p-ISSN 2086-6380, e-ISSN 2548-7949

Jurnal Ilmu Kesehatan Masyarakat (JIKM)

# ERGONOMIC HAZARD CONTROL MODELING FOR INFORMAL WELDING WORKERS IN GREATER BANDUNG: A STUDY ON MUSCULOSKELETAL DISORDERS (MSDs)

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ARTICLE INFO

**Article History:**

Received : September 30, 2024
Accepted : December 12, 2024
Published: March 4, 2025

**DOI:**

https://doi.org/10.26553/jikm.2025.16.1.18-31

**Available online at**

http://ejournal.fkm.unsri.ac.id/index.php/jikm

## ABSTRACT

Ergonomic hazards are one of the causes of health problems in workers, including causing Musculoskeletal Disorders (MSDs) complaints. MSDs in workers affect physical fitness, reduce working days/hours, and ultimately are unable to work. WHO states that around 1.71 billion people have musculoskeletal conditions worldwide. MSDs complaints in Indonesia are a separate focus, research on MSDs complaints in the informal sector shows that 66% of workers experience MSDs complaints. One industry that has a high risk of MSDs is welding. The purpose of this study was to create an ergonomic hazard control model for informal welding sector workers in Greater Bandung. The research approach is quantitative, the type of analytical observational research with a cross-sectional design. The study population was informal welding sector workers in Greater Bandung, sample was taken using a purposive sampling technique, and the total number of samples in this study was 100 workers. The analysis used in this study was the chi-square test to see the relationship between variables. Modeling in this study will use binary logistic regression. The results of the study showed that working climate, working posture, workload, and physical fitness simultaneously influenced MSDs complaints of informal welding workers (p-value < 0.05). Based on these findings, the control of MSDs complaints can be achieved by effectively managing work climate, working posture, workload, and physical fitness.

**Keywords:** welding, ergonomics, musculoskeletal disorders, working posture

## Introduction

Decent work is a critical aspect of achieving the Sustainable Development Goals (SDGs), emphasizing the right of all workers to health and safety guarantees in their work activities. This aligns with other SDGs targets, particularly ensuring healthy and prosperous lives.[1] However, not all employment sectors currently receive adequate Occupational Health and Safety (OHS) protection, with informal sector workers being particularly underserved. According to data from the Central Statistics Agency (*Badan Pusat Statistik* or BPS) in 2023, informal sector workers dominate the national workforce, comprising approximately 59.11%, compared to 40.89% in the formal sector. Similarly, in West Java, 54.61% of workers are in the informal sector, while in Bandung City, at least 40.95% of the workforce in 2023 was classified as informal.[2]

One of the informal industries with K3 risks is the informal welding industry, in general, the welding process begins with the preparation stage of selecting materials, cutting, welding, and finishing.[3] Each stage of welding has health risks, including ergonomic risks. Ergonomic risk factors that commonly occur during the welding process are prolonged static work postures.[4,5] Welding workers have a high ergonomic risk, and cause complaints in the upper neck and lower back, waist, wrists, and shoulders, other complaints include muscle pain in the right groin and left groin, ankles, and lower back pain because workers often do welding work in a squatting and bending position.[6,7] Some of these complaints are known as Musculoskeletal Disorders (MSDs). MSDs in workers will affect physical fitness, reduce working days/hours, cause serious illnesses, and ultimately make them unable to work.[8,9]

The World Health Organization (WHO) states that approximately 1.71 billion people worldwide have musculoskeletal conditions, making these conditions the leading cause of disability globally.[10] According to 2020 data from the Bureau of Labor Statistics (BLS), there were 247,620 reported cases of musculoskeletal disorders or injuries in the United States that resulted in days away from work.[11] Similarly, the latest statistics from the Health and Safety Executive (HSE) indicate that in the United Kingdom (UK) during 2020/21, around 470,000 workers reported work-related musculoskeletal disorders (MSDs). MSDs accounted for 28% of all work-related illnesses in the UK during this period, with total health costs exceeding £16 billion.[12] In Indonesia, MSDs are also a significant focus. A study on MSDs complaints in the informal sector revealed the following distribution of complaint categories: Low (6.7%), Medium (23.3%), High (66%), and Very High (3.3%). Another study found that 53.4% of workers experienced severe MSDs complaints due to non-ergonomic work postures.[13]

