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Musculoskeletal Disorders (MSDs) and Ergonomic Assessment of Working Posture in Wood-Cutting Operators

Agung Kristanto[1, 2, *], Dery Bagus Setiawan[1, 2], Choirul Bariyah[1, 2], and Farid Ma'ruf[1, 2]

[1]Department of Industrial Engineering, Faculty of Industrial Technology, Universitas Ahmad Dahlan, Yogyakarta 55166, Indonesia

[2]Research Center in Ergonomics and Occupational Safety and Health, Universitas Ahmad Dahlan, Yogyakarta 55166, Indonesia

*Corresponding author; E-mail: agung.kristanto@ie.uad.ac.id

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Abstract

The industrial sector, particularly at the furniture SME center, relied heavily on human labor but lacked adequate infrastructure, leading to high rates of musculoskeletal disorders (MSDs) among workers. A preliminary study showed that 93% of workers experienced back pain, while significant percentages reported shoulder pain (67%), lower back pain (47%), leg joint pain (40%), and overall body aches (40%). These preliminary findings underscored the urgent need to assess the ergonomic risks specifically faced by wood-cutting workers. This study aimed to assess ergonomic risks for wood-cutting workers using the Quick Exposure Check (QEC) method and to examine the correlation between self-reported MSDs and ergonomic risk levels. A total of 60 workers from the wood-cutting workstation were surveyed. The independent variable was the workers' pain levels, measured using a modified SNQ-VAS questionnaire, while the dependent variable was the exposure level to injury risks in specific body parts, assessed using the QEC questionnaire. Chi-Square and Fisher's exact analyses were employed to explore the relationship between these variables. Results indicated that 88.33% of workers experienced ergonomic risks at action level 4, necessitating urgent intervention. Significant correlations were found, with MSDs in the upper and lower backs showing strong associations with QEC exposure levels ($\chi^2 = 3.965$, $p = 0.047$ for the upper back; $\chi^2 = 4.044$, $p = 0.044$ for the lower back). Similarly, correlations were significant for right shoulder and wrist MSDs in relation to QEC levels ($\chi^2 = 4.127$, $p = 0.042$; $\chi^2 = 3.860$, $p = 0.049$, respectively), as well as for neck MSDs correlated with neck exposure levels ($\chi^2 = 29.492$, $p = 0.033$). These findings called for immediate ergonomic improvements to enhance the health and safety of workers at the SME Center.

Keywords: *body posture; MSDs; QEC; SMEs; visual analogue scale*

1. Introduction

The industrial sector in Indonesia, particularly the Small and Medium Enterprises (SMEs), played an essential role in the country's economic growth. Aladin et al. (2021) stated that around 66 million SMEs contribute 61% of Indonesia's Gross Domestic Product (GDP). These SMEs, with their vast reach, employed approximately 117 million workers, a number that underscored their significance in the national workforce (World Bank, 2022). Despite this success, the reliance on manual labor, especially in labor-intensive industries like woodworking, presented substantial health and safety challenges. One of the most critical issues facing workers in these sectors was the prevalence of Musculoskeletal Disorders (MSDs), which affected their overall well-being and productivity (World Health Organization, 2021). Studies indicate that the physical demands of woodworking, such as repetitive motions

and awkward postures, significantly increased the risk of developing MSDs among workers (Das, 2020; Yoopat et al., 2024).

MSDs, which affected the muscles, tendons, ligaments, nerves, and other supporting structures, were a significant concern for Indonesian workers. These conditions, often linked to repetitive movements, awkward postures, and prolonged exposure to physically demanding tasks, were prevalent in industries such as woodworking (Odebiyi & Okafor, 2023). According to the Indonesian Ministry of Manpower, the Southeast Asian region, including Indonesia, has reported 369 million cases of MSDs, with Indonesian workers being particularly vulnerable due to the physically demanding nature of SME jobs (Adiratna et al., 2022).

In Indonesia's woodworking industry, many SMEs operated with outdated and manual machinery, leading workers to adopt suboptimal postures and perform repetitive motions without adequate ergonomic support. This condition, which was entirely preventable, increased the strain on their musculoskeletal system (Hilmi et al., 2024). Tasks such as cutting, sanding, and assembling wood involved repetitive movements, awkward postures, and excessive manual force, contributing to the high incidence of MSDs (Tran et al., 2023). Workers in these settings frequently reported pain in their backs, necks, shoulders, arms, and legs (Adiratna et al., 2022). Research indicates that these postures and repetitive movements without proper support were major risk factors for MSDs, as noted by Chiasson et al. (2015) and Pavlovic-Veselinovic et al. (2016), which emphasized that poor ergonomic practices significantly increased the likelihood of musculoskeletal strain. Individual characteristics of workers, such as age, body mass index (BMI), smoking habits, and physical fitness, played a significant role in influencing the risk of developing MSDs. It was crucial to understand that these factors, when combined with the challenging physical environment, could further complicate the issue. For instance, studies show that older workers, typically those aged 35 to 65, are more prone to musculoskeletal complaints due to their bodies being less resilient to repetitive physical strain (Collins & O'Sullivan, 2015). Similarly, workers with higher BMI, particularly those who were overweight or obese, faced added pressure on their joints and muscles, making them more susceptible to MSDs (Bostanpara et al., 2024). The impact of smoking habits should not be overlooked, as smokers tended to have reduced oxygen flow to their muscles, leading to fatigue and an increased likelihood of injury during physically demanding tasks (Shandu et al., 2023).

