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Ergonomic Analysis Regarding Work-Related Musculoskeletal Disorder among Car Mechanics

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Abstract

Ergonomics, a critical component of occupational safety and health, aims to improve worker well-being and efficiency by enhancing safety, comfort, and productivity, thereby reducing injury risks. Despite its importance, ergonomics is still nascent in Malaysian workplaces. This study evaluates ergonomic standards in automotive workshop in Parit Raja, focusing on work-related musculoskeletal disorders (WMSDs). Using Self-Assessment Musculskeletal Pain Survey Form and ergonomic assessments with RULA and REBA method, the study identifies the prevalence of WMSDs and suggests preventive actions to improve workplace conditions and reduce physical strain.

1. Introduction

The history of ergonomic came from way back in the industrial revolution in the mid-19th century. After the Industrial Revolution in the mid-19th century, large-scale production took place. This emphasis on improving processes and production was based on ergonomic principles (Dennerlein, 2017). Ergonomic in Malaysia is in the infant stage and developing at a relatively slow pace in the field of research, education and community practice (Loo & Richardson, 2012). In the study conducted by Tosi (2020), ergonomics can be defined as the scientific discipline dedicated to comprehending the interactions between humans and various elements within a system, the definition also highlights ergonomics as both a scientific field and a profession that applies theoretical frameworks, principles, empirical data, and methodological approaches to optimize human well-being and the overall performance of systems (Tosi, 2020).

Despite its crucial role, ergonomics is still in its early stages of being implemented in Malaysian workplaces, especially in research, education, and community settings. A study is underway in automotive workshops in Parit Raja to evaluate the ergonomic standards and pinpoint any deficiencies that might lead to Work-related Musculoskeletal Disorders (WMSDs). Musculoskeletal disorders (MSDs) represent a major concern for occupational health in Malaysia, necessitating reporting under the Factories and Machinery Act 1967. Employees in various sectors are exposed to risks from repetitive motions, heavy lifting, and uncomfortable positions. The incidence of MSD cases has risen, with 201 cases reported in 2021, up from 112 in 2016 reported from SOCSO (*Department of Statistics Malaysia*, n.d.).

The goals of this research include identifying the frequency of WMSDs, evaluating ergonomics in the workplace using RULA and REBA, and suggesting preventive actions. The study incorporates self-evaluation questionnaires, ergonomic evaluations, and the application of tools like KINOVEA to gather data. The importance of this study lies in identifying ergonomic issues, preventing injuries in the workplace, and boosting productivity by offering employers effective strategies to improve the work environment.

2. Methodology

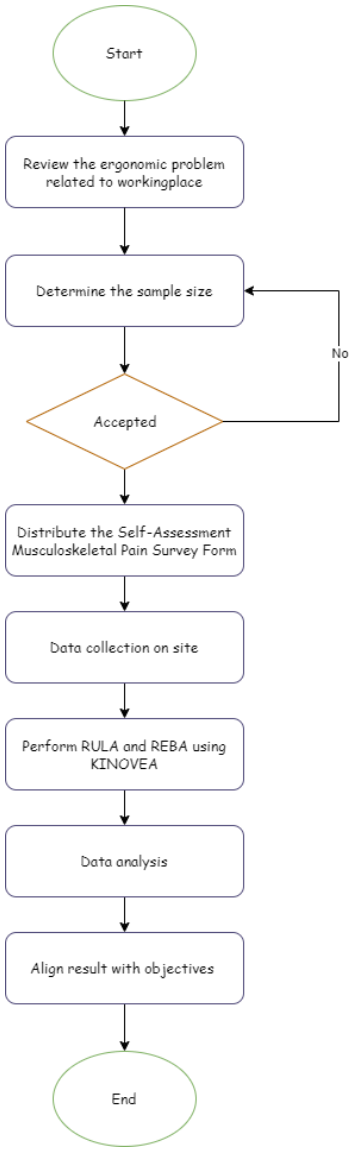

Figure 3.1: Research Methodology Flow chart

2.1 Data Collection Method

Data collection involved a Self-Assessment Musculoskeletal Pain Survey Form, Rapid Upper Limb Assessment (RULA), and Rapid Entire Body Assessment (REBA). The survey assessed the prevalence of work-related musculoskeletal disorders (WMSDs), while RULA and REBA evaluated ergonomic risks based on employees' work positions. Interviews, photographs, and videos documented employees' postures, allowing for a detailed ergonomic risk assessment. Each photo and video was meticulously analyzed using KINOVEA software to determine posture angle of mechanics. Score for RULA and REBA were determined by using the posture angle that come from the software.

