JOURNAL LA MEDIHEALTICO

VOL. 06, ISSUE 03 (813-825), 2025
DOI: 10.37899/journallamedihealtico.v6i3.2256

Analysis of Musculoskeletal Disorders (MSDs) Complaints Among Shoe Production Workers and Posture Improvement Using the Posture Evaluation Index (PEI)

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Article Info

Article history:
Received 24 May 2025
Received in revised form 15 June 2025
Accepted 7 July 2025

Keywords:
Musculoskeletal Disorders
PEI
Work Posture

Abstract

This study aims to analyze Musculoskeletal Disorders (MSDs) complaints in shoe production workers at PT XYZ and evaluate work postures using the Posture Evaluation Index (PEI) approach. The methods used include data collection through direct observation, distribution of Cornell Musculoskeletal Discomfort Questionnaire (CMDQ), and posture assessment using OWAS, RULA, and REBA methods. The results showed that complaints most often occurred in the upper back, neck, and right shoulder, which were mostly caused by non-ergonomic work postures. The PEI assessment showed that the work section with the highest risk was the packing section, with a score of 2.7 indicating the need for immediate improvement. After improving the work posture according to ergonomic principles, the PEI score decreased to 1.6, indicating increased comfort and decreased risk of injury. This study emphasizes the importance of periodic ergonomic evaluations to improve work comfort and productivity.

Introduction

In the industrialized world, worker comfort and safety are very important. High productivity demands often force workers to adapt to repetitive workloads and positions, which can pose health risks if not adapted to the human physical condition. Ergonomics is the study of the harmony between humans and their work which aims to make work, equipment, information, and the environment harmonious with one another and reduce discomfort at work. Musculoskeletal disorders are one of the occupational diseases that need more attention, especially in the industrial sector (Odebiyi & Okafor, 2023; Kamijantono et al., 2024; Hilmi & Hamid, 2023; Amri & Putra, 2022; Rafeemanesh et al., 2021; Taifa, 2022). Musculoskeletal Disorders (MSDs) are generally caused by postures that are not in accordance with ergonomic principles. In the shoe industry, workers involved in production often face the challenge of unergonomic work postures, which have the potential to cause long-term injuries if not properly addressed (Hernandez et al., 2021; Najihah et al., 2024; Cao et al., 2024).

PT XYZ is a shoe industry company that has successfully met the needs of the domestic market and has also exported in various countries. The company is located in Pandaan, East Java. In the production process, PT XYZ has stages of production process, which are carried out systematically to ensure the quality of the products produced. PT XYZ pays great attention to worker comfort to ensure the productivity of each worker is maintained by providing adequate work facilities. But in fact, the facilities provided by the company are still not up to standard, such as chairs that are not equipped with backrests and tables that are too low in height, making workers feel uncomfortable when working for a long time (Saptiansyah et al., 20230. Based on observations, workers in the production department often complain about skeletal muscle disorders, which can affect their comfort and productivity.

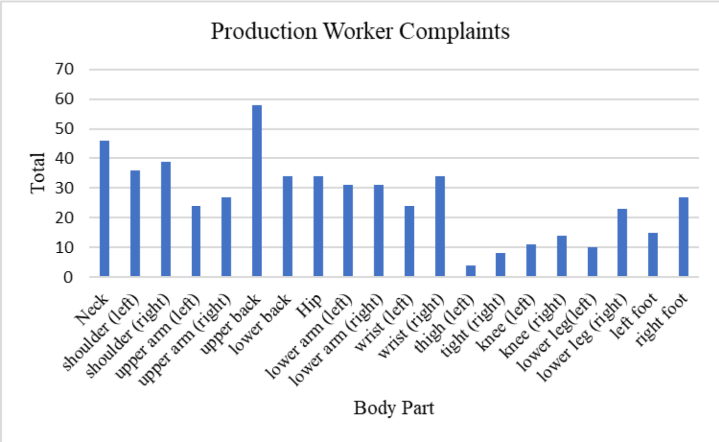

Figure 1. Production worker complaint data

Based on the complaint data of each worker in the production section, it is known that the most common complaints felt by production workers are the upper back as many as 58 workers, neck as many as 46 workers, and right shoulder as many as 39 workers. These complaints are generally caused by repetitive work for 8 hours 15 minutes of work with a break time of 45 minutes and often still have to work overtime if the production target has not been achieved and work facilities that are not in accordance with the anthropometry of workers. This condition not only affects the comfort and health of workers, but can also reduce company productivity due to decreased work quality for workers who experience these disorders.

