International Journal of
Occupational Safety and Health

ISSN: 2091-0878 (Online) ISSN: 2738-9707 (Print)

Original Article

Analysis of potential ergonomic hazards in metal craft welding workers

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Date of submission: 01.08.2024
Date of acceptance: 22.02.2025
Date of publication: 01.04.2025

Conflicts of interest: None
Supporting agencies: None
DOI:https://doi.org/10.3126/ijosh.v15i2.66529

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ABSTRACT

Introduction: Welding work is usually done according to the condition of the object being welded. The working posture of the welding process is usually sitting, standing, or half-bending for a long time. This posture includes awkward postures that cause a lot of problems for the worker's body. It is necessary to conduct an analysis to be able to provide recommendations for improvement of the work position.

Methods: This study was conducted using an observational method based on a survey sheet from the measurement of potential ergonomic hazards (SNI 9011 of 2021) and the RULA (Rapid Upper Limb Assessment) method in 12 metal craft industry sites in the province of Bali, Indonesia. Data were taken in March and April 2024 based on measurement procedures and analyzed in a quantitative, descriptive manner based on the interpretation of potential ergonomic hazards.

Results: Obtained, 83.3% and 16.7% of samples experienced frequent and continuous pelvic (waist) pain, both on the right and left sides. As many as 77.8% of samples were in the red zone with a score of 9 or 12 and an ergonomic risk factor score greater than 7.

Conclusion: The level of ergonomic hazards reached a score of 8–16, meaning a high-risk level, and the ergonomic risk factor reached a score greater than 7, which meant dangerous. It is recommended that there is a need for immediate ergonomic intervention in the welding section of the metal craft industry to reduce musculoskeletal disorders and improve work posture.

Keywords: Ergonomic risk factors, musculoskeletal disorders, potential ergonomic hazards.

Introduction

Welding work is a job that we encounter a lot, both in metal crafts and in motor vehicle repair shops. The products of these metal craftsmen vary from crafts to making decorations, musical instruments, and household furniture to building construction work such as windows, doors, house frames, fences, and so on. Welding is the process of joining two metals that is usually done by welders. Welding work has its own techniques so that the welded metal can be connected neatly and strongly. The welding tools used are mostly electric.

The working posture of the welding process is usually sitting, standing, or half-bending for a long time. Most welding positions in making household furniture, iron fences, windows, and doors are done by sitting and bending. This posture includes awkward postures that cause many problems for the worker's body. Suppose you have musculoskeletal disorders, quick fatigue, and the risk of work accidents. Generally, they have used eye or face protection. Incorrect sitting posture results in increased pressure on the spine when sitting.[1,2] However, working with a sitting posture for a long time, especially sitting with an unnatural or forced posture, will quickly cause fatigue. There is a sense of fatigue quickly; workers will often rest so that effective working hours are reduced, which in the end will reduce work productivity. In addition, bad body posture that is maintained for too long will cause musculoskeletal "strains" and negatively affect health. The wrong or unnatural body position, especially in a forced posture, clearly reduces a person's productivity.[3–5] So it is necessary to make efforts to harmonize work (tools and machines, work methods, job content, and work environment) with humans (abilities, limitations).[6–8]

The welding process in the metal craft industry has a high potential for ergonomic hazards, and further analysis is needed so that the right intervention can be proposed later. One of the analyses of potential ergonomic hazards that can be used as a measuring tool is the Measurement and Evaluation of Potential Ergonomics in the Workplace, SNI 9011 of 2021, issued by the National Standardization Agency and compiled by the Technical Committee for Occupational Safety and Health and the Ministry of Manpower of the Republic of Indonesia. There are three evaluations in it, namely the evaluation of the danger of musculoskeletal disorders, the evaluation of ergonomic risk factors (ERF), and RULA analysis. Potential hazard analysis needs to be carried out on workers as a basis for intervention in order to reduce potential hazards and increase their work productivity.[9–11]

The purpose of this study is to make an ergonomic risk factor analysis of the working posture of welding workers in metal crafts in Bali in a measurable manner with an ergonomic science approach. The research results can be used to provide input on local government policies for small industries so that assistance and improvements can be made to work productivity problems.

