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ORIGINAL ARTICLE

Ergonomic Oriented Working for Controlling Photokeratitis and MSD Complaints in the Informal Welding Sector

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ABSTRACT

Introduction: : Informal welding workers often experience health problems such as musculoskeletal disorders (MSDs) and photokeratitis. Hazard identification revealed that informal welding sector workers in Bogor Street, Bandung City have a high risk of MSDs (75%) and photokeratitis (51.7%). This study aims to analyze the differences between MSD and photokeratitis complaints based on the results of ergonomic oriented working intervention. **Methods:** This study used an experimental design with a quantitative approach. Two treatments were administered to participants and the results of the ergonomic oriented working intervention were measured twice. The population of this study consisted of informal welding workers who met the inclusion and exclusion criteria. The minimum sample size required was calculated to be 33 workers using the comparison of two means formula. Data were collected using a simple random sampling technique and analyzed using a paired t-test and the Wilcoxon signed-rank test. **Results:** The analysis revealed that the mean scores for photokeratitis and MSD complaints were lower with ergonomic oriented working than with non-ergonomic oriented working. There was a significant difference in the incidence of photokeratitis complaints ($p = 0.005$) and MSD complaints ($p < 0.001$) before and after working with and without ergonomic oriented intervention. **Conclusion:** Ergonomic oriented working has been found to effectively control photokeratitis and MSD complaints.

Keywords: ergonomic oriented working, photokeratitis, MSDs

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INTRODUCTION

According to Indonesia's occupational health profile, the number of occupational diseases and work accidents increases every year, with an increase from 221,740 cases in 2020 to 234,370 cases in 2021 (Ministry of Manpower, 2022). This increase is likely due to the inadequate protection of informal sector workers. In 2021, the Central Statistics Agency reported that informal sector workers accounted for approximately 59.45% of the national workforce compared to formal workers. Similarly, 54.61% of workers in West Java are informal sector workers. Specifically, in 2020, at least 41.74% of workers in Bandung City were informal sector workers (Statistics Agency of West Java Province, 2021).

Informal sector workers are susceptible to various risks associated with their work environment, which can result in occupational diseases. The lack of occupational health information related to hazards in the work environment is a driving factor in the emergence of occupational health problems among informal workers. In addition, business owners often have low understanding and concern for the health of their workers, leading to a lack of effort to control hazards in the workplace. Health problems commonly experienced by informal sector workers include complaints of musculoskeletal disorders (MSDs) and photokeratitis (Andriani, Camelia and Faisya, 2020; Suherdin, Sutriyawan and Natanegara, 2023).

Photokeratitis is an inflammation of the cornea caused by exposure to light or rays, with ultraviolet light being the most common cause. This condition is often associated with welding. Acute exposure to ultraviolet radiation can lead to symptoms such as blurred vision, red eyes, and twitching eyelids. In

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the long term, chronic exposure can cause eyelid swelling and damage to the eyes. On the other hand, MSDs refer to abnormalities in body tissues such as muscles, tendons, ligaments, nerves, or spinal joints. People who suffer from MSDs experience pain in various parts of the body, including the neck, shoulders, arms, back, waist, and lower body muscles. If left untreated, MSDs can lead to injury, paralysis, and even death (Kusumawardhani, Djamalus and Lestari, 2023; Suherdin, Sutriyawan and Natanegara, 2023).

According to the World Health Organization (WHO), musculoskeletal conditions are the leading cause of disability worldwide, affecting approximately 1.71 billion people (World Health Organization, 2022). In 2020, the Bureau of Labor Statistics (BLS) reported 247,620 cases of musculoskeletal injuries or disorders (Bureau of Labor Statistics, 2020). According to the latest statistics from the Health and Safety Executive (HSE) for 2020/2021, approximately 470,000 workers in the United Kingdom were reported to be suffering from work-related MSDs (Health and Safety Executive, 2022).