Ergonomic risk factors contributing to MSDs can be assessed using the WHO Healthy Workplace Model, which links hazards to specific conditions in the work environment. Several risk factors for MSDs complaints are categorized into environmental factors, work factors, and individual factors.[14] Previous research has identified strong correlations between MSDs complaints and environmental factors such as lighting, noise, work climate, and work posture.[15] Individual factors, including smoking habits, Body Mass Index (BMI), and physical fitness, also play significant roles. Efforts to control hazards in the work environment must follow established guidelines. According to the Minister of Manpower Regulation No. 5 of 2018, the control hierarchy should be based on work activities and the results of hazard identification.[16–18] In a preliminary study conducted in the informal welding industry in Bandung City, ergonomic risks were observed in nearly all stages of work, with risk levels classified as high.[19] The findings underscore the presence of multiple factors contributing to MSDs risks among informal welding workers, emphasizing the need for targeted interventions to address these risks effectively.[20]

Currently, research on ergonomic hazards is still focused on risk factors for MSDs complaints. Several previous studies have not been able to explain the control model and control hierarchy design based on the routine activities of informal sector workers, while the formal sector is only limited to several industries such as hospitals.[21,22] This study aims to model control efforts and design a control hierarchy based on routine activities to reduce the number of Occupational Diseases (*Penyakit Akibat Kerja* or PAK) MSDs in informal welding sector workers.

## Methods

This study employed a quantitative approach with an analytical observational design and a cross-sectional method. The population consisted of informal welding sector workers in Greater Bandung, including Bandung City, West Bandung Regency, Bandung Regency, and Cimahi City. Purposive sampling was used to select respondents based on inclusion criteria, namely workers who had been employed in the informal welding sector for at least five years and were involved in all work stages, from the preparation of tools and materials to finishing. Part-time workers were excluded based on the study's exclusion criteria. The selection of welding locations was based on inclusion criteria: workers who had been employed in the welding sector for at least five years, were involved in all work stages from the preparation of tools and materials to finishing, and were not part-time workers. The 100 respondents were distributed among 44 welding locations in Greater Bandung, consisting of 26 kiosks in Bandung City, 9 kiosks I n Bandung Regency, 5 kiosks in West Bandung Regency, and 4 kiosks in Cimahi City.

Data collection focused on several aspects. Musculoskeletal Disorder (MSDs) complaints were measured using the Nordic Body Map (NBM) questionnaire, workers are categorized as having low MSD complaints if the score is < 46, and high MSD complaints if the score is ≥ 46. Individual factors such as age, length of service, smoking habits, BMI, and physical fitness were also assessed. Work factors included work posture, which was evaluated using the Rapid Entire Body Assessment (REBA) tool, categorized as awkward (score ≥10) or normal (score <10). Workload was assessed using the Physical Workload Questionnaire (PWQ), and length of work was measured through a questionnaire. Work environment factors were measured using specialized instruments: noise with a sound level meter, work climate with a heat stress monitor, vibration with a vibration meter, and lighting with a lux meter. Interviews were also conducted to gather additional information on routine work activities.

Data analysis was conducted in three stages. Univariate analysis described the frequency distribution of all variables, both independent and dependent, using percentage values. Bivariate analysis employed the chi-square test ($\chi^2$) to explore the relationships between variables. Multivariate analysis was performed using binary logistic regression to develop the ergonomic risk control model. Independent variables with p-values <0.25 in the simple logistic regression were included as candidates for the multiple logistic regression. The ergonomic risk control model was derived from the final binary logistic regression equation. This study received ethical approval from the ethics committee with protocol number 223/09.KEPK/UBK/IX/2024.