3. Result and Discussion

3.1 Self-Assessment Musculoskeletal Pain

An ergonomic analysis of work-related musculoskeletal disorders (WMSDs) was conducted using the Self-Assessment Musculoskeletal Pain survey by DOSH, completed by 14 mechanics. Table 3.1 shows the data for discomfort over the last 12 months, with 92.86% of respondents experiencing upper and lower back discomfort, and 85.71% reporting shoulder pain. This high prevalence highlights the long-term impact of their work, emphasizing the need to address factors causing upper back, lower back, and shoulder pain. Additionally, 85.71% of mechanics experienced knee pain, and 71.43% reported calf pain, underscoring the effects of prolonged standing and squatting during repairs.

The least affected areas were the ankle and lower arm, with only 7.14% of respondents reporting discomfort. This indicates that while these areas are less impacted, a comprehensive approach is still necessary to address overall musculoskeletal health. Pain in unilateral body parts suggests that musculoskeletal problems affect the entire body, requiring treatments that consider the interconnectedness of different body parts. Addressing these issues is crucial to prevent reduced productivity, increased injury risk, and the need for more sick days, which can disrupt workflow and burden coworkers. Workplace adjustments are essential to prevent WMSDs and maintain mechanics' well-being.

Table 3.1: Prevalence of WMSDs during work in last 12 months

n = 14	**Frequency and Percentage of Discomfort of Mechanics During Work in Last 12 Months**							
	Single Region		Left & Right		Left Only		Right Only	
	f	%	f	%	f	%	f	%
Neck	7	50.00	-	-	-	-	-	-
Shoulder	12	85.71	-	-	-	-	-	-
Upper Back	13	92.86	-	-	-	-	-	-
Upper Arm	-	-	5	35.71	2	14.29	4	28.57
Elbow	-	-	4	28.57	2	14.29	1	7.14
Lower Arm	-	-	1	7.14	3	21.43	6	42.86
Wrist	-	-	9	64.29	2	14.29	0	0
Hand	-	-	5	35.71	2	14.29	2	14.29
Lower Back	13	92.86	-	-	-	-	-	-
Thigh	-	-	5	35.71	0	0	2	14.29
Knee	-	-	12	85.71	1	7.14	1	7.14
Calf	-	-	10	71.43	1	7.14	2	14.29
Ankle	-	-	1	7.14	0	0	1	7.14
Feet	-	-	2	14.29	3	21.43	1	7.14

Table 4.2 presents the frequency and percentage of discomfort among mechanics, divided into single region, both left and right body parts, left body parts only, and right body parts only. The single region column shows a high prevalence of shoulder pain, with 92.86% of respondents affected, highlighting the impact of daily activities. Additionally, 71.43% reported upper back pain, and 78.57% experienced lower back pain, due to awkward working positions such as kneeling, bending, and reaching overhead.

In the second column, knee pain was significant, with 92.86% of respondents affected, likely due to prolonged kneeling and standing. Calf pain was reported by 71.43% of respondents. The least affected regions were the thigh and feet, with only 7.14% experiencing discomfort. These findings emphasize the need for ergonomic interventions, regular breaks, and posture maintenance to improve mechanics' overall performance and well-being, ultimately enhancing workplace productivity.

