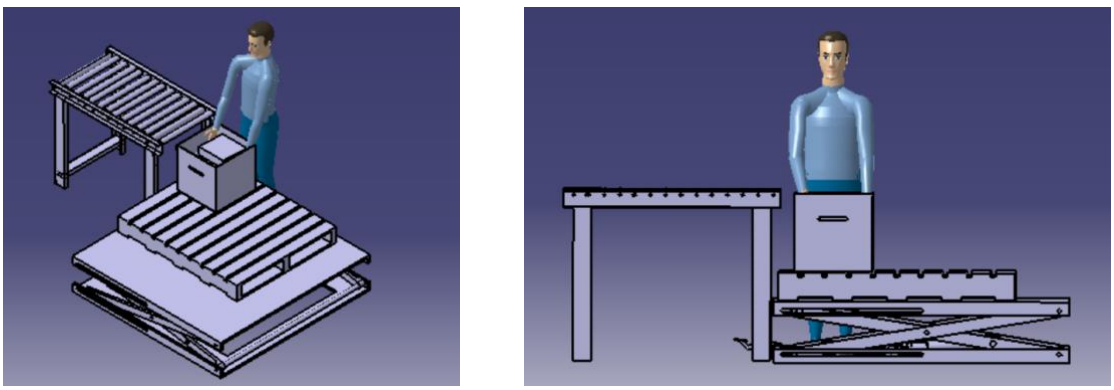

Figure 4. CATIA Mannequin

The RULA analysis results in Figure 5 show that the body parts on the right side, including the upper arm, wrist twist, muscle usage, neck, trunk, leg, wrist, and wrist and arm, all received green coloring. This indicates that the worker's posture is comfortable and acceptable for the body. However, the forearm received a red color, indicating that the posture with this position is hazardous. Despite this, the forearm's score is relatively low, at 3.

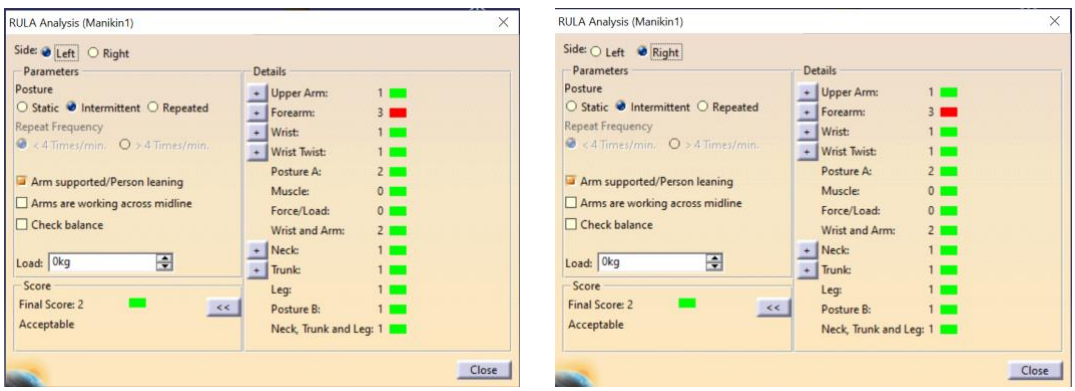

Figure 5. The RULA Analysis Results After the Redesign

In Figure 5 the body parts on the left side show that the upper arm, wrist twist, muscle usage, neck, trunk, leg, wrist, and wrist and arm all received green coloring, indicating that the worker's posture is comfortable and acceptable for the body. However, the forearm received a red color, indicating that this posture is hazardous. Nevertheless, the forearm has a low score of 3.

The final RULA score for both the right and left sides is 2, with green coloring. This score indicates that the body parts are free of risk and are comfortable. It shows that the operator's posture is acceptable after the improvement, as it aligns closely with ergonomic standards and minimizes the potential for injury.

Conclusion

The manufacturing industry faces a significant challenge with musculoskeletal disorders (MSDs), which often result in injuries and lost work time due to the physical demands of the job, such as repetitive movements and uncomfortable postures. The use of ergonomic assessments, particularly the Rapid Upper Limb Assessment (RULA), is crucial in identifying and mitigating these risks. This study demonstrated that the worker's posture at the assembly workstation was initially assessed as hazardous, with a RULA score of 7, indicating an immediate need for intervention.

By analyzing the worker's posture using both the RULA table and CATIA software, the study identified specific body parts requiring modification to reduce risk. The proposed solution involved redesigning the assembly process, including the introduction of a hydraulic lift to adjust the work height and support ergonomic postures. After implementing these changes, the final RULA analysis showed significant improvements, with a RULA score of 2, indicating a safe and comfortable working posture. These findings highlight the importance of ergonomic interventions in preventing MSDs and improving worker safety in the manufacturing industry. Implementing such solutions can significantly reduce injury rates, improve worker comfort, and enhance overall productivity.

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