## Results

Table 1 shows the results of the univariate analysis of each variable were as follows:

**Table 1. Frequency Distribution of Work Environment Factors, Job Factors, Individual Factors, and MSDs Complaints in Informal Welding Industry Workers in Greater Bandung**

| Variables | Category | Frequency (n=100) | Percentage (%) |
|---|---|---|---|
| Noise | Above TLV | 81 | 81.0 |
| | Below TLV | 19 | 19.0 |
| Working climate | Above TLV | 53 | 53.0 |
| | Below TLV | 47 | 47.0 |
| Vibration | Above TLV | 54 | 54.0 |
| | Below TLV | 46 | 46.0 |
| Lighting | Does not meet the required | 11 | 11.0 |
| | Meets the required | 89 | 89.0 |
| Working Posture | Awkward | 68 | 68.0 |
| | Normal | 32 | 32.0 |
| Workload | High | 64 | 64.0 |
| | Low | 36 | 36.0 |
| Length of Work | Risky | 32 | 32.0 |
| | Not Risky | 68 | 68.0 |
| Age | ≥ 40 Year | 55 | 55.0 |
| | < 40 Year | 45 | 45.0 |
| Working Period | ≤ 5 Year | 26 | 26.0 |
| | > 5 Year | 74 | 74.0 |
| Smoking Habits | Smoking | 32 | 32.0 |
| | No Smoking | 68 | 68.0 |
| BMI | Obesity | 14 | 14.0 |
| | Fat | 12 | 12.0 |
| | Normal | 70 | 70.0 |
| | Thin | 4 | 4.0 |
| Physical Fitness | Not Fit | 32 | 32.0 |
| | Fit | 68 | 68.0 |
| MSDs Complaints | High | 75 | 75.0 |
| | Low | 25 | 25.0 |

Based on Table 1, the results indicate that a significant majority of workers (81%) are exposed to disturbances exceeding the Threshold Limit Value (TLV). More than half of the workers (53%) are exposed to a work climate above the TLV, 54% are exposed to vibrations above the TLV, and 11% work in lighting conditions that do not meet standards. The findings also reveal that 68% of workers perform their tasks with awkward working postures, 65% have a high physical workload, and 68% have a working period classified as not at risk of MSDs complaints. In terms of individual characteristics, the majority of workers (68%) are aged ≥40 years, 74% have long working periods, 68% do not smoke, and 70% have a normal BMI. Regarding musculoskeletal complaints, 75% of welding workers experience high MSDs complaints, as measured using the Nordic Body Map (NBM) tool. The NBM identifies 28 specific body points where complaints may occur. The measurement results indicate that 75 informal welding workers report high MSDs complaints.

**Table 2. Relationship between Work Environment Factors and MSDs Complaints in Informal Welding Industry Workers in Greater Bandung**

| Work Environment Factors | MSDs Complaints | | | | Total | | p-value | *PR 95% CI (Lower-Upper)* |
|---|---|---|---|---|---|---|---|---|
| | High | | Low | | | | | |
| | n | % | n | % | n | % | | |
| **Noise** | | | | | | | | |
| Above TLV | 64 | 79.0 | 17 | 21.0 | 81 | 100 | 0.077 | 1.365 (0.915-2.035) |
| Below TLV | 11 | 57.9 | 8 | 42.1 | 19 | 100 | | |
| **Working climate** | | | | | | | | |
| Above TLV | 47 | 88.7 | 6 | 11.3 | 53 | 100 | 0.002 | 1,489 (1.154-1.920) |
| Below TLV | 28 | 59.6 | 19 | 40.4 | 47 | 100 | | |
| **Vibration** | | | | | | | | |
| Above TLV | 41 | 75.9 | 13 | 24.1 | 54 | 100 | 1.000 | 1.027 (0.818-1.290) |
| Below TLV | 34 | 73.9 | 12 | 26.1 | 46 | 100 | | |
| **Lighting** | | | | | | | | |
| Does not meet the required | 10 | 90.9 | 1 | 9.1 | 11 | 100 | 0.283 | 1.245 (0.993-1.560) |
| Meets the required | 65 | 73.0 | 24 | 27.0 | 89 | 100 | | |