In woodworking SMEs, such as those in Banjarnegara, where workers were exposed to physically strenuous tasks without proper ergonomic intervention, individual factors often amplified the risks of MSDs. A survey conducted in this region found that most workers were men aged 25 to 65, many of whom reported working long hours under physically demanding conditions. The preliminary study revealed that 90% of workers had experienced chronic back pain, while 60% reported discomfort in their shoulders and legs. These musculoskeletal complaints were often linked to awkward postures and individual risk factors, such as advanced age and poor physical fitness. However, the implementation of ergonomic interventions could have significantly reduced these risks and improved the overall health and safety of the workforce.

Previous research consistently showed that a combination of workplace conditions and individual characteristics contributed significantly to the prevalence of MSDs. For instance, studies by Krishnan et al. (2021) and Shaikh et al. (2022) demonstrated that poor ergonomic practices, coupled with factors like age and physical health, significantly increased the risk of MSDs in workers. Additionally, De Sio et al. (2018) emphasized that ergonomic risk factors, such as improper posture, could be mitigated through proper ergonomic design and equipment. These studies also highlighted the need for ergonomic interventions consider environmental and individual risk factors to effectively reduce the burden of MSDs (Karimi et al., 2020).

Given these challenges, this research aimed to assess ergonomic risks for wood-cutting workers and examine the correlation between self-reported MSDs and ergonomic risk levels. The research employed the Quick Exposure Check (QEC) to assess the risk of exposure to ergonomic hazards in the workplace (David et al., 2008) and the Visual Analogue Scale (VAS) to evaluate the severity of musculoskeletal strain (Hawker et al., 2011), along with the Standard Nordic Questionnaire (SNQ) to identify areas of the body most affected by these disorders (Kuorinka et al., 1987). By identifying the most significant risk factors in terms of workplace conditions and individual characteristics, the study sought to propose ergonomic interventions that could mitigate MSD risk while considering the unique challenges workers faced in Indonesia's SME sector.

The novelty of this research lies in its integrated approach to assessing the combined impact of ergonomic factors and individual worker characteristics on the risk of MSDs in Indonesia's woodworking SMEs. Whereas previous studies typically focused on either

workplace ergonomics or individual worker traits, this study uniquely examined both dimensions concurrently to provide a more holistic understanding of MSD risks. By utilizing a combination of the QEC, SNQ, and VAS tools, the research offered a comprehensive assessment of musculoskeletal strain. Moreover, it went beyond simple risk identification by proposing practical, low-cost ergonomic interventions tailored to the needs of Indonesia's SME sector. By considering individual factors such as age, BMI, and smoking habits together with workplace conditions, this study contributes new insights into how ergonomic improvements can be implemented in labor-intensive industries with limited resources, ultimately enhancing worker health and productivity.

2. Objectives

This study significantly contributed to the burgeoning field of ergonomics research in Indonesia. It provided valuable insights into how individual factors, such as age and lifestyle choices, influenced the development of MSDs in high-risk industries. By proposing practical, low-cost ergonomic solutions that address environmental and personal risk factors, this research aimed to improve the working conditions for Indonesian workers, enhance their productivity, and reduce the prevalence of MSDs across the country's labor-intensive industries.

3. Materials and Methods

3.1 Participants

The research was conducted at the Furniture SME Center in Banjarnegara Regency, Central Java, with a working population consisting entirely of males between 25 and 65 years old. This study involved wood-cutting workers at the furniture SME center who met the inclusion criteria and agreed to participate. Participants had a minimum of one year of working experience in the wood-cutting process and were required to have no current injury to the lower extremity or any previous history of surgery or fracture. A total of 60 workers were recruited, representing all eligible participants present during the data-collection period. The sample size was determined by feasibility, as every qualified worker at the study site was included. A sensitivity power analysis for a chi-square test of independence ($\alpha = 0.05$) confirmed that a sample of 60 provided approximately 80% power to detect a medium effect size (Cohen's $w \approx 0.33$–0.35), indicating that the sample was sufficient for testing the study's primary hypotheses (Cohen, 2013; Faul et al., 2009). The study protocol was reviewed and approved by the Human Ethics Committee of Universitas Ahmad Dahlan (Ethical Clearance No. 012406160; approval date: 23 July 2024). All participants were informed about the study procedures and provided written informed consent prior to participation.

