An Ergonomic Assessment of Musculoskeletal Disorder Risks among Welders in the Malaysian Boiler Fabrication Sector

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Abstract- This study investigates ergonomic constraints and musculoskeletal disorder (MSD) risks among welders in the boiler fabrication industry. Twelve welders were assessed using the Rapid Entire Body Assessment (REBA), Rapid Upper Limb Assessment (RULA), and Cornell Musculoskeletal Discomfort Questionnaire (CMDQ). The analysis revealed that 33.3% of welders were exposed to high ergonomic risk, while 66.7% experienced medium risk. Pearson correlation between RULA and REBA ($r = –0.194$, $p = 0.546$) and between REBA and CMDQ ($r = –0.347$, $p = 0.269$) indicated weak associations. Lower back, neck, and upper limbs were the most affected regions. The results underline the need for ergonomic interventions including workstation redesign, training, job rotation, and rest schedules. The findings contribute to occupational safety literature by linking ergonomic assessment to MSD prevalence in industrial welding environments.

Index Terms- Musculoskeletal disorders, REBA, RULA, Welders, Boiler fabrication

I. Introduction

The boiler fabrication sector in Selangor, Malaysia, plays a pivotal role in the nation's industrial landscape, supplying essential components for power generation and manufacturing operations. Central to this industry are skilled welders, whose precision and expertise are fundamental to the quality, safety, and efficiency of production. However, welding is an inherently dangerous and physically demanding profession characterized by significant ergonomic constraints. Welders are frequently required to adopt awkward and static postures for extended periods, handle heavy equipment, and contend with environmental hazards such as intense heat, poor illumination, and vibration [1]. These conditions create a high risk for developing work-related musculoskeletal disorders (WMSDs), which are injuries affecting muscles, nerves, tendons, and skeletal structures. Work-related lower back pain, in particular, is a prevalent occupational health issue among welders, leading to long-term incapacity, diminished productivity, and a reduced quality of life.

According to a report by the Social Security Organization [2] of Malaysia, industrial accidents have been on the rise, with thousands of cases of occupational musculoskeletal disorders reported annually. This underscores the urgent need to address ergonomic hazards in high-risk professions like welding. While Malaysian regulations under the Department of Occupational Safety and Health [3] aim to protect worker welfare, a gap often exists between policy and practice. This study addresses this gap by investigating the specific ergonomic challenges confronting welders in the boiler fabrication industry. By identifying the predominant ergonomic hazards and evaluating their impact, this research aims to provide actionable insights for improving worker well-being, enhancing productivity, and strengthening workplace safety protocols. The findings are intended not only to benefit the specific industry in Selangor but also to contribute to the broader field of ergonomics by offering solutions for similar physically demanding occupations.

Ergonomics is the scientific discipline concerned with optimizing the interaction between humans and their work systems to enhance well-being and performance. In industrial settings, ergonomic principles are applied to prevent WMSDs, which can arise from repetitive tasks, awkward postures, and forceful exertions [4]. Welding is a prime example of an occupation where these risk factors are prevalent.

Studies have shown that a majority of welders' experience discomfort and pain while working, often due to non-ergonomic workstation designs and the repetitive, static nature of their tasks [5]. This can lead to poor work quality and reduced productivity.

MSDs are a leading cause of occupational injury and disability, affecting muscles, joints, tendons, and nerves. These disorders often develop gradually from the cumulative effect of physical stressors. In welding, common MSDs include back injuries, shoulder tendonitis, and carpal tunnel syndrome, frequently caused by overhead welding, heavy lifting, and vibration [1]. Research in Malaysia has identified a high prevalence of lower back pain (LBP) among various occupations, with working posture and lifting heavy loads being key risk factors [6].

Several key risk factors contribute to the high incidence of MSDs among welders:

- Awkward Postures: Deviating from the body's neutral position while twisting, bending, or reaching places excessive strain on muscles and joints [7]. Welding often requires workers to adopt such postures to access workpieces.
- Repetitive Motion: Performing the same movements repeatedly without sufficient rest can lead to muscle fatigue and wear and tear on tissues [8].
- Vibration: The use of power tools exposes welders to hand-arm or whole-body vibration, which is a known contributor to musculoskeletal and neurological disorders [9].