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Table 3.2: Prevalence of WMSDs comes from work

n = 14	Frequency and Percentage of Discomfort of Mechanics Comes from Work							
	Single Region		Left & Right		Left Only		Right Only	
	f	%	f	%	f	%	f	%
Neck	5	35.71	-	-	-	-	-	-
Shoulder	13	92.86	-	-	-	-	-	-
Upper Back	10	71.43	-	-	-	-	-	-
Upper Arm	-	-	3	21.43	3	21.43	3	21.43
Elbow	-	-	4	28.57	0	0	2	14.29
Lower Arm	-	-	2	14.29	2	14.29	0	0
Wrist	-	-	2	14.29	1	7.14	1	7.14
Hand	-	-	5	35.71	3	21.43	1	7.14
Lower Back	11	78.57	-	-	-	-	-	-
Thigh	-	-	1	7.14	1	7.14	1	7.14
Knee	-	-	13	92.86	1	7.14	1	7.14
Calf	-	-	10	71.43	2	14.29	2	14.29
Ankle	-	-	6	42.86	2	14.29	2	14.29
Feet	-	-	1	7.14	0	0	0	0

3.2 RULA and REBA

3.2.1 Mechanic A

Figure 3.1 Posture Angle of Neck & Trunk

Figure 3.2: Posture Angle of Upper Arm & Wrist

Figures 3.1 and 3.2 show Mechanic A servicing a vehicle and replacing an oil filter, requiring them to lean over the engine compartment. The body posture was analyzed using RULA and REBA techniques and KINOVEA software. Figure 3.1 shows a trunk angle of 59.1 degrees and a neck angle of 19.6 degrees, while Figure 3.2 indicates an upper arm angle of 86.7 degrees and a wrist angle of 70.2 degrees. The RULA analysis reveals scores of 3 for the upper arm, 2 for the lower arm, 3 for the wrist, 2 for the neck, 3 for the trunk, and 1 for the legs. The muscle score is 1, and the load score is 0, resulting in a Wrist and Arm score of 5 and a Neck, Trunk, and Leg score of 5.

Using the RULA worksheet and interpolation, the final REBA score of 6 suggests an urgent need for investigation and potential adjustments to reduce the risk of MSDs. This evaluation indicates that Mechanic A's posture during the oil filter replacement task requires further examination and modifications to enhance working conditions and reduce physical strain. Table 3.3 summarizes the RULA analysis.

Table 3.3: RULA score Mechanic A

Mechanic	Wrist and Arm Score	Neck, Trunk and Leg Score	Total Score	Risk Level
A	5	5	6	Further investigation, change soon

Mechanic A's posture was analyzed using the REBA method with Figures 4.1 and 4.2 as references. Figure 3.1 shows the neck bent at 19.6 degrees, earning a score of 1, the trunk bent at 59.1 degrees, scoring 3, and the legs straight with no weight shift, scoring 1. Figure 3.2 shows the upper arm bent at 86.7 degrees with a raised shoulder, scoring 3, the lower arm slightly bent, scoring 2, and the wrist bent at 70.2 degrees, scoring 3. The light weight (under 2 kg) and good interaction both scored 0.

Using the REBA worksheet, Posture Score A (neck, trunk and leg) was 2, and Posture Score B (arm and wrist) was 5. Adding the Load Score to Score A kept it at 2, and adding the Coupling Score to Score B kept it at 5. Interpolating these in REBA Table C gave a Score C of 4. Adding the activity score of 1 resulted in a final REBA score of 5, indicating a medium risk of developing WMSDs. This suggests further investigation and potential adjustments are needed. Table 3.4 summarizes the REBA analysis.

Table 3.4: REBA score Mechanic A

Mechanic	Score A	Score B	Score C	Activity Score	Total Score	Risk Level
A	2	5	4	1	5	Medium risk, further investigation, change soon