There is a significant focus on addressing MSD complaints in Indonesia. Studies have shown that 66% of MSD complaints among workers in ice cube factories fall under the high category, with 3.3% being very high. Similarly, tailors reported that the moderate and severe categories accounted for 75% of their complaints. Among farmers, 35% out of 102 farmers reported MSD complaints, while 75% of welding workers with high ergonomic risks had MSD complaints (Suryanto, Ginanjar and Fathimah, 2020; Dwiseptianto and Wahyuningsih, 2022; Rovendra, Meilinda and Sari, 2022; Yusuf *et al*., 2023). Another study found that 53.4% of workers experienced severe MSD complaints due to non-ergonomic work postures. The most common complaints of workers with MSDs were related to their back, waist, calves and neck (Ajhara, Novianus and Muzakir, 2022).

Previous research on photokeratitis complaints in the informal welding sector in Bogor Street, Bandung City found that out of the 60 workers observed, the most common complaint was visual impairments, such as blurred vision experienced by 51.7% of workers. The least common complaint was shedding a lot of tears experienced by 15% of workers (Suherdin, Sutriyawan and Natanegara, 2022). MSD and photokeratitis complaints if left untreated can cause permanent disability in workers. Therefore, it is necessary to implement control efforts, one of which is by implementing ergonomic oriented working (Nasar *et al*., 2021; Black *et al*., 2023).

The ergonomics approach to controlling occupational health risks for welding workers is considered effective (Hamid *et al*., 2020) as ergonomics is the most dominant hazard for welding workers. Welding workers in Bogor Street, Bandung City performed several welding stages, including material preparation, iron cutting, welding, and finishing. Each stage poses occupational health risks. Previous research has shown that workers are at a high risk of experiencing MSDs during the material preparation, iron cutting, and welding stages. The risk factors associated with this work include awkward working postures, a hazardous eye distance (<60 cm), lifting and carrying without considering load weight, as well as prolonged static postures, such as squatting and bending (Suherdin, Sutriyawan and Natagerara, 2022).

There are currently no efforts to control ergonomic hazards for welding workers in Bogor Street, Bandung City. One potential control effort is to implement ergonomic oriented working methods in the welding process. This method involves applying ergonomic principles, such as anthropometric adjustments, ergonomic work postures, and consideration of load weight during manual handling, to each work stage that the workers go through. Ergonomic oriented working can reduce MSD complaints by 17.82% and work fatigue by 11.86% (Negara *et al*., 2019). In addition, ergonomic working positions have the potential to reduce complaints of photokeratitis, a condition commonly experienced by welding workers due to the eyes being too close to the UV light source during the welding process. This is due to the stooped work posture of the workers during the welding process (Suherdin, Sutriyawan and Natanegara, 2023).

Based on the aforementioned explanation, it is necessary to investigate ergonomic oriented working and its influence on reducing complaints of MSDs and photokeratitis. Therefore, this study aims to analyze the differences between MSD and photokeratitis complaints based on the results of ergonomic oriented working intervention.

METHODS

This study used a quantitative approach with an experimental design, where treatments were

administered to participants. The treatment-by-subject design was chosen with two treatments. The participants experienced both treatment 1 and treatment 2. Treatment 1 was carried out for two weeks. During this period, the participants worked in non-ergonomic oriented working conditions: awkward working postures, a hazardous eye distance (<60 cm), lifting and carrying without considering load weight, and prolonged static postures. Similarly, treatment 2 was also carried out for two weeks. During this period, the participants worked in ergonomic oriented conditions: ergonomic working postures, a non-hazardous eye distance (>60 cm), ergonomic manual handling, and working at a workstation designed according to anthropometry. In this study, a one-week washing out period was used to prevent treatment 1 from influencing treatment 2. This study was conducted from June to August 2023.