3.2 Description of the Activity

In the process of wood cutting at the furniture SME, workers faced working conditions that required them to adopt non-ergonomic body postures, which increased the risk of injury. When measuring and marking wood, workers bent for prolonged periods, which caused strain on the lower back. Additionally, workers had to lift and move wood weighing more than 5 kg without proper lifting techniques, such as not bending their knees and overloading their backs, which put them at risk of spinal injuries. During the cutting process, workers used table saws or band saws that often required them to tilt their bodies unnaturally to guide the wood into the blade, which led to muscle tension in the back, shoulders, and arms. Hands positioned too close to the blade while holding the wood also increased the risk of hand injuries. Using jigsaws or wood profiling machines in unstable working positions produced excessive vibrations, which posed risks of muscle fatigue, circulatory disturbances, and even loss of control over the tool, potentially resulting in workplace accidents. Furthermore, workers who did not use workbenches of appropriate height often had to work in a squatting or bending position for an average of 8 hours a day, which could cause knee and back pain.

3.3 Data Acquisition

3.3.1 MSDs Pain Perception

The pain perception questionnaire was used to collect the self-report of pain for each joint of the lower extremities (Indonesian version) (Kristanto et al., 2022). The SNQ, consisting of a body part map, was used to create the questionnaire. Pain was assessed using 10 cm VAS, which is sensitive to treatment effects. The pain rating VAS scales ranged from 0 to 10 points, where 0 represented no pain, and 10 represents intolerable pain. The questions included participants' perceived pain on both sides of each upper extremity part, such as the left and right sides of their shoulders, wrists, and elbows.

3.3.2 Ergonomic Risk Exposure Assessment

The QEC questionnaire assessed the risk of injury experienced by workers. In this study, the QEC questionnaire followed the procedure described by (David et al., 2008). The QEC questionnaire consisted of

two assessment questionnaires: the first was completed by the workers, and the second was completed by the researcher while observing the workers' activities during their tasks. The QEC questionnaires for workers and researchers had different purposes. The worker's QEC questionnaire was designed to identify the complaints experienced by workers while performing their tasks. In contrast, the researcher's QEC questionnaire primarily aimed at assessing the workers' body posture while they were working. The QEC score was obtained by combining the results of the assessments conducted by the researcher and the workers using the QEC worksheet. The QEC score comprised two scores: the QEC score for body movements and the QEC score derived from other factors, including driving activities, machine vibrations, work speed, and stress.

3.4 Statistical Analyses

Descriptive statistics were employed to examine the participants' characteristics. The mean and standard deviation were used to analyze continuous variables, including age, weight, height, work experience, daily work hours, smoking habits, and physical fitness. The independent variable in this study was the level of pain complaints in the workers' musculoskeletal system, which was measured using a modified SNQ-VAS questionnaire. The dependent variable in this study was the level of exposure to injury risk in specific body parts (neck, shoulder/arm, wrist, and back), measured using the QEC method. Chi-square and Fisher's exact tests were employed to evaluate the associations between musculoskeletal disorders (MSDs) and the ergonomic risks experienced by workers. A p-value of less than 0.05 was considered to indicate statistical significance. All statistical analyses were performed using SPSS version 26 (IBM SPSS, USA).

3.5 Hypothesis

This study hypothesized a correlation between MSDs and ergonomic risk factors associated with wood-cutting activities. It was therefore designed to examine the relationship between ergonomic risk factors and musculoskeletal disorders among wood-cutting workers in Indonesia, addressing an important occupational health concern.

4. Results

4.1 Participants

The demographic characteristics of the participants and the summary statistics were presented in Table 1.

Based on Table 1, the average work break duration was 1.17 hours, daily rest duration was 7.73 hours, work experience was 12.03 years, and work duration was 7.47 hours per day. The majority of participants (36.67%) exercised once a week. Additionally, 56.67% of participants drank more than three cups of coffee daily and consumed 10.88 cigarettes daily.