This research is important to analyze musculoskeletal disorders (MSDs) complaints felt by workers, by looking at the frequency of pain, the level of discomfort, and the intensity of pain felt (Sani & Widajati, 2021; Silva et al., 2021; Greggi te al., 2024; Hamja et al., 2025; Hilmi & Hamid, 2023). This approach was chosen because through this Posture Evaluation Index (PEI) approach, it is hoped that a solution can be found to improve or change ergonomic work postures, which not only increase worker comfort, but also reduce the potential for injury and improve overall production performance.

Work Posture

Work posture is the determining point for analyzing the effectiveness of a job. The condition of the work posture performed will affect the fatigue experienced by the body and the occurrence of abnormalities in the shape of the body's bones (Apriliansyah & Suryoputro, 2022; Nugraha et al., 2024; Yizengaw et al., 2021). If the body easily experiences fatigue, it will have an impact on the decline and mismatch of expected performance (Purbasari & Mardhiyah, 2022; Behrens te al., 2023; Melin et al., 2024; Nurmi & Pakarinen, 2023).

***Musculoskeletal Disorders* (MSDs)**

Musculoskeletal disorders (MSDs) are health problems that affect the musculoskeletal system including muscles, nerves, tendons, joints, cartilages and spinal discs. MSDs can be caused by various factors including individual factors, work factors, and environmental factors (Zulkarnain et al., 2021; Afsharian et al., 2023). Individual factors include aspects such as age, gender, length of work, body size, and health conditions or physical fitness of workers. Occupational factors include work posture, length of work, repetitive movements, use of force or manual handling and the nature of the object being lifted. Meanwhile, environmental factors include conditions such as temperature, lighting, vibration, and microclimate in the workplace (Mindhayani & Suhartono, 2022; Králiková et al., 2021).

***Cornell Musculoskeletal Discomfort Questionnaire* (CMDQ)**

Cornell Musculoskeletal Discomfort Questionnaire (CMDQ) is a subjective questionnaire regarding the mapping of body parts that are felt to experience pain at work, with additional questions about the prevalence of musculoskeletal pain, severity, and its impact on respondents' performance (Aulia & Mahachandra, 2023). CMDQ is a combination of the *Nordic Body Map* (NBM) with additional questions about the severity and impact on respondents' job performance (Andriansyah & Putra, 2023).

***Posture Evaluation Index* (PEI)**

PEI is a score parameter in work posture assessment included in the OWAS method and integrated with other studies such as RULA and REBA. The purpose of PEI is to ergonomically optimize work postures in the work environment so as to produce an index number that represents the level of comfort and health in the workplace (Debora, 2025). The value or score resulting from the PEI calculation is categorized as high because it is close to the maximum PEI value of 3.42. If the value produced by the PEI calculation is 2.6-3.42, it is included in the high category and improvements must be made immediately to the workplace area. The formula used in this PEI method is as follows:

$$PEI = I_1 + I_2 + (I_3 \times mr)$$

While

$$I_1 = \frac{OWAS}{4} + I_2 = \frac{RULA}{7} + \left(I_3 = \frac{REBA}{15} \times 1{,}42\right)$$

Description:
mr = amplification factor with a value of 1.42

***Ovako Working Posture Analysis* (OWAS)**

The OWAS method identifies the frequency and adaptation time of body postures when given a task and is a system for studying and evaluating situations so that it can recommend corrective actions to improve the condition of workers' postures, so that job performance can be improved continuously. The OWAS method is fast in identifying and analyzing work attitudes in the movement of body parts in the back, arms, legs and the weight of the worker's load (Purbasari & Mardhiyah, 2022).

***Rapid Upper Limb Assesment* (RULA)**

According to (Adiyanto, et al., 2022) RULA consists of three steps, namely the development of work posture records, the development of an assessment system, and the development of an action level scale that provides risk level results. This method does not require special equipment in determining the assessment of neck, back, and upper arm posture. Each movement is given a predetermined score (Restiyanti & Sundari, 2021).

***Rapid Entire Body Assesment* (REBA)**

The REBA method is used to calculate and analyze all parts of the human body. By using this method, an assessment can be made by providing an assessment score between risks. If there is the highest score, it can result in a large risk in a job. Therefore it is very necessary to make improvements to reduce risks during work (Anthony, 2020).

Methods

Data collection is used to obtain relevant data and information in order to solve the problem being studied. Data collection was carried out by distributing questionnaires and observing workers' posture. The population in this study were all workers in the shoe production section.

ISSN 2721-1215 (Print), ISSN 2721-1231 (Online)

The population used in this study amounted to 79 people with details of 13 cutting, 9 screen printing, 6 marking, 33 sewing, 15 assembly, and 3 packing.