Furthermore, the independent variables in this study were ergonomic oriented working and non-ergonomic oriented working, while the dependent variables were photokeratitis and MSD complaints. The study was conducted on informal welding workers along Bogor Street, Bandung City. The population consisted of 60 informal welding workers who met the inclusion criteria: full-time workers with a minimum work period of six months who used goggles in their daily work. Meanwhile, the exclusion criteria were workers without chronic eye health problems and no history of MSD complaints before working. The minimum sample size required was 33 workers, calculated using the comparison of two means formula with a confidence level of 95% and an absolute precision required of 10%. The 33 workers were randomly selected from a pool of 68 workers.

The Nordic Body Map (NBM) questionnaire was used to assesses 28 types of MSD complaints. Complaint levels 1 to 4 were chosen, with a minimum score of 28 and a maximum score of 112. On the other hand, an instrument consisted of seven questions was used to assess photokeratitis complaints, including blurred vision; foreign body sensation; eye pain, sensitivity to light; excessive tearing; eye redness; and swollen eyelids. The minimum score for photokeratitis complaints is 0 and the maximum score is 7. This instrument was adapted from previous research on photokeratitis complaints (Suherdin, Sutriyawan and Natanegara, 2022). Nine variables were examined, namely age, work period, type of personal protective equipment (PPE), use of PPE, welding distance, exposure time (hours/day), working time, welding site, and complaints of photokeratitis. Data on complaints of photokeratitis were collected through interviews using seven questions about the symptoms of photokeratitis.

Data analysis was conducted using descriptive and inferential approaches. The frequency distributions of MSD and photokeratitis complaints were analyzed using descriptive statistics. Meanwhile, inferential statistics was used for variables with normal data distribution using the paired t-test and for variables with abnormal data distribution using the Wilcoxon signed-rank test, with a significance level at 95%. This study was approved by the Health Research Ethics Committee of Bhakti Kencana University with a certificate number 057/09.KEPK/UBK/VI/2023.

RESULTS

Distribution of Photokeratitis and MSD Complaints with and without Ergonomic Oriented Working

Photokeratitis complaints were assessed using seven questions regarding its typical symptoms. The collected data were analyzed descriptively and presented in the following Table 1.

Table 1 shows that non-ergonomic oriented working resulted in a 31.08% increase in mean photokeratitis complaints, while ergonomic oriented working only led to a 3.06% increase in mean photokeratitis complaints. These findings suggest that ergonomic oriented working can reduce photokeratitis complaints among informal welding workers. Similarly, the results of the descriptive analysis of MSD complaints are presented in Table 2.

Table 2 shows a 31.32% increase in mean MSD complaints with non-ergonomic oriented working and a 6.78% decrease with ergonomic oriented working. These findings suggest that ergonomic oriented working can reduce MSD complaints among informal welding workers.

Normality Test

This study analyzed 12 variables. Prior to conducting inferential analysis, a data normality test was performed using the Shapiro-Wilk test considering the sample size of less than 50 participants.

Table 1. Distribution of Photokeratitis Complaints with and without Ergonomic Oriented Working

Worker	Complaints of photokeratitis with non-ergonomic oriented working		Complaints of photokeratitis with ergonomic oriented working	
	Before working score	After working score	Before working score	After working score
1	3	4	3	2
2	4	5	2	3
3	3	4	2	2
4	3	3	3	3
5	4	7	4	6
6	6	6	6	2
7	2	3	2	2
8	0	4	2	0
9	0	2	0	2
10	1	3	2	1
11	4	5	4	4
12	2	2	2	2
13	2	2	2	1
14	2	4	2	4
15	3	7	3	4
16	6	7	4	3
17	4	5	4	4
18	6	3	6	3
19	4	4	4	4
20	5	3	3	3
21	1	2	1	2
22	3	4	3	4
23	3	3	3	3
24	2	5	2	5
25	5	5	5	5
26	4	5	4	5
27	5	4	4	4
28	1	5	0	0
29	3	3	3	3
30	3	5	3	5
31	2	1	4	1
32	5	5	4	5
33	2	5	1	3
Mean	3.12	4.09	2.94	3.03
± SD	1.635	1.508	1.435	1.520
% Step-up	31.08		3.06	

