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Ergonomic Risks in Pottery Crafting: Impact on Work-Related Fatigue and Musculoskeletal Disorders

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ABSTRACT

Pottery workers frequently work in non-ergonomic conditions, including awkward postures and repetitive movements. These factors not only have an impact on workers' productivity and well-being but also contribute to long-term occupational health problems. This study aims to evaluate the ergonomic risk factors in pottery crafting and their impact on the incidence of MSDs and fatigue in Karanganyar Village. A cross-sectional design was employed, involving 43 pottery crafters selected randomly. Ergonomic risk factors have been evaluated using the Ergonomic Risk Factor (ERF) Checklist as per SNI 9011: 2021 standards. Musculoskeletal disorders were assessed with the Nordic Body Map questionnaire, and work-related fatigue was evaluated using a reaction timer. The research analysis uses the Pearson correlation test to measure the strength and direction of the relationship between ergonomic risk and work-related fatigue, as well as between ergonomic risk and musculoskeletal disorders, with a significance threshold of $p < 0.05$. The results indicated a positive relationship between ergonomic risk levels and the prevalence of MSDs and work-related fatigue. This suggests that higher ergonomic risks are associated with increased occurrences of musculoskeletal issues and fatigue. The findings underscore the need for targeted ergonomic interventions to mitigate these risks in pottery crafting.

Keywords: Ergonomic Risk, Fatigue, Musculoskeletal Disorders

INTRODUCTION

Musculoskeletal disorders (MSDs) are a range of conditions that impact joints, spinal vertebrae, muscles, tendons, and other related tissues (Australia, 2016). Globally, musculoskeletal disorders are the primary cause of disability, affecting approximately 1.71 billion individuals (Cieza et al., 2020; Hartvigsen et al., 2018; Williams et al., 2018). Sixty per cent European workers report different musculoskeletal disorders, such as backache and muscular pains in the upper and lower limbs (Work et al., 2019). MSDs are caused by numerous factors that can be categorized into individual and work-related factors (Tang, 2022). Individual factors include improper ergonomic practices, such as incorrect lifting techniques and poor posture, which increase physical strain and delay recovery (Tang, 2022). Work-related factors are caused by repetitive tasks and forceful exertions that demand high muscular effort (Da Costa & Vieira, 2010). MSDs significantly contribute to workplace absenteeism, with substantial economic impacts (Da Costa & Vieira, 2010). For example, in Germany, production losses due to MSDs amounted to EUR 17.2 billion in 2016, or 0.5% of the GDP.

In Australia, MSDs accounted for 60% of all work-related severe claims between 2009 and 2014, totalling 360,180 cases (Australia, 2016).

In addition to musculoskeletal disorders (MSDs), work fatigue is a health issue that often coexists with and exacerbates MSDs (Mehdizadeh et al., 2020). Work-related fatigue is a primary occupational safety and health concern, mainly when workers cannot avoid conditions contributing to their fatigue (Cunningham et al., 2022). Fatigue is a protective response indicating the need for rest, triggered by individual factors like age and job duration, as well as ergonomic factors such as workload, workstation design, and repetitive tasks (Cunningham et al., 2022). Between 2012 and 2021, fatigue was responsible for the deaths of 907 Australians, with 68% of these fatalities occurring among females (Statistics, 2023). Addressing both fatigue and MSDs is essential to improving worker health and preventing long-term issues (Mehdizadeh et al., 2020).

The informal sector plays a crucial role in Indonesia's economy, providing 90% employment opportunities for

the population (Rothenberg et al., 2016). However, workers in this sector often endure inadequate workplace conditions due to non-compliance with formal regulations, which forces them to adapt to challenging work environments and tasks (Ahonen et al., 2018). These conditions are prevalent in handicraft industries such as pottery crafting, where traditional methods involve manual labour that exposes workers to significant ergonomic risks (Arora et al., 2020). Pottery workers typically sit on small chairs, using both hands to shape clay—one hand rotates the turntable while the other molds the piece (Barik & Sofiana, 2020). This work often results in prolonged periods of awkward posture, repetitive movements, and manual handling of heavy materials, all due to inadequate workstation design (Susana & Putra, 2023). Such substandard conditions contribute to work-related fatigue and increase the risk of MSDs (Arora et al., 2020).