Table 1 Demographic characteristics and work-related variables of wood-cutting workers (N = 60)

Characteristics	N (%)	Mean ± SD	Min	Max
Age (years)		41.72 ± 8.86	25.70	64.01
Weight (kg)		59.65 ± 5.41	47.00	70.00
Height (cm)		166.80 ± 4.91	155.00	178.00
BMI (kg/m2)		21.45 ± 1.36	18.59	24.46
Normal	60 (100)			
Work experience (years)		12.03 ± 5.80	2.25	25.25
Daily work hours (hours/day)		7.47 ± 0.69	6.30	9.30
Exercise frequency (times/week)				
Never	20 (33.33)			
Once	22 (36.67)			
Twice	1 (1.67)			
More than 3 times	17 (28.33)			
Daily rest duration* (hours/day)		7.73 ± 1.06	6.30	10.00
Smoking habit (sticks/day)		10.88 ± 4.35	0.00	18.00
Coffee drinking habit (glass/day)				
Never	1 (1.67)			
One	4 (6.67)			
Two	21 (35.00)			
More than three	34 (56.67)			
Work break duration (hours)		1.17 ± 0.58	0.30	2.15

Note: *Daily rest duration refers to total resting time within a 24-hour period, including sleep and non-working rest, not short breaks during work hours.

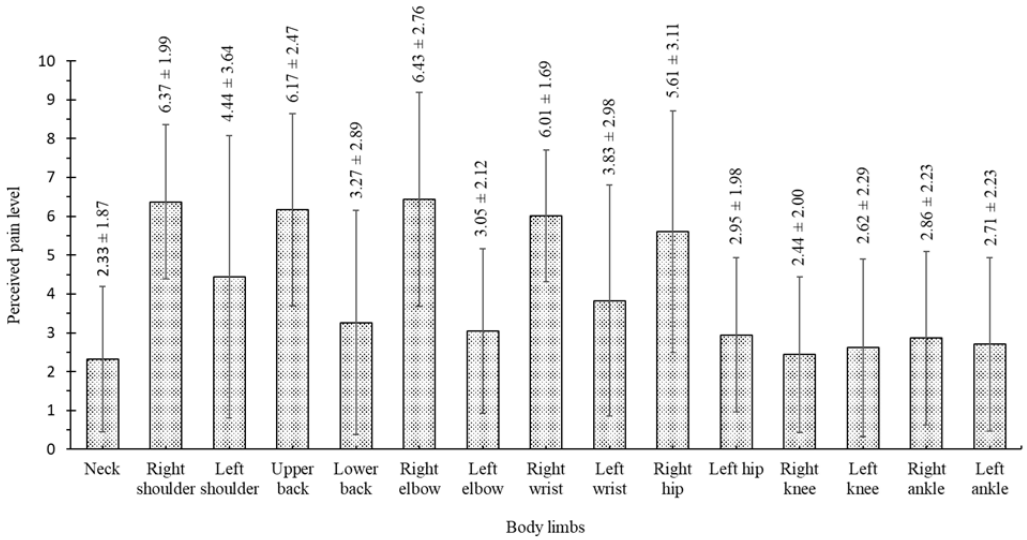

Figure 1 Average perceived pain levels across body regions in wood-cutting workers (N = 60), measured using VAS scale (0-10)

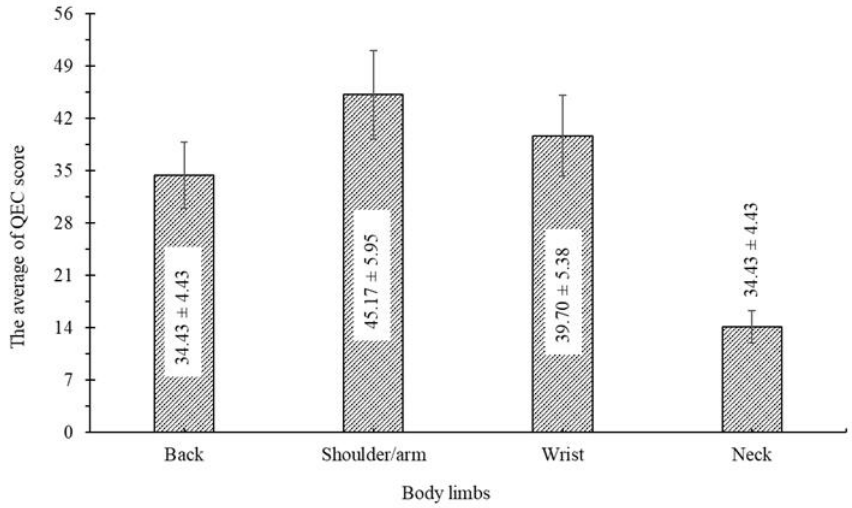

Figure 2 Average QEC exposure scores by body region among wood-cutting workers.

4.2 MSDs Analysis

Figure 1 presented the MSDs data in workers' limbs at the SMEs furniture center in Banjarnegara. Based on Figure 1, the five body limbs that experienced the highest pain levels were the right elbow (6.43 ± 2.76), right shoulder (6.37 ± 1.99), upper back (6.17 ± 2.47), right wrist (6.01 ± 1.69), and right hip (5.61 ± 3.11).