Based on Table 2, the results show that almost all workers (79%) exposed to noise levels above the TLV experience high MSDs complaints. However, the chi-square test results indicate a p-value of 0.077 (>0.05), suggesting no significant relationship between noise exposure and MSDs complaints. The analysis reveals that 88.7% of workers exposed to a work climate above the TLV experience high MSDs complaints. The chi-square test results show a p-value of 0.002 (<0.05), indicating a significant relationship between work climate and MSDs complaints. Furthermore, the Prevalence Ratio (PR) calculation of 1.489 (95% CI: 1.154–1.920) suggests that workers exposed to a work climate above the TLV are 1.489 times more likely to experience high MSDs complaints compared to those not exposed.

Additionally, 75.9% of workers exposed to vibration levels above the TLV report high MSDs complaints. However, the chi-square test results yield a p-value of 1.000 (>0.05), indicating no significant relationship between vibration exposure and MSDs complaints. Finally, 90.9% of workers operating under lighting conditions that do not meet standards report high MSDs complaints. Despite this, the chi-square test results show a p-value of 0.283 (>0.05), suggesting no significant relationship between inadequate lighting and MSDs complaints.

**Table 3. Relationship between Work Factors and MSDs Complaints in Informal Welding Industry Workers in Greater Bandung**

| Job Factors | MSDs Complaints | | | | Total | | p-value | *PR 95% CI (Lower-Upper)* |
|---|---|---|---|---|---|---|---|---|
| | High | | Low | | | | | |
| | n | % | n | % | n | % | | |
| **Work Posture** | | | | | | | | |
| Awkward | 58 | 85.3 | 10 | 14.7 | 68 | 100 | 0,001 | 1.606 (1.143-2.256) |
| Normal | 17 | 53.1 | 15 | 46.9 | 32 | 100 | | |
| **Workload** | | | | | | | | |
| High | 58 | 90.6 | 6 | 9.4 | 64 | 100 | <0.001 | 1.919 (1.347-2.736) |
| Low | 17 | 47.2 | 19 | 52.8 | 36 | 100 | | |
| **Length of Work** | | | | | | | | |
| Risky | 27 | 84.4 | 5 | 15.6 | 32 | 100 | 0.216 | 1.195 (0.965-1.480) |
| Not Risky | 48 | 70.6 | 20 | 29.4 | 68 | 100 | | |

Based on Table 3, the results show that a significant majority (85.3%) of workers who perform tasks with awkward postures experience high MSDs complaints. The chi-square test results indicate a p-value of 0.001 (<0.05), demonstrating a significant relationship between work posture and MSDs complaints. Furthermore, the Prevalence Ratio (PR) calculation of 1.606 (95% CI: 1.143–2.256) suggests that workers with awkward postures are 1.606 times more likely to experience high MSDs complaints compared to those with normal postures. Additionally, 90.6% of workers with a high workload report high MSDs complaints. The chi-square test results yield a p-value of <0.001, indicating a significant relationship between workload and MSDs complaints. The PR calculation of 1.919 (95% CI: 1.347–2.736) suggests that workers with a high workload are 1.919 times more likely to experience high MSDs complaints compared to those with a moderate or low workload. Contrast, 84.4% of workers with a long work period are reported to have high MSDs complaints. However, the chi-square test results show a p-value of 0.216 (>0.05), indicating no significant relationship between the length of work period and MSDs complaints.