3.2.2 Mechanic B

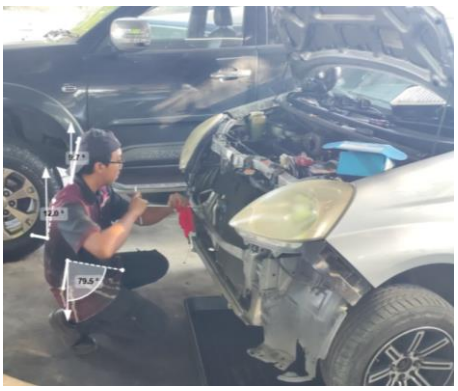

Figure 3.3

Figure 3.4

Figures 3.3 and 3.4 show Mechanic B fixing the radiator fan, requiring a kneeling position to access it. Mechanic B's posture was analyzed using the RULA technique and KINOVEA software. Figure 3.3 shows a neck angle of 9.7 degrees, a trunk angle of 12 degrees, and leg angle of 79.5 degrees. Figure 3.4 shows an upper arm angle of 40.4 degrees, a lower arm angle of 133 degrees, and a wrist angle assumed to be between 0-15 degrees. The RULA analysis for Mechanic B gives an upper arm score of 2, a lower arm score of 2, a wrist score of 2, a wrist twist score of 1, a neck score of 1, a trunk score of 2, and a leg score of 1. The Muscle Score was 1, and the Load Score was 0.

Using the RULA worksheet, Posture Score A was determined by interpolating Table A to get a value of 3. Adding the Muscle and Load Scores resulted in a Wrist and Arm Score of 4. The Posture B Score was 2, and adding the Muscle and Load Scores resulted in a Neck, Trunk, and Leg Score of 3. Interpolating these scores in Table C gave a final RULA score of 3. This score indicates that change may be needed and further investigation is required to mitigate the risk of MSD. Table 3.5 summarizes the RULA analysis.

Table 3.5: RULA score Mechanic B

Mechanic	Wrist, Arm Score	Neck, Trunk and Leg Score	Total Score	Risk Level
B	4	3	3	Further investigation, change may be needed

Mechanic B's posture was analyzed using the REBA method. In Figure 3.3, the neck angle was about 9.7 degrees (score 1), trunk angle was 12 degrees (score 2), and leg angle was 79.5 degrees (score 3). Figure 3.4 showed an upper arm angle of 40.4 degrees (score 2) and a lower arm angle of 133 degrees (score 2), with a wrist score of 1. Given the weight involved was light, the Weight Score and Coupling Score were both 0.

Using the REBA worksheet, Posture Score A was found to be 4, and Posture Score B was 2. Adding the Load Score to Posture Score A and the Coupling Score to Posture Score B resulted in Score A and Score B both being 4. Interpolating these in REBA Table C gave a Score C of 4. With an activity score of 1, the ultimate REBA score was determined to be 5, suggesting a medium risk of MSDs associated with the workplace. Further research and potential changes to the job task or surroundings are necessary to lower the risk of harm. Table 3.6 summarizes the REBA analysis.

Table 3.6: REBA score Mechanic B

Mechanic	Score A	Score B	Score C	Activity Score	Total Score	Risk Level
B	4	2	4	1	5	Medium risk, further investigation, change soon