Many studies have examined the impact of unergonomic workplaces on fatigue and work-related musculoskeletal disorders (MSDs). However, no studies have considered daily working time, environmental load and repetitive motion when conducting ergonomic risk factor assessments. The ERF Checklist in SNI 9011:2021 provides a framework for measuring and evaluating potential ergonomic hazards in the workplace by considering all these factors. Incorporating them into ergonomic risk assessments can yield more accurate and relevant data, highlighting the importance of conducting this research.

METHODS

This research employed a cross-sectional observational design, focusing on pottery makers in Karanganyar Village, Borobudur District, Magelang Regency, Central Java Province, Indonesia. Data collection targeted the village's 70 pottery crafters. Using Lemeshow's simple random sampling method, 43 crafters were selected as participants. The sampling was done randomly, without specific criteria. The study's independent variable is ergonomic risk factors, while the dependent variables are work-related fatigue and musculoskeletal disorders (MSDs).

Ergonomic risk factors were assessed using the ERF Checklist according to SNI 9011: 2021 standards, which measure potential ergonomic hazards in the workplace. This process involved recording a complete work cycle on video and conducting interviews to gather task details. The results are then analysed and classified as follows: a score of 0-7 indicates no risk, 8-16 indicates low risk, 17-25 indicates medium risk, 26-35 indicates high risk, and a score above 35 indicates very high risk.

Musculoskeletal disorders were assessed with the Nordic Body Map questionnaire, where respondents identified body parts that experienced pain or discomfort after work and the severity of these symptoms. The scoring indicators are as follows: 1 for no pain, 2 for mild pain, 3 for pain, and 4 for severe pain. Based on these scores, the complaint levels are categorised as no

complaints (score of 0), low (28-49), medium (50-70), high (71-91), and very high (92-112).

Work-related fatigue was assessed by measuring the crafters' reaction times 20 times using a reaction timer immediately after working for at least four hours, ensuring an accurate assessment of their fatigue level. The average reaction time was calculated and classified into four categories: normal (150.0-240.0 milliseconds), mild work fatigue (>240.0-<410.0 milliseconds), moderate work fatigue (>410.0-<580.0 milliseconds), and heavy work fatigue (>580.0 milliseconds).

After collecting all data from the workers, it was processed in several steps. First, data editing was performed to ensure completeness for each variable under study. Next, data coding was done manually for each variable, followed by data entry into processing applications. The data was then tabulated to streamline the processing. The research analysis was conducted using the SPSS data processing program, which involved bivariate analysis to determine the distribution and frequency of independent and dependent variables. Pearson correlation test, with a significance threshold of $p < 0.05$, was used for analysis. The findings were presented in distribution tables and discussed narratively. This study received ethical approval from the Health Research Ethics Commission of the Faculty of Public Health, Universitas Airlangga (approval number 184/EA/KEPK/2022).

RESULTS AND DISCUSSION

The study included 43 pottery crafters from Karanganyar Village, all women. Pottery crafting is a skill passed down through generations, so many began working in this craft during their teenage years, as their formal education typically ended after elementary school. Table 1 presents the respondents' characteristics. The data reveals that 35 participants (81.4%) are 40 or older, while only 8 (18.6%) are under 40. Most have over ten years of experience in pottery crafting, with 37 participants (86%) working in the field for more than a decade and only 6 (14%) for less than ten years. All crafters are self-employed in informal work settings, allowing them to manage their work schedules. Among them, 32 (74%) work fewer than 8 hours daily, while 11 (26%) work more than 8 hours daily.

Tabel 1.