The calculation stage of the number and percentage of complaints experienced by workers based on frequency, severity and pain intensity values obtained from the Cornell Musculoskeletal Disorders Questionnaire (CMDQ) uses the following calculations:

Table 1. The scores for the final score

Frequency Score	**Never**	**0**
	1-2 times for week	1.5
	3-4 times for week	3.5
	Every day	5
	Several times a day	10
Discomfort Score	Slightly uncomfortable	1
	Moderately uncomfortable	2
	Very uncomfortable	3
Interfence Score	Not at all	1
	Slightly interferted	2
	Substantially interfered	3

Source: (Aljouhar & Alzayed, 2024)

Table 2. Final Score

Rating	Score
No Discomfort	0
Mild Discomfort	1.5
Moderate Discomfort	1.6 – 10
Severe Discomfort	> 10.5

Source: (Aljouhar & Alzayed, 2024)

The data analysis technique uses the Posture Evaluation Index (PEI) which is a score parameter in the assessment of work postures included in the OWAS method integrated with RULA and REBA. The results of the three methods can provide an assessment for work operations or the work environment. PEI is applied to optimize the work environment or even the operating system in terms of ergonomics. This method aims to describe work positions that are or are not in accordance with the parameters of ergonomics. The following is the Posture Evaluation Index Score used in this study:

Table 3. PEI Score

PEI Score	Description
0,47-1,04	The minimum PEI score that indicates the worker's posture has no workload.
1,05-2,5	PEI Score that indicate good work posture.
2,6-3,42	The maximum PEI Score is high and immediate improvements must be made to the workplace area.

Source: (Oktaviani, 2022).

Result and Discussion

Data Collection

Researchers collected data and information from the PT XYZ company to solve the problem of workers' posture in the production section. The data collected are primary and secondary data. Primary data is obtained from direct interviews and distributing questionnaires, while secondary data is obtained from several literatures such as books, journals, the internet and other sources related to the object of research and the subject matter to be discussed.

Cutting Section

Table 4. Recapitulation of CMDQ Questionnaire for Cutting Workers

Body Parts	No Discomfort Score (0)	Mild Discomfort Score (1,5)	Moderate Discomfort Score (1,6-10)	Server Discomfort Score (> 10,5)
Neck	7 (54%)	3 (23%)		3 (23%)
Left Shoulders	5 (38%)	4 (31%)	1 (8%)	3 (23%)
Right Shoulders	9 (69%)	4 (31%)		
Left Upper Arm	5 (38%)	5 (38%)	1 (8%)	2 (16%)
Right Upper Arm	13 (100%)			
Upper Back	4 (30%)	7 (54%)	1 (8%)	1 (8%)
Lower Back	10 (77%)	3 (23%)		
Hip	13 (100%)			
Left Lower Arm	4 (30%)	7 (54%)	1 (8%)	1 (8%)
Right Lower Arm	7 (54%)	5 (38%)	1 (8%)	
Left Wrist	5 (38%)	8 (62%)		
Right Wrist	6 (46%)	7 (54%)		
Left Thigh	10 (77%)	3 (23%)		
Right Thigh	8 (62%)	4 (30%)	1 (8%)	
Left Knee	7 (54%)	4 (30%)	1 (8%)	1 (8%)
Right Knee	5 (38%)	6 (46%)	2 (16%)	
Left Lower Leg	10 (77%)	3 (23%)		
Right Lower Leg	5 (38%)	7 (54%)	1 (8%)	
Left Foot	7 (54%)	4 (31%)	1 (8%)	1 (8%)
Right Foot	3 (23%)	2 (16%)	3 (23%)	5 (38%)

Based on table 4.3, it is known that the body part with the most mild discomfort is complained of in the left wrist as many as 8 workers. Moderate discomfort is most complained about on the right foot as many as 3 workers. While the most complained server discomfort is on the right foot as many as 5 workers.

Screen Printing Section

Table 5. Recapitulation of CMDQ Questionnaire for Screen Printing Workers

Body Parts	No Discomfort Score (0)	Mild Discomfort Score (1,5)	Moderate Discomfort Score (1,6-10)	Server Discomfort Score (> 10,5)
Neck	3 (33%)	3 (33%)	3 (33%)	
Left Shoulders	4 (44%)	5 (56%)		
Right Shoulders	3 (33%)	4 (44%)		2 (22%)
Left Upper Arm	5 (56%)	4 (44%)		
Right Upper Arm	3 (33%)	3 (33%)	1 (11%)	2 (22%)
Upper Back	2 (22%)	1 (11%)	3 (33%)	3 (33%)
Lower Back	5 (56%)	4 (44%)		
Hip	9 (100%)			