To quantify ergonomic risks, researchers and practitioners use various standardized assessment tools. This study utilized three prominent methods:

- Cornell Musculoskeletal Discomfort Questionnaire (CMDQ): A self-reported survey used to assess the frequency, severity, and work interference of aches and pains across 20 body parts [10].
- Rapid Upper Limb Assessment (RULA): A survey method designed to investigate work-related upper limb disorders by scoring the posture of the neck, trunk, and upper limbs [11].
- Rapid Entire Body Assessment (REBA): A tool for evaluating the risk of MSDs associated with whole-body postures, particularly those that are static or strenuous [12].

These tools provide a structured framework for identifying high-risk tasks and prioritizing ergonomic interventions to create a safer work environment.

II. METHODOLOGY

This research employed a cross-sectional study design to assess ergonomic constraints among welders in a boiler fabrication facility in Selangor, Malaysia. The study population consisted of 12 male welders aged between 21 and 60. Data was collected through a multi-faceted approach in compliance with the DOSH Guidelines on Ergonomics Risk Assessment at the Workplace [3].

A self-administered questionnaire was used to gather sociodemographic data and information on work history. Ergonomic risks were evaluated using a combination of qualitative and quantitative methods:

- Initial Ergonomic Risk Assessment (ERA): A walk-through survey and checklist-based assessment were conducted to identify potential ergonomic risk factors such as awkward postures, repetitive motion, and forceful exertion, as outlined in the DOSH guidelines [3].
- Cornell Musculoskeletal Discomfort Questionnaire (CMDQ): Participants completed the CMDQ to report the frequency, severity, and work-related interference of any musculoskeletal discomfort experienced in the past week. This provided a subjective measure of the prevalence of MSDs. The CMDQ form is shown in Figure 1.1.

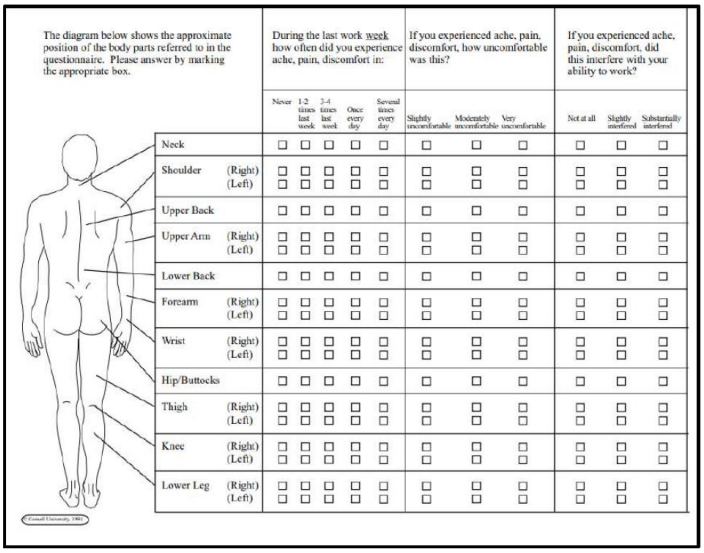

Figure 1.1: Cornell Musculoskeletal Discomfort Questionnaire (CMDQ)

- Advanced Ergonomic Risk Assessment (RULA and REBA): For tasks identified as high-risk during the initial ERA, advanced assessments were performed. Worker postures were documented through photographs and videos. The Rapid Upper Limb Assessment (RULA) [11] and Rapid Entire Body Assessment (REBA) [12] worksheets were used to score the postures and quantify the level of MSD risk. The overall assessment framework is depicted in Figure 1.2.