Methods

This study was conducted using an observational method on metal craftsmen in the welding section of Bali Province, Indonesia. Observations were made on 36 workers as research samples (according to the minimum sample amount) at 12 metal craft industry locations in Denpasar City, Badung Regency, and Tabanan Regency. Data collection was carried out in March and April 2024. The determination of the minimum sample size was carried out using the Slovin formula[12] so that 36 samples were obtained. Slovin's formula is as follows:

$$n = \frac{N}{1+(N.e^2)} \quad (1)$$

Description:
n = number of samples
N = population of horticultural farmers
e = error rate

Because there are 12 metal craft industry locations in Denpasar City, three workers were taken from each industry. The determination of three welding workers in each industry was carried out randomly using the lottery technique.[13,14] Observations of potential ergonomic hazards in workers were carried out on work postures by conducting assessments based on surveys (checklists, questionnaires, and scoring) of potential musculoskeletal disorder hazards and survey sheets for evaluating ergonomic risk factors (SNI 9011) in 2021.[15]

The procedure for filling out the survey is as follows:

- Determine the potential hazards of the detected ergonomics factor.
- Determine the duration of exposure to each potential hazard

- Perform manual load handling assessments
- Summing up all scores in a checklist

The data was analyzed quantitatively and descriptively using Microsoft Excel, based on the assessment and interpretation of potential musculoskeletal disorders and ergonomic risk factors on the SNI 9011 of 2021 workplace potential measurement and evaluation sheet and using the RULA (Rapid Upper Limb Assessment) method.

The interpretation of musculoskeletal disorders is as follows:

Table 1: Risk Level of Musculoskeletal Disorders.

Frequency	Severity			
	None problem (1)	No Comfortable (2)	Sick (3)	Severe Sick (4)
Never (1)	1	2	3	4
Sometimes (2)	2	4	6	8
Often (3)	3	6	9	12
Always (4)	4	8	12	16

The interpretation of the risk level of musculoskeletal disorders based on Table 1 is as follows:

a. Green (1-4) = low risk level
b. Yellow (6) = moderate risk level
c. Red (8 -16) = high risk level

As for the assessment of the results of the observation of the ergonomic hazard potential checklist based on SNI 9011 of 2021, the interpretation of the ergonomic risk assessment is as follows:

a. < value 2 = safe workplace conditions
b. Values of 3 - 6 = need further observation
c. value of 7 = dangerous

Based on the analysis of work posture using RULA which has a score of 1 to 7, it shows the following levels of action:

a. Level 1: A score of 1 or 2 indicates that this posture is acceptable if it is not maintained or repeated over a long period of time.
b. Level 2: A score of 3 or 4 indicating that further examination is required and changes are also needed.
c. Level 3: Score of 5 or 6 indicates that checks and changes need to be made immediately.
d. Level 4: A score of 7 indicates that, under this condition, it is dangerous, so an examination and change are needed very immediately.

The inclusion criteria for the research sample are willingness to be a sample by signing the informed consent form, being male gender, being of productive age, and not experiencing illness or disability that interferes with the research process. The exclusion criteria are if the sample provides extreme data. The sample is declared a dropout if it states to leave as a research sample. The standard operating procedure and ethics of this research have been approved by the P3M institution of the Politeknik Negeri Bali, considering the independence of the research and the rights of the research sample. The research sample may raise objections, ask about the research results, and not publish its privacy data. Recommendations from the research results can be directly applied to the industry where the sample works.

Results

The working posture of a welder is to sit and stand, sometimes using a small seat measuring 20 x 20 cm with a height of 10 cm, and sometimes sitting, squatting, standing, or half-squatting. This posture is maintained for a long time or is maintained briefly but repeatedly during the welding process. Rest time is only allocated for one hour, namely from twelve to one o'clock in the afternoon. A standing or slightly walking position is used when preparing a tool or picking up something. But this is only done occasionally, if necessary.

Figure 1: Multiple working postures of metal craftsmen welding parts.

Musculoskeletal disorders due to work refer to complaints or pain resulting from injuries and disorders in muscles, tendons, joints, nerves, and other soft tissues. The results of measuring musculoskeletal disorders in welding workers are shown in Table 2 below.

Table 2: Results of Measurement of Musculoskeletal Disorders.