4.3 Risk Exposure Analysis

4.3.1 QEC Analysis

Figure 2 showed the results of the analysis of the average QEC score on the workers' body limbs.

Based on Figure 2, the body limbs ranked from the largest to smallest average QEC scores were the shoulder/arm (45.17 ± 5.95), wrist (39.70 ± 5.38), back (34.43 ± 4.43), and neck (14.13 ± 2.16).

The QEC values also involved other factors, including driving factors, vibration, work speed, and stress levels. The average QEC values due to these other factors were presented in Figure 3.

Based on Figure 3, the vibration factor had the highest average QEC score (7.20 ± 2.48), followed by the work pace factor (2.40 ± 1.50), driving activity (2.35 ± 2.06), and stress level (1.98 ± 1.63).

4.3.2 Exposure Score Analysis

The exposure score QEC was classified into four categories to determine the level of exposure risk experienced by body limbs due to work activities. Figure 4 showed the exposure score QEC percentage distribution for each body limb.

Based on Figure 4, among the 60 participants involved in this study, participants were exposed to a very high-risk level in 3 body limbs: the back (86.67% of participants), shoulders/arms (76.67% of participants), and wrists (51.67% of participants). Meanwhile, the neck was exposed to a risk in the high category (55.00% of participants).

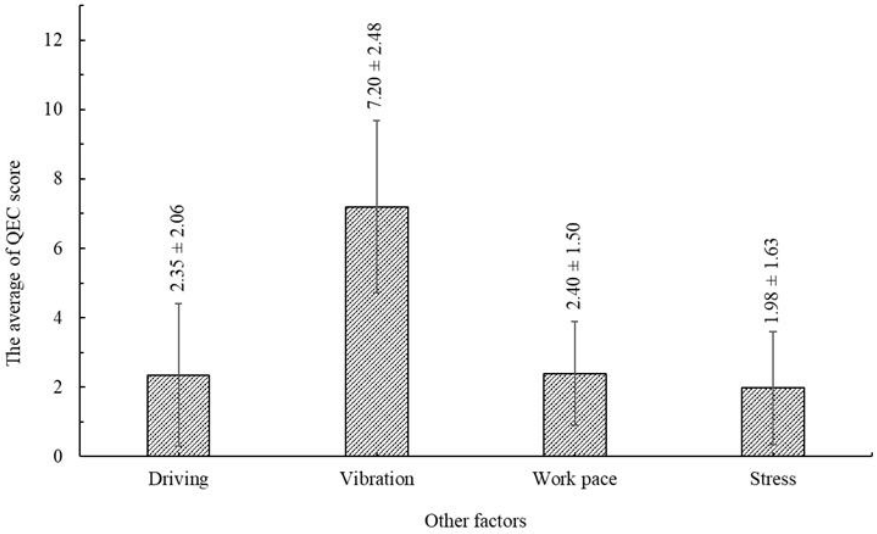

Figure 3 Average QEC scores for non-postural risk factors (driving, vibration, work pace, and stress)

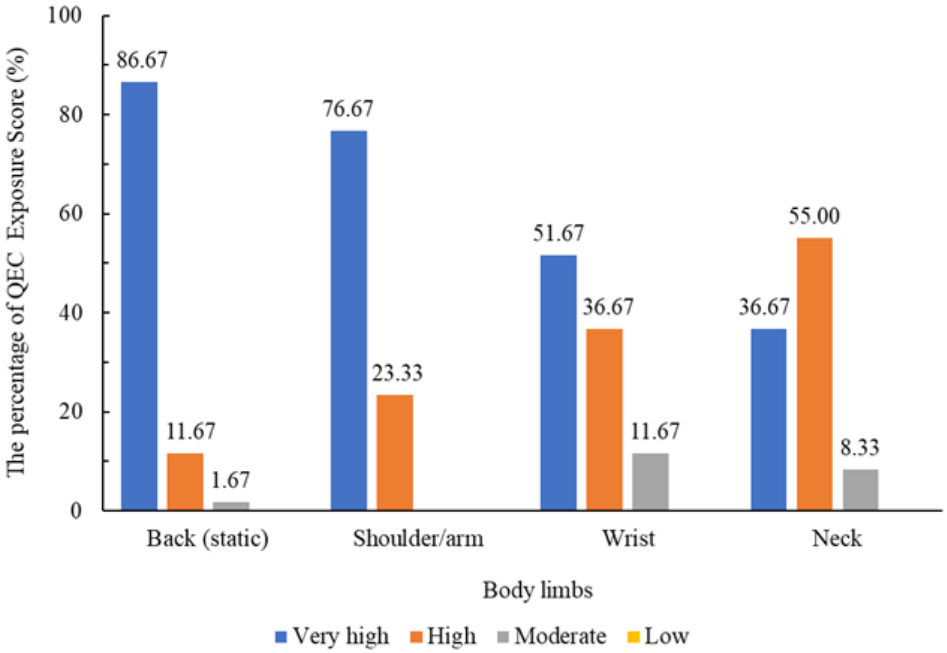

Figure 4 Distribution of QEC exposure risk categories across body regions (N = 60)