Characteristics Of Respondents		
Variables	Frequency	Percentage
Age		
≥ 40 years (at risk)	35	81.4
< 40 years (not at risk)	8	18.6
Work Tenure		
≥ 10 years (long)	37	86
< 10 years (not long)	6	14
Daily Working Hours		
> 8 hours (long)	11	26
≤ 8 hours (not long)	32	74

SNI 9011: 2021 standard used to measure ergonomic risk. This Indonesian national standard, introduced by the Ministry of Manpower in mid-2022, utilizes the Ergonomic Risk Factors (ERF) questionnaire (BSN, 2021). Pottery crafters are exposed to five types of ergonomic hazards: posture-related risks, repetitive movements, workstation design, manual handling, and environmental factors, all assessed by the ERF questionnaire. Among the 43 crafters measured, 26 (60.3%) were found to have low ergonomic risk, 15 (35%) had medium ergonomic risk, and 2 (4.7%) were categorized as having high ergonomic risk.

Pottery crafters with low ergonomic risk primarily face issues from repetitive movements like wheel throwing and hand building, as well as manual handling tasks such as lifting materials. However, those with medium and high ergonomic risks also encounter problems related to workstation design and poor posture. Manual handling and repetitive movements often require the continuous use of muscles without adequate rest, leading to muscle fatigue and straining tendons and ligaments (Ezugwu et al., 2020). This strain can cause inflammation and micro-tears, reducing muscle function and increasing the risk of injury (CCOHS, 2020).

Pottery crafters with medium and high ergonomic risk often place clay and finished products on the floor, leading

to constant bending, which strains the back, knees, and other joints, leading to MSDs (Ezugwu et al., 2020). They also sit on small chairs without backrests, which can lead to muscle discomfort, pain, and the development of myofascial trigger points due to reduced oxygen transport in the muscles (Kastelic et al., 2018). Prolonged static sitting places uneven stress on intervertebral discs, leading to tension and pain in the neck and shoulders (Kastelic et al., 2018; Lohne et al., 2024). Additionally, sitting on a hard surface for extended periods can cause discomfort and potential joint issues (Kastelic et al., 2018). Pottery crafters with high ergonomic risk in this study often work for prolonged periods, leading to increased fatigue and discomfort, which can eventually result in chronic pain in the back, neck, and shoulders (Barthelme et al., 2021; Lohne et al., 2024).

Further analysis of the ergonomic risk factors highlighted the prevalence of specific hazards among the crafters. Posture-related risks were predominantly associated with using non-adjustable workstations, while repetitive movements were commonly linked to the manual handling of clay. These specific risks varied among the crafters, with those experiencing medium to high ergonomic risks being more affected by poor workstation design and prolonged static postures.

Tabel 2.
Cross-Tabulation Between Ergonomic Risk and Musculoskeletal Disorders

Ergonomic Risk	MSDs										Total	P-value	CC	
	No		Low		Medium		High		Very high					
	n	%	n	%	n	%	n	%	n	%				
No risk	0	0	0	0	0	0	0	0	0	0	0	0	0.004	0.432
Low risk	0	0	25	58	1	2.3	0	0	0	0	26	60.3		
Medium risk	0	0	12	28	3	7	0	0	0	0	15	35		
High risk	0	0	0	0	2	4.7	0	0	0	0	2	4.7		
Very high risk	0	0	0	0	0	0	0	0	0	0	0	0		
Total			37	86	6	14					43	100		

Table 2 presents the musculoskeletal disorders (MSDs) distribution among pottery crafters according to their ergonomic risk levels. Among the 26 crafters with low ergonomic risk, 25 reported low MSDs complaints, and 1 reported medium MSDs complaints. Of the 15 crafters with medium ergonomic risk, 12 had low MSD complaints, and 3 had medium MSD complaints. Both crafters with high ergonomic risk reported medium MSDs complaints.

The data in Table 2 indicates that higher ergonomic risk levels are associated with increased MSDs complaints. This finding is supported by a Pearson correlation test, which yielded a p-value of 0.004. This p-value is below the standard significance level of 0.05, providing statistically solid evidence of a relationship between ergonomic risk and MSDs complaints. The correlation coefficient of 0.432 suggests a moderate positive relationship, meaning that MSDs complaints also tend to increase as ergonomic risk increases. Thus, a meaningful and statistically significant

moderate positive relationship exists between ergonomic risk and MSDs complaints.