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Body Parts	No Discomfort Score (0)	Mild Discomfort Score (1,5)	Moderate Discomfort Score (1,6-10)	Server Discomfort Score (> 10,5)
Left Lower Arm	6 (67%)	3 (33%)		
Right Lower Arm	4 (44%)	5 (56%)		
Left Wrist	5 (56%)	4 (44%)		
Right Wrist	4 (44%)	3 (33%)	1 (11%)	1 (11%)
Left Thigh	8 (89%)	1 (11%)		
Right Thigh	6 (67%)	2 (22%)	1 (11%)	
Left Knee	5 (56%)	3 (33%)	1 (11%)	
Right Knee	5 (56%)	3 (33%)	1 (11%)	
Left Lower Leg	5 (56%)	3 (33%)	1 (11%)	
Right Lower Leg	5 (56%)	3 (33%)	1 (11%)	
Left Foot	2 (22%)	2 (22%)	2 (22%)	3 (33%)
Right Foot	2 (22%)		2 (22%)	5 (56%)

Based on table 4.4, it is known that the body parts with the most mild discomfort are complained about in the left shoulder and right forearm as many as 5 workers. Moderate discomfort is most complained of in the upper back as many as 3 workers. While the most complained server discomfort is on the right foot as many as 5 workers.

Marking Section

Table 6. Recapitulation of CMDQ Questionnaire for Marking Workers

Body Parts	No Discomfort Score (0)	Mild Discomfort Score (1,5)	Moderate Discomfort Score (1,6-10)	Server Discomfort Score (> 10,5)
Neck	1 (17%)		3 (50%)	2 (33%)
Left Shoulders	3 (50%)	3 (50%)		
Right Shoulders	2 (33%)	1 (17%)	2 (33%)	1 (17%)
Left Upper Arm	5 (83%)	1 (17%)		
Right Upper Arm	5 (83%)	1 (17%)		
Upper Back	1 (17%)	2 (33%)	1 (17%)	2 (33%)
Lower Back	3 (50%)	3 (50%)		
Hip		1 (17%)	5 (83%)	
Left Lower Arm	5 (83%)	1 (17%)		
Right Lower Arm	2 (33%)	3 (50%)	1 (17%)	
Left Wrist	5 (83%)	1 (17%)		
Right Wrist	2 (33%)	2 (33%)	1 (17%)	1 (17%)
Left Thigh	6 (100%)			
Right Thigh	6 (100%)			
Left Knee	6 (100%)			
Right Knee	6 (100%)			
Left Lower Leg	3 (50%)	3 (50%)		
Right Lower Leg	4 (67%)	2 (33%)		
Left Foot	6 (100%)			
Right Foot	6 (100%			

Based on table 4.5, it is known that the body parts with the most mild discomfort are complained of in the left shoulder, lower back, right forearm and left Lower Leg as many as 3 workers. Moderate discomfort is most complained about in the buttocks as many as 5 workers.

ISSN 2721-1215 (Print), ISSN 2721-1231 (Online)

While the most complained server discomfort is in the neck and upper back as many as 2 workers.

Sewing Section

Table 7. Recapitulation of CMDQ Questionnaire for Sewing Workers

Body Parts	No Discomfort Score (0)	Mild Discomfort Score (1,5)	Moderate Discomfort Score (1,6-10)	Server Discomfort Score (> 10,5)
Neck	14 (42%)	13 (39%)	5 (15%)	1 (3%)
Left Shoulders	25 (76%)	8 (24%)		
Right Shoulders	20 (61%)	5 (15%)	2 (6%)	6 (18%)
Left Upper Arm	28 (85%)	5 (15%)		
Right Upper Arm	19 (58%)	12 (36%)	2 (6%)	
Upper Back	10 (30%)	12 (36%)	1 (3%)	10 (30%)
Lower Back	17 (52%)	14 (42%)	3 (9%)	
Hip	11 (33%)	16 (48%)	3 (9%)	3 (9%)
Left Lower Arm	21 (67%)	12 (36%)		
Right Lower Arm	27 (82%)	6 (18%)		
Left Wrist	29 (88%)	4 (12%)		
Right Wrist	25 (76%)	5 (15%)	2 (6%)	1 (3%)
Left Thigh	33 (100%)			
Right Thigh	33 (100%)			
Left Knee	33 (100%)			
Right Knee	33 (100%)			
Left Lower Leg	33 (100%)			
Right Lower Leg	25 (76%)	8 (24%)		
Left Foot	33 (100%)			
Right Foot	25 (76%)	3 (9%)	4 (12%)	1 (3%)

Based on table 4.6, it is known that the body part with the most mild discomfort is complained about on the buttocks as many as 16 workers. Moderate discomfort is most complained about in the neck as many as 5 workers. While the most complained server discomfort is in the upper back as many as 10 workers.