Source: Primary data (2023)

Table 2. Distribution of MSD Complaints with and without Ergonomic Oriented Working

Worker	CComplaints of MSDs with non-ergonomic oriented working		Complaints of MSDs with ergonomic oriented working	
	Before working score	After working score	Before working score	After working score
1	50	58	48	44
2	55	72	54	55
3	44	62	43	60
4	45	59	46	59
5	58	73	55	62
6	49	66	49	57
7	73	90	75	61
8	43	62	43	55
9	47	67	36	65
10	57	81	58	60
11	58	84	59	52
12	62	82	62	60
13	59	73	57	57
14	62	77	62	62
15	49	64	53	52
16	62	77	62	63
17	49	64	51	55
18	58	98	58	59
19	45	62	42	54
20	53	72	53	58
21	45	60	45	54
22	49	61	45	55
23	51	62	49	59
24	55	71	56	67
25	52	62	53	58
26	71	77	71	63
27	65	79	67	65
28	59	71	61	55
29	43	56	44	56
30	42	51	49	43
31	71	86	71	53
32	57	72	53	66
33	40	84	40	48
Mean	53.88	70.76	53.64	57.33
± SD	8.792	10.837	9.440	5.688
% Step-up	31.32		6.87	

Source: Primary data (2023)

The results of the normality test showed that 10 variables have a normal data distribution, while two variables have an abnormal data distribution.

Table 3. Data Normality Test Results

Variable	P-Value*
Non-ergonomic oriented: Photokeratitis before working	0.183
Non-ergonomic oriented: MSDs before working	0.189
Non-ergonomic oriented: Photokeratitis after working	0.075
Non-ergonomic oriented: MSDs after working	0.426
Ergonomic oriented: Photokeratitis before working	0.075
Ergonomic oriented: MSDs before working	0.675
Ergonomic oriented: Photokeratitis after working	0.180
Ergonomic oriented: MSDs after working	0.234
Non-ergonomic oriented difference: Photokeratitis	0.083
Non-ergonomic oriented difference: MSDs	0.000
Ergonomic oriented difference: Photokeratitis	0.016
Ergonomic oriented difference: MSDs	0.712

Source: Primary data (2023)

For variables with normal distribution, the mean difference between non-ergonomic and ergonomic oriented working was determined using the paired t-test. Meanwhile, for variables with abnormal distribution, the Wilcoxon signed-rank test was used to determine the mean difference between non-ergonomic and ergonomic oriented working (Table 3).

Differences in Mean Photokeratitis Complaints between Non-Ergonomic Oriented Working and Ergonomic Oriented Working

Table 4 presents the results of the analysis of photokeratitis complaints with non-ergonomic and ergonomic oriented working before and after working. The mean photokeratitis complaints before working with non-ergonomic oriented working was 3.12, while with ergonomic oriented working was 2.94. The paired t-test resulted in a p-value of 0.245, indicating no significant difference in the mean between the two. After working, the mean for non-ergonomic oriented working was 4.09, while for ergonomic oriented working was 3.03. The paired t-test resulted in p-value of less than 0.001, indicating a significant difference in the mean between the two. The Wilcoxon signed-rank test to compare the scores of photokeratitis complaints

Table 4. Differences in Mean Photokeratitis Complaints between Non-Ergonomic Oriented Working and Ergonomic Oriented Working

Variable	Non-ergonomic oriented working		Ergonomic oriented working		t	p-value
	Mean	SD	Mean	SD		
Complaints before working	3.12	1.635	2.94	1.435	1.184	0.245
Complaints after working	4.09	1.508	3.03	1.520	4.123	<0.001
Difference before and after working	0.97	1.630	0.09	1.548	-2.832*	0.005*

*Wilcoxon signed-rank test

Source: Primary data (2023)

Table 5. Differences in Mean MSD Complaints between Non-Ergonomic Oriented Working and Ergonomic Oriented Working