	Right				Left			
	Never	Sometimes	Often	Always	Never	Sometimes	Often	Always
Neck		76.9%				76.9%		
Shoulder			33.3%				33.6%	
Elbow								
Upper Back								
Arm			83.3%				23.5%	
Lower Back								
Hand		100%				66.7%		
Hip			83.3%	16.7%			83.3%	16.7%
Thigh		30.1%				30%		
Knee		30.1%				30%		
Betis								
Foot		66.7%				66.7%		

The interpretation of the assessment results revealed that 83.3% of the research sample and 16.7% of the research sample experienced frequent and constant pain in the hip (waist), both on the right and left sides. The calculation of the score yielded the following results:

Table 3: Results of score calculation of musculoskeletal disorders in lumbar complaints

Frequency	Severity			
	None problem (1)	No Comfortable (2)	Sick (3)	Severe Sick (4)
Never (1)				
Sometimes (2)				
Frequent (3)			11	
Always (4)			17	

SNI 9011:2021 was used to identify work-related musculoskeletal disorders. Table 3 shows that 28 out of 36 people (77.8%) were in the red zone with a score of 9 or 12.Based on the check, the ergonomic risk factor score in welding workers was greater than 7, which means that the level of ergonomic risk is dangerous and immediate intervention is needed to reduce these risk factors.

Based on RULA's analysis of work posture, the following results were obtained:

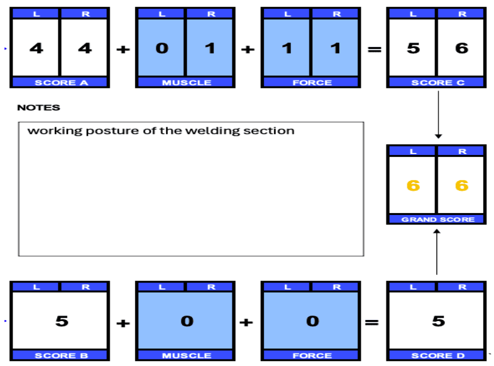

Figure 2: RULA Score Results.

Discussion

Figure 1 shows the working posture of welding workers. This unergonomic posture will cause many problems, such as fatigue quickly, firefly eyes, stiffness in the neck, and pain in the waist, back, calves, and legs. It will also cause complaints in the skeletal muscular system and ultimately reduce workers' productivity.[2,16,17]

Based on Table 3, a red mark on a score of 8–16 indicates a high level of risk or hazard and requires immediate handling of ergonomic interventions. The ergonomic hazard level reaches a score of 8–16, meaning that the ergonomic hazard level among workers is high and will give rise to many complaints regarding the musculoskeletal system and other complaints. This complaint about musculoskeletal disorders will impact the work productivity of craftsmen. Therefore, it is necessary to immediately carry out ergonomic interventions to provide solutions to worker complaints. Certain musculoskeletal disorders also affect metal craftsmen, including those involved in gamelan or gong construction.[18] Effective ergonomic solutions can be performed on workers by using methods to measure musculoskeletal disorders, fatigue, and productivity.[19–21] Task demands are greatly influenced by the nature and type of tasks, organization and environment; therefore, the level of work efficiency will continue to increase if it is still above the worker's ability and decrease immediately if it has exceeded the worker's ability.[22,23] The posture of welders described above, namely a sitting posture bent for too long, will cause musculoskeletal strains and negatively affect health.[24,25]

As shown in Figure 2, a grand score of 6 was obtained based on the RULA analysis. This shows that the examination and change of work posture need to be carried out immediately. This indicates that ergonomic intervention is needed to improve the working posture of welders as soon as possible.

Ergonomic intervention is essential in small and medium industries because many ergonomic problems remain, ranging from work posture to work environment hazards to work productivity problems.[26,27] Problems with work posture and systems will be solved using the ergonomic approach method.[11,28] Measuring work posture using a specific measurement system will be effective in providing a solution,[29,30] and can implement an ergonomic intervention system.[31,32] Based on the results and discussion of this research, it is recommended that further research on ergonomic interventions be conducted in small industries such as metal welding to provide solutions to issues related to work posture, potential ergonomic hazards, and skeletal muscle complaints. The government, which has policies on small and medium-sized enterprises, should guide ergonomic work practices to avoid ergonomic hazards for workers.

Conclusion

The working posture is not ergonomic in welders, causing complaints of fatigue quickly, glowing eyes, neck stiffness, and waist pain, back, calves and legs. The ergonomic hazard level reaches a score of 8-16, meaning that the ergonomic hazard level in workers is high. Ergonomic risk factors achieved scores greater than 7 in both the SNI 9011 method and the RULA method, meaning that the ergonomic risk level was at a dangerous level. Therefore, it is recommended that immediate ergonomic intervention be implemented in the welding section of the metal craft industry in Bali.

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