Assembly Section

Table 8. Recapitulation of CMDQ Questionnaire for Assembly Workers

Body Parts	No Discomfort Score (0)	Mild Discomfort Score (1,5)	Moderate Discomfort Score (1,6-10)	Server Discomfort Score (> 10,5)
Neck	7 (47%)	5 (33%)	3 (20%)	
Left Shoulders	6 (40%)	8 (53%)	1 (7%)	
Right Shoulders	6 (40%)	7 (46%)	1 (7%)	1 (7%)
Left Upper Arm	11 (73%)	4 (27%)		
Right Upper Arm	11 (73%)	4 (27%)		
Upper Back	5 (33%)	5 (33%)	3 (20%)	2 (14%)
Lower Back	10 (66%)	4 (27%)	1 (7%)	
Hip	9 (60%)	3 (20%)	2 (13%)	1 (7%)
Left Lower Arm	12 (80%)	3 (20%)		
Right Lower Arm	9 (60%)	5 (33%)	1 (7%)	

Body Parts	No Discomfort Score (0)	Mild Discomfort Score (1,5)	Moderate Discomfort Score (1,6-10)	Server Discomfort Score (> 10,5)
Left Wrist	11 (73%)	4 (27%)		
Right Wrist	8 (53%)	5 (33%)	2 (14%)	
Left Thigh	15 (100%)			
Right Thigh	15 (100%)			
Left Knee	15 (100%)			
Right Knee	15 (100%)			
Left Lower Leg	15 (100%)			
Right Lower Leg	15 (100%)			
Left Foot	15 (100%)			
Right Foot	15 (100%)			

Based on table 4.7, it is known that the body part with the most mild discomfort is complained about in the left shoulder as many as 8 workers. Moderate discomfort is most complained of in the neck and upper back as many as 3 workers. While the most complained server discomfort is in the upper back as many as 2 workers.

Packing Section

Table 9. Recapitulation of CMDQ Questionnaire for Packing Workers

Body Parts	No Discomfort Score (0)	Mild Discomfort Score (1,5)	Moderate Discomfort Score (1,6-10)	Server Discomfort Score (> 10,5)
Neck	2 (67%)	1 (33%)		
Left Shoulders		2 (67%)	1 (33%)	
Right Shoulders				3 (100%)
Left Upper Arm	1 (33%)	2 (67%)		
Right Upper Arm	1 (33%)			2 (67%)
Upper Back				3 (100%)
Lower Back		3 (100%)		
Hip	3 (100%)			
Left Lower Arm		2 (67%)		1 (33%)
Right Lower Arm		2 (67%)	1 (33%)	
Left Wrist	1 (33%)	2 (67%)		
Right Wrist	1 (33%)	2 (67%)		
Left Thigh	3 (100%)			
Right Thigh	3 (100%)			
Left Knee	1 (33%)	1 (33%)		1 (33%)
Right Knee			2 (67%)	1 (33%)
Left Lower Leg	2 (67%)	1 (33%)		
Right Lower Leg	2 (67%)	1 (33%)		
Left Foot	1 (33%)			2 (67%)
Right Foot	1 (33%)			2 (67%)

Based on table 4.8, it is known that the body part with the most mild discomfort is complained of in the lower back as many as 3 workers. Moderate discomfort is most complained of in the right knee as many as 2 workers. While the most complained server discomfort is on the right shoulder and upper back as many as 3 workers.

OWAS, RULA, and REBA Calculation

ISSN 2721-1215 (Print), ISSN 2721-1231 (Online)

RULA, REBA, and OWAS are ergonomic analysis methods to assess work posture risks. RULA focuses on the upper body such as the neck, back, and arms. REBA covers the whole body including the legs and is suitable for heavier physical work. While OWAS is used to assess general postures in industrial activities, such as bending or lifting. All three help identify the risk of injury. Here are the OWAS, RULA, REBA values of each section.

Table 10. Recapitulation of OWAS, RULA, REBA Score

Section	OWAS Score	RULA Score	REBA Score
Cutting	1	5	3
Screen Printing	2	5	5
Marking	2	4	5
Sewing	2	4	5
Assembly	2	3	4
Packing	3	7	10

Based on the table, the Packing work section shows the highest score in all three ergonomic assessment methods (OWAS: 3, RULA: 7, REBA: 10), which indicates a very high level of ergonomic risk and requires immediate intervention to prevent injury. Meanwhile, the Cutting section has the lowest OWAS score (1), indicating that the work posture in this section is relatively safe. Other sections such as Screen Printing, Marking, Sewing, and Assembly have moderate scores, indicating potential ergonomic risks especially in upper body areas such as arms and shoulders. Thus, the Packing section requires special attention in improving work design or work posture, while other sections still need to be monitored and improved so that overall work safety and comfort can be maintained.