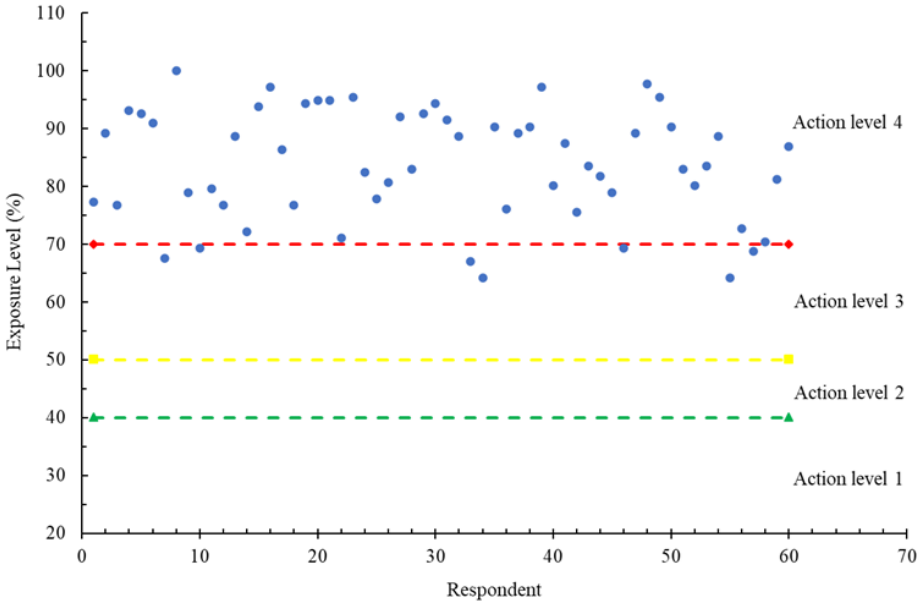

Figure 5 Distribution of participants by QEC action level category (N = 60)

Table 2 Correlation between musculoskeletal disorder complaints and QEC exposure levels by body region (N = 60).

MSDs of body limbs obtained from VAS	Exposure level of body limbs obtained from QEC	Chi-square (*p*-value)
Upper back	Back (static)	3.965 (0.047)*
Lower back		4.044 (0.044)*
Right shoulder	Shoulder/arm	4.127 (0.042)*
Left shoulder		1.818 (0.178)
Right wrist	Wrist	3.860 (0.049)*
Left wrist		1.324 (0.391)
Neck	Neck	29.492 (0.033)*

Note: * Statistically significant correlation ($p < 0.05$)

4.3.3 Exposure Level Analysis

The exposure level was calculated to determine the participants' action level category of risk. This action level served as a basis for identifying necessary follow-up steps to address issues related to MSDs, thereby reducing the risk of injury. The distribution of exposure levels for 60 participants was depicted in Figure 5.

Figure 5 shows the exposure level for 60 workers in the wood-cutting workstation at the SME Furniture Center. 88.33% (57/60) of participants fell into the action level 4 category, while 11.67% (7/60) were in the action level 3 category. This finding indicated the need for immediate investigation and changes.

4.4 Correlation between Pain Perception and Ergonomic Risk Exposure

The results of the Chi-Square and Fisher's exact analyses were presented in Table 2. Based on Table 2, MSDs in the upper and lower back had a significant correlation with the QEC exposure level in the back area ($\chi^2 = 3.965$ with a p-value of 0.047 for the upper back and $\chi^2 = 4.044$ with a p-value of 0.044 for the lower back). MSDs in the right shoulder also significantly correlated with the QEC exposure level in the shoulder/arm area ($\chi^2 = 4.127$ with a p-value of 0.042). This study also revealed a significant correlation between MSDs in the right wrist and the QEC exposure level in the wrist area ($\chi^2 = 3.860$ with a *p-value* of 0.049). MSDs in the neck also

significantly correlated with the QEC exposure level in the neck area ($\chi^2 = 29.492$ with a p-value of 0.033).