Based on Table 4, the results show that the majority (78.2%) of workers aged ≥40 years report high MSDs complaints. However, the chi-square test results yield a p-value of 0.562 (>0.05), indicating no significant relationship between age and MSDs complaints. Similarly, 84.6% of workers with new work experience get high MSDs complaints. The chi-square test results show a p-value of 0.292 (>0.05), suggesting no significant relationship between work experience and MSDs complaints. Additionally, 75.9% of workers with a smoking habit report high MSDs complaints. The chi-square test results yield a p-value of 0.759 (>0.05), indicating no significant relationship between smoking habits and MSDs complaints. In terms of BMI, 71.4% of workers classified as obese report high MSDs complaints. However, the chi-square test results indicate a p-value of 0.595 (>0.05), demonstrating no significant relationship between BMI and MSDs complaints. Conversely, 90.6% of workers categorized as physically unfit report high MSDs complaints. The chi-square test results yield a p-value of <0.001, indicating a significant relationship between physical fitness and MSDs complaints. The Prevalence Ratio (PR) calculation of 1.919 (95% CI: 1.347–2.735) suggests that physically unfit workers are 1.919 times more likely to experience high MSDs complaints compared to their physically fit counterparts.

**Table 4. Relationship between Individual Factors and MSDs Complaints in Informal Welding Industry Workers in Greater Bandung**

| Individual Factors | MSDs Complaints | | | | Total | | p-value | *PR 95% CI (Lower-Upper)* |
|---|---|---|---|---|---|---|---|---|
| | High | | Low | | | | | |
| | n | % | n | % | n | % | | |
| **Age** | | | | | | | | |
| ≥ 40 Year | 43 | 78.2 | 12 | 21.8 | 55 | 100 | 0.562 | 1.099 (0.871-1.388) |
| < 40 Year | 32 | 71.1 | 13 | 28.9 | 45 | 100 | | |
| **Working Period** | | | | | | | | |
| ≤ 5 Year | 22 | 84.6 | 4 | 15.4 | 26 | 100 | 0.292 | 1.181 (0.950-1.469) |
| > 5 Year | 53 | 71.6 | 21 | 28.4 | 74 | 100 | | |
| **Smoking Habits** | | | | | | | | |
| Smoking | 63 | 75.9 | 20 | 24.1 | 83 | 100 | 0.759 | 1.075 (0.773-1.496) |
| No Smoking | 12 | 70.6 | 5 | 29.4 | 17 | 100 | | |
| **BMI** | | | | | | | | |
| Obesity | 10 | 71.4 | 4 | 28.6 | 14 | 100 | 0.595 | - |
| Fat | 8 | 66.7 | 4 | 33.3 | 12 | 100 | | |
| Normal | 53 | 75.7 | 17 | 24.3 | 70 | 100 | | |
| Thin | 4 | 100 | 0 | 0 | 4 | 100 | | |
| **Physical Fitness** | | | | | | | | |
| Not Fit | 58 | 90.6 | 6 | 9.4 | 64 | 100 | <0.001 | 1.919 (1.347-2.735) |
| Fit | 17 | 47.2 | 17 | 52.8 | 36 | 100 | | |

After conducting partial statistical tests, to determine the ergonomic hazard control model (MSDs), simultaneous statistical tests need to be conducted. Simultaneous tests are conducted on variables with a p-value <0.25, the statistical test used is binary logistic regression. The following are candidate variables that will be tested simultaneously:

**Table 5. Candidate Variables for Binary Logistic Regression Test**

| Variables | P-Value | Information |
|---|---|---|
| Noise | 0.077 | **Candidate** |
| Working Climate | 0.002 | **Candidate** |
| Vibration | 1.000 | Not Candidate |
| Lighting | 0.283 | Not Candidate |
| Working Posture | 0.001 | **Candidate** |
| Workload | <0.001 | **Candidate** |
| Length of Work | 0.216 | **Candidate** |
| Age | 0.562 | Not Candidate |
| Working Period | 0.292 | Not Candidate |
| Smoking Habits | 0.759 | Not Candidate |
| BMI | 0.595 | Not Candidate |
| Physical Fitness | <0.001 | **Candidate** |

Based on table 5, it is known that the candidate variables for multiple logical regression tests are noise, working climate, working posture, workload, length of work, and physical fitness. The results of the modelling test are as follows:

**Table 6. Ergonomic Hazard Control Final Models**

| Independent Variables | *B* | *P-Value* | OR | *95% CI (Lower-Upper)* | Information |
|---|---|---|---|---|---|
| **Working Climate** | | | | | |
| Above TLV | | *Reference* | | | **Significant** |
| Below TLV | 1,841 | 0,011 | 6,303 | 1,531-25,957 | |
| **Working Posture** | | | | | |
| Awkward | | *Reference* | | | **Significant** |
| Normal | 1,923 | 0,006 | 6,838 | 1,759-26,588 | |
| **Workload** | | | | | |
| High | | *Reference* | | | **Significant** |
| Low | 1,476 | 0,027 | 4,374 | 1,178-16,234 | |
| **Physical Fitness** | | | | | |
| Not Fit | | *Reference* | | | **Significant** |
| Fit | 2,318 | 0,002 | 10,157 | 2,385-43,253 | |
| ***Constant*** | -4,941 | <0.001 | -4,941 | - | **Significant** |

Based on table 6, the analysis shows that work climate, work posture, workload, and physical fitness simultaneously influence MSDs complaints among informal welding workers. A positive B value indicates that an increase in MSDs complaints is associated with an improved work climate, awkward work posture, high workload, and poor physical fitness. The Odds Ratio (OR) values reveal that physical fitness (OR = 10.157) is the most dominant factor affecting MSDs complaints, followed by work posture (OR = 6.838) as the second most influential variable. This suggests that workers with poor physical fitness are 10.157 times more likely to experience high MSDs complaints compared to physically fit workers. Similarly, workers with awkward work postures are 6.838 times more likely to experience high MSDs complaints compared to those with normal work postures. The priority order of ergonomic hazard control is as follows: 1) Physical fitness improvement; 2) work posture adjustment; 3) work climate management; and 4) workload reduction.

## Discussion

The results of this study indicate that several factors significantly affect musculoskeletal disorders (MSDs) among welding workers in the informal industry of Greater Bandung. Work climate, work posture, workload, and physical fitness are identified as the primary factors influencing MSDs. These findings align with existing ergonomics literature, which highlights the significant impact of the interaction between workers' physical conditions and their work environment on physical health, particularly concerning complaints involving muscles, joints, and other supporting tissues.[23] Physical fitness emerged as the most dominant variable in influencing MSDs complaints, with an OR value of 10.157. This indicates that workers with low physical fitness are 10 times more likely to experience MSDs complaints compared to those with adequate physical fitness. Poor physical fitness compromises the body's ability to endure physical workloads during work activities, leading to increased muscle fatigue, stiffness, and soft tissue injuries.[24]

Decreased physical fitness results in reduced muscle strength and endurance, causing muscles to tire more quickly during prolonged physical activities. Fatigued muscles are unable to support proper posture, leading to mechanical stress on the joints and spine, which subsequently triggers MSDs complaints. Conversely, workers with good physical fitness are better equipped to maintain proper posture and minimize excessive physical strain, thereby significantly reducing the risk of MSDs complaints.[25]

Welding workers in Greater Bandung generally lack proper workstations, including welding tables, resulting in the welding process being carried out in awkward working postures. These awkward postures significantly contribute to the increase in MSDs complaints, with an Odds Ratio (OR) value of 6.838. Non-ergonomic working postures, such as prolonged bending or twisting of the body, lead to uneven load distribution across the body. This imbalance exerts excessive pressure on specific muscle groups, particularly in the lower back, neck, and shoulders, which are the most common areas affected by MSDs complaints.[26] Abnormal body positions during work impose excessive mechanical stress on soft tissues and joints, which, over time, lead to the degeneration of these structures. Poor working posture creates excessive localized stress, particularly on the lower back, one of the most vulnerable areas for MSDs injuries. The implementation of appropriate work aids and improvements in workplace design can significantly reduce hazardous working postures and minimize the risk of MSDs.[27]

The third variable with a significant influence is workload, with an Odds Ratio (OR) value of 4.374. A high workload places excessive physical strain on the body, especially when coupled with long working hours and insufficient rest. A workload that exceeds the physical capacity of workers can lead to acute muscle injuries and increase the risk of chronic musculoskeletal tissue damage.[28] Physical fatigue caused by excessive workload can cause biomechanical imbalances in the body. Chronic fatigue that is not addressed has the potential to cause injury to muscle structures, ligaments, and tendons. In addition, the body's inability to recover from physical workload can accelerate the occurrence of MSDs complaints, especially if not supported by adequate physical fitness.[29]