Evaluation of Workers' Posture with PEI

Evaluation of workers' posture is carried out to determine the level of fatigue or potential risk of injury to workers using the PEI method. Before calculating the PEI value, first an analysis is carried out using the OWAS, RULA, and REBA methods. After obtaining a score from each method, then the PEI calculation and analysis is carried out. The following is the PEI value of each section

Table 11. Recapitulation of PEI Score

Section	PEI Score	Description
Cutting	1,24	PEI Score that indicate good work posture
Screen Printing	1,68	PEI Score that indicate good work posture
Marking	1,54	PEI Score that indicate good work posture
Sewing	1,54	PEI Score that indicate good work posture
Assembly	1,3	PEI Score that indicate good work posture
Packing	2,7	The maximum PEI Score is high and immediate improvements must be made to the workplace area

Table 1.11 shows the PEI (Posture Evaluation Index) scores for several work sections. In general, almost all sections such as Cutting, Screen Printing, Marking, Sewing, and Assembly have PEI scores between 1.24 to 1.68, which indicates a good working posture and is still within safe limits. However, the Packing section has the highest score of 2.7, which is categorized as the maximum value and indicates a high ergonomic risk. Therefore, immediate improvement is needed in the working posture of the Packing section to reduce the risk of injury due to non-ergonomic working postures.

ISSN 2721-1215 (Print), ISSN 2721-1231 (Online)

Improvement Recommendations

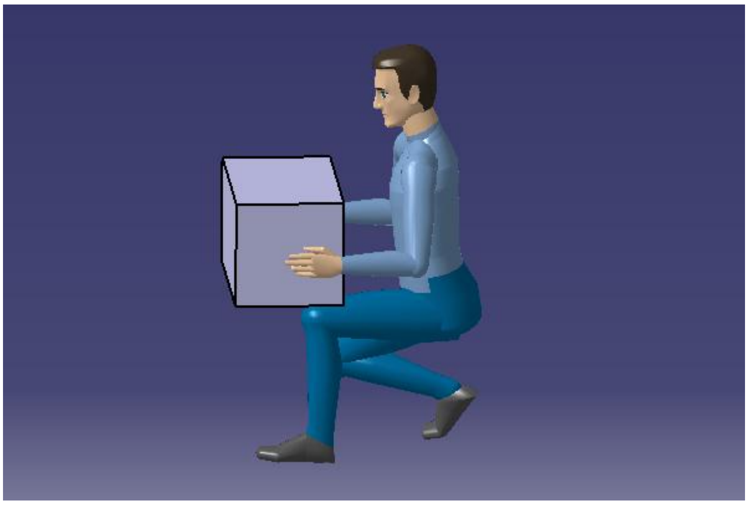

Figure 3. Suggested Posture Improvement When Lifting a Box

Proposed improvements to the packing work posture are given to reduce injury to workers' skeletal muscles so that workers can work optimally. This proposal includes adjusting the position of the body when lifting and moving boxes, such as keeping the back straight, adjusting the angle of the arms and wrists to remain in a neutral position which can be seen in Figures 1.2 and 1.3. With the application of ergonomic work postures, not only can the risk of injury be minimized but it can also increase work comfort. After improving the work posture. The PEI value in packing work before the improvement was 2,7 decreased to 1.6. This score indicates that the work posture is good.

Conclusion

Based on the results of the study, it can be concluded that musculoskeletal disorders (MSDs) complaints are mostly felt by workers in the upper back, neck, and right shoulder. These complaints are caused by work postures that are not ergonomic and work facilities that are not in accordance with workers' anthropometry. Evaluation using the OWAS, RULA, and REBA methods shows that the packing section has the highest level of ergonomic risk, with a PEI score of 2.7 which is included in the high category and requires immediate improvement. After improving the work posture by adjusting the body position when lifting and moving goods, the PEI score decreased to 1.6, indicating that the work posture has improved and is in the safe category. This shows that proper application of ergonomic principles can reduce the risk of injury, increase work comfort, and support increased worker productivity. Therefore, periodic evaluation and improvement of work posture is essential to create a safe and healthy work environment. To improve work comfort and safety, companies are advised to regularly evaluate work postures, especially in parts with high PEI scores, and provide ergonomic facilities and training on correct postures. Work rotation should also be implemented to reduce static load and repetitive motion. These steps can reduce the risk of MSDs and improve work efficiency and productivity.