5. Discussion

MSDs were prevalent among workers in the industrial sector, particularly in work environments that required high physical activity, such as wood-cutting stations. The body parts most vulnerable to these disorders was the upper and lower back, which were heavily utilized in wood-cutting activities, including lifting, pushing, and pulling wooden materials (Thetkathuek & Meepradit, 2018). The QEC was an ergonomic risk assessment method used to evaluate workers' exposure to risk factors that could lead to MSDs. The study found a significant correlation between MSD levels in the upper and lower back and QEC exposure level on the workers' backs. Statistical analysis indicated that the higher the exposure to workload measured by QEC, the greater the level of MSD complaints among workers (Bulduk et al., 2014). Previous studies of crane operators found that increased exposure levels on the QEC positively correlated with increased MSD complaints, particularly in the upper back (Ibrahim et al., 2020). Several main factors contributed to the increased risk of musculoskeletal disorders (MSDs) in workers' upper and lower backs at wood-cutting stations. One significant factor was non-ergonomic working postures, where workers frequently bent or performed repetitive movements that strained the upper back, as noted by Ezugwu et al. (2020). Prior research indicated that these non-ergonomic postures, combined with long working hours, significantly heightened the risk of MSDs among factory workers (Jakobsen et al., 2018). Another contributing factor was the excessive lifting loads, as the wood-cutting process often required lifting and moving heavy logs (Kamat et al., 2017). Additionally, prolonged exposure duration led to workers spending hours in one work cycle with little opportunity for rest (Putsa et al., 2022). These findings strengthened the suspicion that ergonomic interventions were necessary to reduce the risk of MSDs among workers in this sector. Based on this analysis, several recommendations were made to reduce exposure risk. One suggestion is to design ergonomic workstations with adjustable table heights and wood-cutting tools that accommodate the workers' natural posture, as highlighted by Bhatt & Bhatia (2023). Previous studies have emphasized that ergonomic interventions, such as workplace redesign and weight reduction, can significantly decrease the occurrence of MSDs in heavy industry (Zare et al., 2020). Another recommendation is to reduce lifting loads by utilizing mechanical aids, which can alleviate the manual burden on workers (Qu et al., 2021). Lastly, increasing the frequency of breaks by implementing work schedules that allow for more frequent rest periods can help reduce fatigue accumulation in the upper back, as suggested by Luger et al. (2019). With the implementation of these measures, a significant reduction in the level of MSDs experienced by workers was expected. Previous research showed that workers with high exposure to ergonomic risk factors had higher incidences of MSDs than those working in environments that had undergone ergonomic improvements (Hosseini et al., 2019).

A significant correlation existed between MSDs in the right shoulder and the QEC exposure level in the shoulder/arm area, while left shoulder MSDs did not show a significant correlation. This observation could be explained by the fact that most individuals had a dominant right hand, which was more frequently used in work activities requiring strength and precision. This situation led to a higher biomechanical load on the right shoulder than on the left shoulder, which increased the risk of MSDs (Chowdhury et al., 2018). Additionally, work activities that involved repetitive movements, lifting loads, or work positions that required more frequent use of the right arm could have increased exposure levels to ergonomic risk factors measured by the QEC (Seidel et al., 2019). Another factor was the unbalanced body position, such as leaning to one side or twisting the body while working, which often put more strain on the right shoulder. This condition was particularly true in jobs that relied on the dominant hand to perform primary tasks (Drigny et al., 2020). Workplace design and tools also played important roles. Many tools and workplace layouts were designed to support workers who used their right hand, thereby increasing the exposure of the right shoulder compared to the left shoulder (Mohamaddan et al., 2021). The left shoulder was often less active or only used as support, resulting in lower exposure to ergonomic risk factors, which may have explained why no significant correlation was found between left shoulder MSDs and QEC exposure levels. These results were consistent with previous research that found that nurses who often used their right hand to lift patients or medical equipment experienced more pain in their right shoulder. In contrast, the less active left shoulder had a lower incidence of MSDs (Lee & Lee, 2017).

In workers at the wood-cutting workstation, the right wrist had been more susceptible to experiencing MSDs than the left wrist. This research demonstrated a significant correlation between the level of MSDs in