Work climate, with an Odds Ratio (OR) value of 6.303, was also found to have a significant effect on MSDs complaints. Non-ideal work climate conditions, such as excessively high temperatures or low humidity, can exacerbate workers' physical conditions. Extreme environmental temperatures affect physical endurance and cause increased fatigue, reducing the muscles' ability to maintain proper posture during work. When workers are exposed to high temperatures or uncomfortable environments, the body must exert extra effort to maintain homeostasis, which diminishes the muscles' capacity to function optimally. This increases the risk of MSDs complaints, especially in physically demanding jobs such as welding. Additionally, poor work climates can lead to dehydration, which reduces muscle elasticity and heightens the risk of injury.[30,31]

Simultaneously, the four variables (physical fitness, work posture, workload, and work climate) interact and increase the risk of MSDs. When workers with low fitness work in awkward postures, with high workloads in an unsupportive work environment, the risk of MSDs increases. Therefore, ergonomic hazard control must consider these four variables holistically. Based on the results of the study, the main priority in ergonomic hazard control is to improve workers' physical fitness. Fitness programs designed to improve muscle endurance, strength, and flexibility can significantly reduce the risk of MSDs. Fitness training can also help workers improve their resistance to physical stress caused by work activities.

Work posture control is the second priority in the ergonomic control model. Ergonomic training, which educates workers on maintaining proper posture and using appropriate assistive devices, is essential to preventing MSDs injuries. Additionally, workplace design that adheres to ergonomic principles can help workers maintain proper posture throughout their tasks. Workload control should focus on matching the physical demands of the job with the worker's capacity. Providing adequate rest and ensuring a balanced workload can help reduce muscle fatigue caused by excessive physical exertion. Implementing more flexible work shifts can also alleviate the risk of chronic fatigue and MSDs complaints. Work climate control can be achieved by improving ventilation and regulating temperature within the workplace. The use of personal protective equipment suited to the climatic conditions can also help maintain thermal balance and reduce the risk of fatigue from extreme environmental factors. Enhancing workplace comfort will not only boost productivity but also reduce the likelihood of MSDs complaints.[32]

This study is the basis for subsequent research with the theme of ergonomics, however, this study has limitations in determining the population which is limited to certain areas that are dense with welding kiosks. However, the Bandung Raya area is outside the population that we have determined. Subsequent research can conduct mapping based on kiosk maps that are evenly distributed in Greater Bandung.

## Conclusion

Musculoskeletal Disorders (MSDs) complaints in informal welding workers are influenced by work climate, work posture, workload, and physical fitness. Therefore, prevention must be carried out comprehensively through four main steps. First, improving physical fitness aims to increase endurance, reduce fatigue, and strengthen muscles and joints to be more resistant to repetitive activities. Second, improving work posture is done by applying ergonomic principles, such as adjusting work positions, using assistive devices, and adjusting the height of tables or work objects to reduce pressure on the body. Third, managing the work climate includes controlling temperature, lighting, and ventilation so that the environment remains safe and comfortable, reducing heat exposure, and preventing excessive fatigue. Fourth, managing workload includes a balanced division of tasks, providing sufficient rest time, and arranging a work schedule that is not excessive to avoid physical fatigue.

### Acknowledgement

The researcher would like to thank all parties involved in this research, especially the respondents, enumerators, and research team whom I cannot mention one by one. Thank you to the Ministry of Education, Culture, Research and Technology for giving trust to fund this research.

### Funding

This research was funded by Ministry of Education, Culture, Research and Technology of the Republic of Indonesia under contract number 0459/E5/PG.02.00/2024 and 002/PEN.DRTPM/UBK-DRPM/VI/2024 for Fiscal Year 2024.

### Conflict of Interest

There is no conflict of interest.

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