References

Adiyanto, O., Mohamad, E., Jaafar, R., Ma'aruf, F., Faishal, M., & Anggraeni, A. (2022). Application of Nordic Body Map and Rapid Upper Limb Assessment for Assessing Work-related Musculoskeletal Disorders: A case study in Small and Medium Enterprises. *The International Journal of Integrated Engineering*, 10-19. http://dx.doi.org/10.30880/ijie.2022.14.04.002

Afsharian, A., Dollard, M. F., Glozier, N., Morris, R. W., Bailey, T. S., Nguyen, H., & Crispin, C. (2023). Work-related psychosocial and physical paths to future musculoskeletal disorders (MSDs). *Safety Science*, *164*, 106177. https://psycnet.apa.org/doi/10.1016/j.ssci.2023.106177

Aljouhar, L., & Alzayed, M. A. (2024). Musculoskeletal Disorders Amongst Undergraduate Engineering Studentd at Kuwait University. *Journal of Engineering Research*. https://doi.org/10.1016/j.jer.2024.12.004

Amri, A. N., & Putra, B. I. (2022). Ergonomic risk analysis of musculoskeletal disorders (MSDs) using ROSA and REBA methods on administrative employees faculty of science. *Journal of Applied Engineering and Technological Science*, *4*(1), 104-110. https://doi.org/10.37385/jaets.v4i1.954

Andriansyah, & Putra. (2023). nalisa Postur Kerja di PT. Karunia Selaras Abadi dengan Metode CMDQ, OWAS dan REBA. *Jurnal Optimasi*. https://doi.org/10.35308/jopt.v9i2.8450

Anthony, M. B. (2020). Analisis Postur Pekerja Pengelasan Di CV. XYZ dengan Metode Rapid Entire Body Assesment (REBA). *JATI UNIK*, 110-119.

Apriliansyah, R., & Suryoputro, M. R. (2022). The Effect of Work Posture on Work Fatigue in the Metal Moulding Department of XYZ Company. *International Journal of Business and Technology Management*, *4*(3), 141-154.

Aulia, & Mahachandra. (2023). nalisis Risiko Ergonomi Menggunakan Metode ROSA dan CMDQ pada Pekerja Dinas Perindustrian dan Perdagangan Jawa Tengah. *Industrial Engineering Journal*.

Behrens, M., Gube, M., Chaabene, H., Prieske, O., Zenon, A., Broscheid, K. C., ... & Weippert, M. (2023). Fatigue and human performance: an updated framework. *Sports medicine*, *53*(1), 7-31. https://doi.org/10.1007/s40279-022-01748-2

Cao, H. L., Elprama, S. A., Scholz, C., Siahaya, P., El Makrini, I., Jacobs, A., ... & Vanderborght, B. (2024). Designing interaction interface for supportive human-robot collaboration: A co-creation study involving factory employees. *Computers & Industrial Engineering*, *192*, 110208. https://doi.org/10.1016/j.cie.2024.110208

Debora, S. (2025). Analysis of Cleaning Service Work Postures to Reduce Musculoskeletal Injuries with the Posture Evaluation Index Approach. *Journal La MultiAPP*, 12-22. https://doi.org/10.37899/journallamultiapp.v6i1.1785

Greggi, C., Visconti, V. V., Albanese, M., Gasperini, B., Chiavoghilefu, A., Prezioso, C., ... & Tarantino, U. (2024). Work-related musculoskeletal disorders: a systematic review and meta-analysis. *Journal of Clinical Medicine*, *13*(13), 3964. https://doi.org/10.3390/jcm13133964

Hamja, A., Latif, M. A., Marma, M., Haq, M. M., Mustafa, M. A., & Morshed, M. S. (2025). Involving employees in reducing musculoskeletal discomfort while implementing lean: insights from the ready-made garments industry. *International Journal of Productivity and Performance Management*. https://doi.org/10.1108/IJPPM-09-2024-0659

Hernandez, C., Llabores, R., & Quevedo, V. (2021). Ergonomics study on productivity of middleaged workers in the shoe industry. In *Proceedings of International Conference on Industrial Engineering and Operations Management* (pp. 966-977).

Hilmi, A. H., & Hamid, A. R. (2023). Musculoskeletal Disorders: Industrial Insights and Ergonomic Interventions. *Malaysian Journal of Ergonomics (MJEr)*, *5*, 61-78. https://doi.org/10.58915/mjer.v5i1.375

Hilmi, A. H., & Hamid, A. R. (2023). Musculoskeletal Disorders: Industrial Insights and

Ergonomic Interventions. *Malaysian Journal of Ergonomics (MJEr)*, *5*, 61-78.

Kamijantono, H., Sebayang, M. M., & Lesmana, A. (2024). Risk Factors and Ergonomic Influence on Musculoskeletal Disorders in the Work Environment. *Journal La Medihealtico*, *5*(3), 660-670. https://doi.org/10.37899/journallamedihealtico.v5i3.1413

Králiková, R., Lumnitzer, E., Džuňová, L., & Yehorova, A. (2021). Analysis of the impact of working environment factors on employee's health and wellbeing; workplace lighting design evaluation and improvement. *Sustainability*, *13*(16), 8816. http://dx.doi.org/10.3390/su13168816

Melin, A. K., Areta, J. L., Heikura, I. A., Stellingwerff, T., Torstveit, M. K., & Hackney, A. C. (2024). Direct and indirect impact of low energy availability on sports performance. *Scandinavian journal of medicine & science in sports*, *34*(1), e14327. https://doi.org/10.1111/sms.14327

Mindhayani, I., & Suhartono, S. (2022). Penilaian Postur Kerja Pada Pekerja Bagian Penggorengan Keripik. *Tekinfo: Jurnal Ilmiah Teknik Industri Dan Informasi*, *11*(1), 28-41.