Variable	Non-ergonomic oriented working		Ergonomic oriented working		t	p-value
	Mean	SD	Mean	SD		
Complaints before working	53.88	8.792	53.64	9.440	0.479	0.635
Complaints after working	70.76	10.837	57.33	5.688	7.357	<0.001
Differences before and after working	16.88	7.688	3.70	9.406	-4.774*	<0.001*

*Wilcoxon signed-rank test

Source: Primary data (2023)

before and after working resulted in a p-value of 0.005, indicating a significant difference in the mean value of the differences between the two. The mean value of photokeratitis complaints after working with ergonomic oriented working was smaller than with non-ergonomic oriented working. This suggests that ergonomic oriented working interventions can reduce the risk of photokeratitis complaints.

Differenced in Mean MSD Complaints between Non-Ergonomic Oriented Working and Ergonomic Oriented Working

Table 5 presents the results of the analysis of MSD complaints with non-ergonomic and ergonomic oriented working. The mean MSD complaints before working with non-ergonomic oriented working was 53.88, while with ergonomic oriented working was 53.64. The paired t-test resulted in a p-value of 0.635, indicating no significant difference in the mean between the two. After working, the mean for non-ergonomic oriented working was 70.76, while for ergonomic oriented working was 57.33. The paired t-test resulted in a p-value of less than 0.001, indicating a significant difference in the mean between the two. The Wilcoxon signed-rank test to compare the scores of MSD complaint before and after working resulted in a p-value of less than 0.001, indicating a significant difference in the mean value of the differences between the two. The mean value of MSD complaints after working with ergonomic oriented working was much smaller than with non-ergonomic oriented working. This suggests that ergonomic oriented working interventions can reduce the risk of MSD complaints.

DISCUSSION

The workplace as a place of interaction between materials, tools, and people is not immune to potential hazards that can cause health problems. In the informal welding sector, MSDs are a common complaints among workers. MSDs occur when the work capacity and anthropometry of a worker are not properly matched to the job, resulting in health problems that affect muscles, nerves, blood vessels, ligaments, and tendons (Kusumawardhani, Djamalus and Lestari, 2023; Melinda *et al*., 2023). The high number of health complaints in informal sector workplaces may be attributed to differences in occupational health and safety (OHS) management. Clear organization in the formal sector ensures the presence of OHS experts who are responsible for managing hazards. However, in the informal sector, which is more like a home industry without organization, OHS management is difficult. Regardless of the low level of awareness and understanding of OHS aspects, every workplace is obliged to implement the OHS practices (Suherdin, 2021).

This study conducted a trial of OHS practices, namely ergonomic oriented working, to reduce complaints of MSDs and photokeratitis in welding workers. The results showed a significant increase in MSD complaints from an average of 53.88 before working to an average of 70.76 after working with non-ergonomic oriented working, resulting in a 31.32% increase. Meanwhile, with ergonomic oriented working, the average before working was 53.64 and the average after working was 57.33, resulting in only a 6.87% increase. These results suggest that ergonomic oriented working has been successful in preventing an increase in MSD complaints. This study also found a significant difference in the average MSD complaints after working between non-ergonomic oriented working and ergonomic oriented working. This is consistent with previous research that concluded that work methods that adhere to ergonomic rules are effective in preventing MSD complaints (Haryawan, Biomi and Prihastini, 2020; Cahyanti and Rosyidi, 2022).

The interventions in this study included improving the positions of head, trunk, legs, arms, forearms, and wrists, as well as improving better manual handling and lifting methods, and adhering to maximum load recommendations. These interventions were based on the results of previous studies that identified several non-ergonomic work postures. Welding workers work up to eight hours in non-ergonomic oriented positions, such as looking down, stooping, tiptoeing, folding legs, bending heels, squatting, and asymmetrical hands and shoulders. Intervention to improve work postures is crucial to control ergonomic hazards as non-ergonomic work postures are one of the risk factors for MSDs. This risk increases as body postures shift away from the center of gravity. MSDs in workers are caused by inappropriate work postures that are sustained for extended periods of time (Nidaan, Suwondo and Jayanti, 2019; Ridlo and Fasya, 2023).