3.2.3 Mechanic C

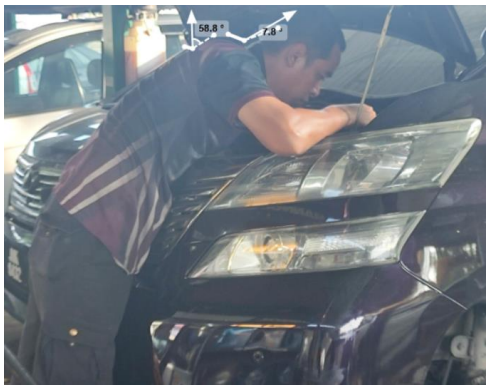

Figure 3.5

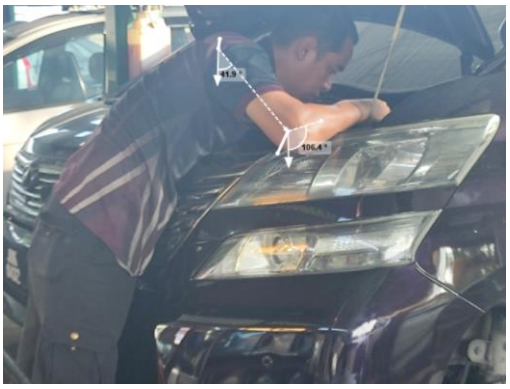

Figure 3.6

Figures 3.5 and 3.6 shows Mechanic C installing a new battery in a vehicle, involving significant physical effort and awkward postures. The Rapid Upper Limb Assessment (RULA) technique was used to evaluate the risk of developing MSDs due to awkward posture, with KINOVEA software determining Mechanic C's posture angles. Figure 3.5 shows a neck angle of 7.8 degrees and a trunk angle of 54.8 degrees, while Figure 3.6 indicates an upper arm angle of 41.9 degrees and a lower arm angle of 106.4 degrees. RULA analysis yielded scores of 2 for the upper arm, 2 for the lower arm, 1 for the wrist, 1 for the wrist twist, 1 for the neck, 3 for the trunk, and 1 for the legs. The Muscle Score was 1, and the Load Score was 1 due to the 10 kg average weight of the car battery.

Using the RULA worksheet, Posture Score A was found by interpolating Table A, resulting in a value of 3. Adding the muscle and load scores to Posture A gave a Wrist and Arm score of 5. The Posture B score was 3, and by adding the Muscle and Load scores, it resulted in a Neck, Trunk, and Leg score of 5. Utilizing Table C, the total RULA score was determined to be 6, indicating an urgent need for investigation and potential adjustments to lower the risk of developing MSDs. Mechanic C's posture during the battery installation task requires further examination and possible modifications to enhance working conditions and reduce physical strain. Table 3.7 summarizes the RULA analysis.

Table 3.7: RULA score Mechanic C

Mechanic	Wrist & Arm Score	Neck, Trunk and Leg Score	Total Score	Risk Level
C	5	5	6	Further investigation, change soon

Mechanic C's posture was analyzed using the REBA method, with Figures 3.5 and 3.6 serving as references for scoring. In Figure 4.5, Mechanic C's neck is bent at approximately 7.8 degrees, scoring 1, while the trunk is bent at around 58.8 degrees, scoring 3, and the legs are straight with no weight shift, scoring 1. Figure 4.6 shows the upper arm bent at about 41.9 degrees, scoring 2, the lower arm angle at 106.4 degrees, scoring 2, and the wrist assumed to be between 0-15 degrees, scoring 1. With a 10 kg weight involved, the Load Score was 2, and the Coupling Score was 1.

Using the REBA worksheet, Posture Score A was found by interpolating Table A, resulting in a score of 2, and Posture Score B by interpolating Table B, resulting in a score of 2. Adding the Load Score to Posture Score A and the Coupling Score to Posture Score B yielded the same values, resulting in Score A of 4 and Score B of 3. Interpolating these in REBA Table C gave a Score C of 4. Adding the activity score of 1 resulted in a final REBA score of 5, indicating a medium risk of developing WMSDs. Further investigation and potential adjustments to the work task or environment are needed to reduce the risk of injury. Table 3.8 summarizes the REBA analysis.

Table 3.8: REBA score Mechanic C

Mechanic	Score A	Score B	Score C	Activity Score	Total Score	Risk Level
C	4	3	4	1	5	Medium risk, further investigation, change soon

4. Conclusion

The study aimed to evaluate ergonomic risks and the prevalence of work-related musculoskeletal disorders (WMSDs) among car mechanics using survey data, RULA (Rapid Upper Limb Assessment), and REBA (Rapid Entire Body Assessment). The survey revealed that a significant number of mechanics suffer from discomfort in the upper limbs and lower back, indicating common ergonomic risk factors such as awkward postures, repetitive motions, and heavy lifting.

The RULA scores ranged from 5 to 6, suggesting a moderate risk level requiring prompt ergonomic intervention. Meanwhile, REBA scores ranged from 2 to 3, indicating a lower risk but still warranting ergonomic improvements. The primary risk factors identified included awkward postures and repetitive tasks due to constrained working spaces and poor access to tools and parts.

To address these risks, several recommendations were made, including improving workstation design, providing training on proper body mechanics, implementing job rotation and regular breaks, and using assistive devices. These findings align with the study's objectives by identifying WMSDs prevalence, assessing ergonomic risks, and suggesting effective prevention methods. Implementing these changes will enhance workplace safety, reduce injuries, and improve overall productivity and well-being for car mechanics.

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