Najihah, K., Bawamenewi, M. A., & Bakara, B. S. (2024). Implementation of Work Improvement in Small Enterprises Program Through Participatory Training for Actors Food Sector. *Jurnal Perilaku Kesehatan Terpadu*, *3*(1), 56-73.

Nugraha, A., Widajati, N., Guan, N. Y., Febriyanto, E. C., & Dewi Oktavia, N. (2024). Risk Analysis of Work Posture and Body Mass Index to Musculoskeletal Disorders among Librarians at Universitas Airlangga. *The Indonesian Journal of Occupational Safety and Health*, *13*(2), 2540-7872. https://doi.org/10.20473/ijosh.v13i2.2024.144-154

Nurmi, N., & Pakarinen, S. (2023). Virtual meeting fatigue: Exploring the impact of virtual meetings on cognitive performance and active versus passive fatigue. *Journal of occupational health psychology*, *28*(6), 343. https://doi.org/10.1037/ocp0000362

Odebiyi, D. O., & Okafor, U. A. C. (2023). Musculoskeletal disorders, workplace ergonomics and injury prevention. In *Ergonomics-new insights*. IntechOpen.

Oktaviani, P. (2022). Analisis Postur Tubuh Pekerja pada Bagian Support Sandblasting di PT PO dengan Menggunakan Metode Posture Evaluation Index (PEI). *Jurnal Teknik Industri*. https://doi.org/10.25105/jti.v12i3.15650

Purbasari, A., & Mardhiyah, R. (2022). Penilaian Postur Tubuh Pekerja Hipes Plating Di PT. ABC Menggunakan Metode OWAS. *Jurnal Profisiensi*, 104-110. https://doi.org/10.33373/profis.v10i2.4739

Rafeemanesh, E., Khooei, A., Niroumand, S., & Shirzadeh, T. (2021). A study on musculoskeletal complaints and working postures in pathology specialists in Iran. *BMC Musculoskeletal Disorders*, *22*, 1-8. https://doi.org/10.1186/s12891-021-04870-w

Restiyanti, & Sundari. (2021). Analisis Postur Kerja Menggunakan Metode Rapid Upper Limb Assesment (RULA) di UMKM Kerupuk Kemplang 32 Kecamatan Bumi Waras Bandar Lampung. *Jurnal Ilmiah Teknik Industri*. https://doi.org/10.37090/indstrk.v5i1.361

Sani, N. T., & Widajati, N. (2021). Factors Affecting Risk of Musculoskeletal Disorders (MSDs) Complaints in Spring Production Workers. *Indian Journal of Forensic Medicine & Toxicology*, *15*(2). http://dx.doi.org/10.37506/ijfmt.v15i2.14854

Saptiansyah, R., Haqi, D. N., & Juwono, K. F. (2023). Proposed workstation design in laboratory for Musculoskeletal Disorder complaints. *Indonesian Journal of Occupational Safety and Health*, *12*(3), 382-390. https://doi.org/10.20473/ijosh.v12i3.2023.382-390

Silva, J. M. N., Gontijo, L. A., Bornia, A. C., Silva, L., Leite, W. K. D. S., & Vieira, E. M. D. A. (2021). Evaluation of musculoskeletal discomfort using item response theory: creation of a scale based on the self-reported pain symptoms. *Ergonomics*, *64*(2), 241-252. https://doi.org/10.1080/00140139.2020.1825823

Taifa, I. W. (2022). A student-centred design approach for reducing musculoskeletal disorders in India through Six Sigma methodology with ergonomics concatenation. *Safety Science*, *147*, 105579. https://doi.org/10.1016/j.ssci.2021.105579

Yizengaw, M. A., Mustofa, S. Y., Ashagrie, H. E., & Zeleke, T. G. (2021). Prevalence and factors associated with work-related musculoskeletal disorder among health care providers working in the operation room. *Annals of Medicine and Surgery*, *72*, 102989. https://doi.org/10.1016/j.amsu.2021.102989

Zulkarnain, M. A., Setyaningsih, Y., & Wahyuni, I. (2021). Personal characteristic, occupational, work environment and psychosocial stressor factors of musculoskeletal disorders (MSDs) complaints on bus driver: literature review. In *IOP Conference Series: Earth and Environmental Science* (Vol. 623, No. 1, p. 012013). IOP Publishing. https://doi.org/10.1088/1755-1315/623/1/012013