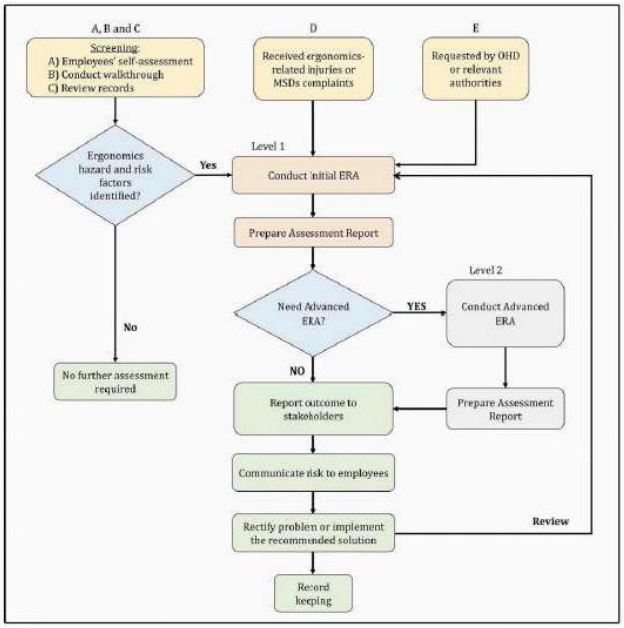

Figure 1.2: Framework for Ergonomic Risk Assessment

Data analysis was performed using descriptive statistics to summarize participant characteristics and assessment scores. Pearson correlation was used to investigate the relationships between the RULA, REBA, and CMDQ scores to determine the level of association between different ergonomic evaluation methods.

III. FINDINGS AND DISCUSSIONS

A. Participant Characteristics and Discomfort Levels

All 12 welders participated, yielding a 100% response rate. The majority of respondents were between 56 and 60 years old (41.7%), with a mean age of 54.67. As detailed in Table 1.1, all welders had completed secondary school education.

Table 1.1: Descriptive Statistics of Socio-Demographic Characteristics (n=12)

Variables	No.(*n*)	(%)	Mean ±	SD	Min - Max	
Age	12	(100)	54.67	8.90	32	67
Gender						
Male	12	(100)				
Female	0	(0)				
Height (cm)	12	(100)	168.92	4.01	163	177
Weight (kg)	12	(100)	66.17	7.77	58	80
Race						
Malay	5	(41.67)				
Chinese	7	(58.33)				
India	0	(0)				
Others	0	(0)				
Education Level						
No Formal	0	(0)				
Primary	0	(0)				
Secondary	12	(100)				
Tertiary	0	(0)				
Martial Status						
Married	11	(91.67)				
Single	1	(8.33)				
If married, No of Child under 6						
0 child	9	(81.82)				
1 child	1	(9.09)				
2 Child	1	(9.09)				
Working Schedule						
Full time	10	(83.33)				
Part time	2	(16.67)				
Shift work	0	(0)				
Total no of working hours						
8 hours	10	(83.33)	7.500	1.168	5	8
5 hours	2	(16.67)				
No of work breaks						
Once	0	(0)				
Twice	0	(0)	3.000	3.000	3.00	3.00
Thrice	12	(100)				
Quarce	0	(0)				
No of people working with you:						
Alone	10	(83.33)				
2-5 person	2	(16.67)				
6-10 person	0	(0)				
>10 person	0	(0)				

Table 1.1: Continue

Do you smoke					
No	5	(41.67)			
Yes	7	(58.33			
If smoking no of cigarette smoke in single day					
5 butt	2	(28.57)	11.43	6.27	5 20
10 butt	3	(42.86)			
20 butt	2	(28.57)			
Hobby/Leisure time activity					
Hunting	2	(16.67)			
Gardening	2	(16.67)			
Fishing	4	(33.33)			
Browsing Internet	1	(8.33)			
Sport	3	(25.00)			
Were you diagnosed of any disease					
Yes	0	(0)			
No	12	(100.00)			
Are your taking any medication?					
Yes	3	(25.00)			
No	9	(75.00)			

The CMDQ results revealed a high prevalence of musculoskeletal discomfort. The highest pain scores were reported in the neck, followed by the lower back and right shoulder. The total CMDQ scores, which combine frequency, discomfort, and work interference, varied significantly among individuals, with a mean score of 48.75 ± 28.33 and a maximum score of 99 (Table 1.2). This indicates that while some welders experience minimal issues, others suffer from substantial discomfort that impacts their work. These findings align with other studies that have identified the neck and back as the most affected body regions for welders [5].