the right wrist and the QEC exposure level in that area. In contrast, the left wrist showed no significant correlation. The results indicated that the higher the workload exposure on the right wrist, as measured by QEC, the higher the level of MSD complaints reported by workers. The main contributing factors to the increase of MSDs in the right wrist included the dominant use of the right hand in operating tools, static working positions, and repetitive movements that led to muscle fatigue. Conversely, the left wrist did not show a significant correlation with the QEC exposure level, likely due to the difference in workload distribution, where the left wrist was more often used for balance rather than as the primary tool in wood cutting. Several factors had increased the risk of MSDs in the right wrist of workers. One significant factor was the dominant use of the right hand, as most workers relied on their right hand to operate the wood-cutting machine, leading to a heavier workload on the right wrist compared to the left. Additionally, non-ergonomic postures contributed to the problem, with hand positions while using tools often exerting excessive pressure on the right wrist, particularly in unnatural positions. Repetitive motion in wood-cutting activities also played a role, requiring repeated movements of the right wrist that could result in muscle fatigue and chronic injury if not offset with sufficient rest. Finally, a lack of movement variation meant that minimal changes in movement during work exposed the right wrist to constant pressure, potentially accelerating the onset of MSD symptoms. Previous research also explained why the right wrist was at higher risk of experiencing MSDs compared to the left wrist in wood-cutting workers, including asymmetric workload, where the dominant use of the right wrist in heavy activities such as moving cutting tools, grasping wood, and making position adjustments led to the right wrist experiencing more pressure than the left wrist. Muscle load imbalance was another causal factor. Due to the difference in usage, the muscles of the right wrist experienced more tension compared to the left wrist, which served more as a balancing tool. Additionally, the lack of task rotation caused workers to use their dominant hand for primary tasks without rotation, leading to more intensive use of the muscles in the right wrist than the left wrist (Abdolalizadeh & Jahanimoghadam, 2015).

The research showed a significant correlation between the level of MSDs in neck movement and the QEC exposure level in the neck area. This finding could be explained through several factors. First, non-ergonomic neck posture played a significant role, as workers at wood cutting stations often had to bend or tilt their heads for extended periods while operating cutting tools or inspecting the results. The QEC noted that neck postures frequently bending more than 20 degrees forward or backward increased the risk exposure value (Farooq, 2022). Additionally, the frequency and duration of exposure were notable, as the QEC exposure level in the neck was generally high when workers engaged in activities that involved frequent occurrences and long durations without sufficient breaks. This high exposure level was correlated with an increased prevalence of neck pain and other musculoskeletal disorders (Genebra et al., 2017). Furthermore, physical load and stress on the neck contributed significantly; workers often had to lift, hold, or control heavy wood, leading to muscle tension in the neck area. This high physical load was associated with increased QEC values and the occurrence of MSDs (Le et al., 2023). Lastly, the lack of ergonomic interventions in some wood-cutting workstations was problematic, as these setups often did not account for optimal ergonomic factors, such as non-adjustable table heights, insufficient lighting, and minimal job rotation, which could help workers change their posture periodically. These conditions further increased the risk of exposure to MSDs (Srivani & Amsamani, 2024).

In this study, there were still some limitations. First, the ergonomic risk assessment using the QEC method was carried out by a single trained observer. Although the observer had been calibrated and followed the standardized procedure to minimize subjectivity, the absence of multiple observers meant that inter-rater reliability could not be examined. Second, the study was conducted in a single furniture SME center with a relatively small sample size, which might have limited the generalizability of the findings to other woodworking industries or occupational settings. These limitations might have introduced potential bias, and future studies were recommended to involve more than one rater and a larger, more diverse sample to improve the reliability and generalizability of the results.

6. Conclusion

In the present research, wood-cutting workers were reportedly exposed to uncomfortable postures and significant ergonomic risks. The findings showed that MSDs in the upper and lower back significantly correlated with the QEC exposure level in the back. MSDs in the right shoulder were also significantly correlated with the QEC exposure level in the

shoulder/arm. This study also revealed a significant correlation between MSDs in the right wrist and the QEC exposure level in the wrist. Additionally, MSDs in the neck significantly correlated with the QEC exposure level in the neck. The findings highlight the need for targeted ergonomic interventions such as workstation redesign, task rotation, and workload adjustments that are feasible for SMEs with limited resources. At the national level, these results can inform occupational health policies and capacity-building programs to support SMEs, which constitute a major part of Indonesia's economy. Thus, the study contributes not only to the scientific understanding of ergonomic risk factors in woodworking operations but also to the development of scalable, low-cost strategies that can enhance worker health, safety, and productivity in resource-constrained settings.

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8. Abbreviations

Abbreviation	Full term
QEC	Quick Exposure Check
MSDs	Musculoskeletal Disorders
SNQ	Standard Nordic Questionnaire
VAS	Visual Analogue Scale
SMEs	Small and Medium Enterprises
GDP	Gross Domestic Product

9. Credit Statement

Agung Kristanto: Conceptualization, Methodology, Formal Analysis, Writing – Original Draft, Writing – Review & Editing, and Supervision.
Dery Bagus Setiawan: Resources, Visualization, and Software.
Choirul Bariyah: Validation, Data Curation, Supervision, and Writing – Review & Editing.
Farid Ma'ruf: Formal Analysis, Investigation, Supervision, and Writing – Review & Editing.

10. References

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