Studies have consistently shown higher ergonomic risks, such as repetitive motions and awkward postures, are associated with increased MSDs complaints. Research on Indonesian clay art workers found a significant correlation between poor ergonomic conditions and high rates of musculoskeletal pain (Julia et al., 2022; Minggu et al., 2024). Additionally, a study on pottery workers in India revealed that higher ergonomic risks were associated with more severe MSDs symptoms, particularly in the neck, shoulders, and lower back (Rathore et al., 2020). Specific ergonomic risk factors in handicraft occupations, including prolonged sitting, repetitive hand movements, and awkward postures, were identified as significant contributors to MSDs (Das & Singh, 2022). These findings highlight the urgent need for targeted ergonomic improvements in the pottery industry to reduce the prevalence of MSDs among crafters.

Tabel 3.
Cross-Tabulation Between Ergonomic Risk And Work-Related Fatigue

Ergonomic Risk	Work-Related Fatigue								Total	P-value	CC	
	Normal		Mild		Moderate		Heavy					
	n	%	n	%	n	%	n	%				
No risk	0	0	0	0	0	0	0	0	0	0.000	0.879	
Low risk	4	9.2	20	46.5	2	4.6	0	0	26			60.3
Medium risk	0	0	0	0	15	35	0	0	15			35
High risk	0	0	0	0	0	0	2	4.7	2			4.7
Very high risk	0	0	0	0	0	0	0	0	0			0
Total	4	9.2	20	46.5	17	4.6	2	4.7	43	100		

Table 3 presents the distribution of Work-Related Fatigue among pottery crafters according to their ergonomic risk levels. Among the 26 crafters with low ergonomic risk, 4 (9.2%) experience normal Work-Related Fatigue, 20 (46.5%) report mild fatigue, and 2 (4.6%) suffer from moderate fatigue. This suggests that even at lower ergonomic risk levels, many crafters still experience some degree of fatigue, although it tends to be milder. All 15 crafters with medium ergonomic risk show moderate Work-Related Fatigue, indicating a consistent fatigue response linked to medium risk levels. Finally, the two crafters with high ergonomic risk endure heavy Work-Related Fatigue, highlighting the severe impact of high ergonomic risks on fatigue levels.

The data in Table 3 suggests that higher ergonomic risk levels are associated with greater severity of work-related fatigue. This conclusion is supported by a Pearson correlation test, which resulted in a p-value of 0.000—well below the standard significance level of 0.05. This indicates a highly statistically significant relationship between ergonomic risk and work-related fatigue. The correlation coefficient 0.879 demonstrates a solid positive relationship, highlighting a high association level between the two variables. Therefore, a highly meaningful and statistically significant positive relationship exists between ergonomic risk and work-related fatigue.

Similar to these research findings, studies on Korean workers have shown that ergonomic risks such as repetitive movements and insufficient recovery time contribute significantly to work-related fatigue (Park & Kim, 2020). Manual handling poses a significant ergonomic risk that leads to work-related fatigue, influenced by load, task duration, posture, and movements like bending, lifting, and holding (Yu et al., 2021).

This study relies on subjective evaluations to assess MSDs, which may be less precise than using objective methods. The sample is limited to a single location, limiting its applicability to environments with diverse workstations and ergonomic hazards.

CONCLUSION

This study investigates the impact of ergonomic risks in pottery crafting on work-related fatigue and musculoskeletal disorders (MSDs), considering factors like daily working time, work tenure, and task repetition using the SNI 9011: 2021 standard. The identified ergonomic

risks include repetitive movements, excessive manual handling, inadequate workstation design, and poor posture. Findings show a relationship between ergonomic risk and MSD complaints, where higher ergonomic risk levels are associated with increased complaints of MSDs and work-related fatigue. If not addressed, these risks could lead to chronic musculoskeletal conditions, potentially impairing workers' physical health and their ability to sustain livelihoods in communities where pottery crafting is a primary income source.

SUGGESTION

To mitigate the ergonomic risks associated with pottery crafting, it is recommended that workstations be redesigned for better posture, workload management strategies like task rotation and regular breaks implemented, and ergonomic training provided for workers. Policymakers should establish and enforce industry-specific ergonomic standards, including in informal sectors, offer health monitoring and support services, and incentivise businesses to invest in ergonomic improvements.

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