Table 1.2: Detailed Scores for Each Patient Safety Factor

Welders (n=12)	Score			CMDQ Total Score
	Frequency	Discomfort	Interference	
W-1	26	37	16	79
W-2	2	20	0	22
W-3	38	41	20	99
W-4	12	20	1	33
W-5	14	23	5	42
W-6	10	22	4	36
W-7	0	20	0	20
W-8	31	38	17	86
W-9	6	21	5	32
W-10	12	23	4	39
W-11	25	34	18	77
W-12	0	20	0	20
Mean StDev	14.67 ± 12.61	26.58 ± 8.27	7.50 ± 7.85	48.75 ± 28.33

B. Ergonomic Risk Assessment Results

The initial ERA confirmed that all welders were exposed to multiple ergonomic risk factors, including awkward postures, static work, repetition, and vibration. The advanced RULA and REBA assessments provided a more detailed quantification of these risks. The average RULA and REBA scores (Table 1.3) indicated that the welders were operating at a medium-risk level, signifying that further investigation and changes are necessary. The analysis of specific postures, such as those shown in Figure 1.3, revealed high-risk scores for tasks requiring bending and kneeling.

Table 1.3: Average RULA and REBA Scores (n=12)

Variable	Average RULA score		Average REBA score	
	Mean	StDev	Mean	StDev
Welders (n=12)	6	1.564	7	0.3892

Figure 1.3: Analysis of Various Bodily Positions of a Welder

C. Correlation Analysis and Discussion

The study investigated the relationship between the different assessment tools to understand their coherence. A significant, positive, but weak correlation was found between the RULA and REBA scores ($r = 0.025$, $p = 0.939$), suggesting that while the tools tend to move in the same direction, the association is not strong. This finding is consistent with systematic comparisons of the two tools [13].

More notably, the correlation analysis between the objective assessment tools (RULA and REBA) and the subjective discomfort survey (CMDQ) revealed weak negative and statistically non-significant relationships (Table 1.4). This implies that a higher risk score from RULA or REBA did not consistently correspond to a higher reported discomfort score from the CMDQ. This lack of strong correlation suggests that ergonomic assessment tools like RULA and REBA, while effective for analyzing posture, may not fully capture the complex, multifactorial nature of a worker's perceived pain and discomfort. Factors such as individual pain tolerance, work experience, and psychological stress can also influence reported discomfort [14]. Therefore, a comprehensive ergonomic assessment should integrate both objective postural analysis and subjective worker feedback to develop effective interventions.

Table 1.4: Correlation between RULA, REBA, and CMDQ Risk Level

Variable	Detail	RULA Score	REBA Score
RULA Score	Correlation (r)	1	0.025
	Probability (p) value	1	0.939
CMDQ score	Correlation (r)	-0.194	-0.347
	Probability (p) value	0.546	0.269

IV. ONCLUSION

This study successfully assessed the ergonomic constraints faced by welders in a Malaysian boiler fabrication industry. The findings confirm that welders are exposed to significant ergonomic risks, leading to a high prevalence of musculoskeletal discomfort, particularly in the neck and back. The use of standardized assessment tools like RULA and REBA identified that a majority of workers are in medium to high-risk categories, necessitating urgent ergonomic interventions.

The research also highlighted a critical insight: the weak correlation between objective postural assessment scores and workers' subjective reports of discomfort. This underscores the need for a holistic approach to ergonomics that does not rely on a single tool but rather combines systematic postural analysis with direct worker feedback to capture the full scope of the problem.

Based on these findings, it is recommended that the industry implement multifaceted ergonomic programs. These should include workstation redesign to reduce awkward postures, the introduction of ergonomic tools, and regular training for workers on proper body mechanics and injury prevention [15]. Continuous evaluation of these interventions is crucial to ensure their effectiveness and to foster a sustainable culture of safety and well-being. Future research should explore these ergonomic challenges with larger sample sizes and across different work settings to develop more robust and refined assessment methodologies for this vital industrial sector.

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