Ergonomic oriented working should be prioritized in the workplace. It indirectly promotes the health and productivity of workers by reducing the risk of MSDs (Arnita *et al*., 2019). The goal

is to prevent more serious conditions, such as limited mobility and dexterity, which can lead to early retirement, reduced well-being, and reduced participation in society. This is consistent with the recommendations of the Occupational Safety and Health Administration (OSHA) that ergonomic measures should be taken to prevent overexertion. These measures include engineering techniques such as adjusting work design and tools (Henningsen and Sayeed, 2023). MSDs are caused not only by ergonomic factors, but also by other risk factors. Therefore the implementation of ergonomic oriented working alone may not be sufficient. It is recommended that it be accompanied by other controls, such as reducing smoking and alcohol consumption, maintaining a normal BMI, engaging in physical activity and stretching, reducing work hours, and considering medical history (Rahayu, Baharuddin and Kalla, 2022; Arjuni and Ramadhani, 2023).

Previous research has identified hazards in welding, including the risk of MSDs and photokeratitis (Suherdin, Sutriyawan and Natagerara, 2022). Photokeratitis is caused by acute inflammation of the cornea and conjunctiva which occurs after exposure to welding sparks that produce UV light. This symptom is commonly known as flash burn, welder's flash, or welder's eye (Yuda, 2018). Similar to MSDs, photokeratitis is caused by unsafe work methods and environments. If left untreated, it can negatively impact the vision of workers. In this study, ergonomic oriented working was implemented to control the risk of photokeratitis. The intervention involved using PPE (goggles) and setting the welding distance to more than 60 cm. This is consistent with previous research that found that welding distance partially influences photokeratitis complaints among welding workers (Suherdin, Sutriyawan and Natanegara, 2023).

The results of this study showed that non-ergonomic oriented working led to an increase in the mean photokeratitis complaints from 3.12 before working to 4.09 after working. In contrast, with ergonomic oriented working, the mean before working was 2.94 and after working was 3.03. The results of the mean difference test after working between non-ergonomic and ergonomic oriented working showed a significant difference. This suggests that ergonomic oriented working is an effective method for controlling photokeratitis complaints. Moreover, the difference in the average increase in complaints with non-ergonomic and ergonomic oriented working were 0.97 and 0.09, respectively. This study used seven photokeratitis symptoms as a measuring instrument. Therefore, an increase in the average photokeratitis complaints of 0.97 in non-ergonomic oriented working had an additional impact on at least one photokeratitis symptom.

Welding workers are exposed to UV rays during the welding process for eight hours. Therefore, in addition the welding duration, the welding distance has a significant impact on the eye health of the workers (Sundawa, Ginanjar and Listyandini, 2020). Adjusting the distance between the eyes and the UV source is one way to mitigate the risk of photokeratitis. Welding distances are included in administrative controls that focus on ergonomic hazards. In addition to setting welding distances, using PPE according to standards can help reduce the risk of photokeratitis (Muliana, Subagiada and Natalisanto, 2021). Through these efforts, it is hoped that the symptoms of photokeratitis such as watery eyes, blurred vision, glare, and swelling of the eyelids can be prevented.

CONCLUSION

Based on the results of this study, it can be concluded that there were differences in MSD and photokeratitis complaints before and after working with non-ergonomic oriented working intervention. However, there were no differences in photokeratitis complaints, but there were differences in MSD complaints with ergonomic oriented working intervention. This study also showed differences in MSD complaints and photokeratitis complaints after working with both non-ergonomic and ergonomic oriented working interventions. The average score for MSD and photokeratitis complaints with ergonomic oriented working was smaller than that with non-ergonomic oriented working, indicating that ergonomic oriented working is effective in controlling MSD and photokeratitis complaints.

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