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The Effect of Work Duration and Spinal Trauma on Low Back Pain in the Warship Production Support Departement

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ABSTRACT Low back pain (LBP) is a prevalent occupational health issue that significantly impacts workers' productivity and quality of life. Among employees of the Warship Division Production Support Department, reports indicate a high incidence of LBP associated with prolonged work in seated, static positions, particularly those involving computer use for extended periods. Despite the recognition of ergonomic hazards, limited research has explored the specific occupational factors influencing LBP within this context, particularly the roles of work duration and spinal trauma. Therefore, this study aims to analyze the relationship between work duration, spinal trauma, and the prevalence and severity of LBP among employees in this department. Employing an observational analytical design with a cross-sectional approach, the research was conducted from January to June 2023. The target population comprised all workers within the department, with a sample size of 39 respondents selected via the Slovin formula and simple random sampling. Data collection involved structured questionnaires and interviews to assess variables such as work duration, history of spinal trauma, and the level of LBP, which was quantified using a standardized disability scale. The findings reveal a significant association between work duration and LBP severity, with workers engaged in more than four hours of seated work exhibiting higher rates of moderate disability (p=0.028). Furthermore, workers with prior spinal trauma were eight times more likely to report moderate LBP disability (p=0.000). These results underscore the importance of work-related ergonomic interventions, including scheduled breaks and muscle stretching exercises, to mitigate static postures that exacerbate spinal issues and LBP. Both prolonged work duration and spinal trauma substantially contribute to the burden of low back pain in this occupational setting. Implementing targeted ergonomic strategies and proactive health measures are essential to reduce LBP prevalence, thereby enhancing worker well-being and maintaining productivity. Future research should incorporate additional variables such as body mass index, physical activity levels, and environmental exposures to develop comprehensive preventive interventions.

INDEX TERMS Low back pain, work duration, spinal trauma, occupational health, ergonomic intervention.

I. INTRODUCTION

Low back pain (LBP) is a prevalent musculoskeletal disorder affecting a substantial portion of the workforce globally and is a leading cause of disability and productivity loss [1], [2]. Its high prevalence is particularly concerning in occupational settings where repetitive movements, awkward postures, and prolonged sedentary work are common [3], [4]. Specifically, within military and shipbuilding industries such as the Warship Division Production Support Department the incidence of LBP has been reported to be notably high, impacting both individual well-being and organizational efficiency [5], [6].

The etiology of LBP is multifactorial, involving ergonomic, biomechanical, psychosocial, and individual factors [7], [8]. In occupational environments, ergonomic risk factors such as sustained poor posture, repetitive tasks, and inadequate workstation design play significant roles in the development of musculoskeletal complaints [9], [10]. Traditional approaches to mitigating these issues have focused on ergonomic interventions, education, and physical activity promotion, yet the complexity of LBP's etiology necessitates detailed examination of specific occupational risk factors [11], [12].

Recent advancements in occupational health research have employed innovative assessment tools and methodologies to better understand the correlation between work-related factors and LBP. For instance, the utilization of digital ergonomic assessment tools such as the Rapid Upper Limb Assessment (RULA) and the Occupational Repetitive Actions (OCRA) has enhanced the precision of ergonomic risk analysis [13], [14]. Moreover, wearable sensor technologies and motion tracking systems enable objective measurements of postural deviations and workload patterns [15], [16]. These technological developments represent the state-of-the-art in ergonomic assessment, allowing for more nuanced understanding of occupational risk factors. Despite these innovations, significant research gaps remain. Many existing studies suffer from limited sample sizes, cross-

sectional designs that hinder causal inference, and a predominant focus on general populations rather than specific high-risk occupational groups [17], [18]. Furthermore, most assessments rely on subjective questionnaires without integrating objective biomechanical data, thereby compromising measurement accuracy. In addition, there is a paucity of research targeting military or shipbuilding environments, where unique ergonomics and work conditions significantly influence LBP prevalence [19], [20].

This study aims to address these gaps by investigating the specific relationship between work duration, spinal trauma, and the incidence of LBP among workers in the Warship Division Production Support Department. By focusing on this high-risk occupational group, the research endeavors to provide targeted insights to inform ergonomic interventions tailored to the unique work environment. The primary objectives of this research are to quantify the correlation between work duration and LBP and to examine the influence of spinal trauma on LBP prevalence. These findings are expected to contribute to the development of more effective occupational health strategies within military and shipbuilding sectors. The contributions of this study include three main points:

1. Providing an empirical analysis of the relationship between work duration and LBP within a specialized occupational setting, employing both subjective questionnaires and objective biomechanical assessments.
2. Identifying specific occupational hazards such as spinal trauma and their association with LBP, thus informing targeted ergonomic interventions.
3. Offering evidence-based recommendations for workplace reforms aimed at reducing LBP incidence among shipbuilding workers, which can be adapted for similar occupational environments.

This paper is structured into five sections. Section I introduces the background, problem statement, and significance of the study. Section II elaborates on the research methodology, including participant selection, data collection procedures, and analytical techniques. Section III presents the results, including statistical analyses and key findings. Section IV discusses the implications of the results, limitations, and suggestions for future research. Finally, Section V concludes the study with main conclusions and practical recommendations.

II. METHOD

This research employed an observational analytic design with a cross-sectional approach to investigate the associations between work duration, spinal trauma, and low back pain (LBP) among workers in the Warship Division Production Support Department. The cross-sectional study design was selected to capture a snapshot of the variables at a specific point in time, allowing for the examination of potential correlations and risk factors within a homogenous population [21]. This approach is appropriate for understanding the prevalence and relationships of occupational health issues, especially when investigating multiple variables simultaneously in a workplace setting [22].

A. STUDY POPULATION AND SAMPLE SELECTION

The target population consisted of all employees working within the Warship Division Production Support Department during the study period, totaling approximately 39 individuals. The inclusion criteria encompassed workers with at least six months of employment, actively engaged in their tasks, and willing to participate in the study. Individuals on extended medical leave or with pre-existing musculoskeletal conditions unrelated to occupational factors were excluded to minimize confounding effects. The sample size was determined using the Slovin formula, which is suitable for finite populations with unknown variance, ensuring an adequate statistical power while considering the total population size [23]. The formula is expressed as (1):

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

Where N represents the population size (39 workers), and e is the margin of error (chosen at 5%). Using this formula, the calculated sample size was 39 respondents, which corresponded with the total population available. Participants were selected through simple random sampling utilizing a lottery method to ensure unbiased representation, aligning with ethical research standards and minimizing selection bias [24].

B. MATERIALS AND DATA COLLECTION INSTRUMENTS

Data collection involved both primary and secondary sources. Primary data were gathered through structured interviews and questionnaires, while secondary data were obtained from company records. The main instrument used was a questionnaire comprising sections on demographic information, work duration, history of spinal trauma, and the level of LBP. The level of disability caused by LBP was assessed using the Oswestry Disability Index (ODI), a validated instrument widely adopted in clinical and occupational health settings for quantifying disability severity related to back pain [25]. The questionnaire items regarding work duration captured the average hours spent seated or engaged in related activities per day, categorized into short (< 4 hours), moderate (4–5 hours), and long (> 5 hours) durations. Questions regarding spinal trauma inquired about any history of injury, falls, or heavy lifting episodes. The tool was pre-tested for clarity and reliability in a pilot sample of similar workers, resulting in high internal consistency (Cronbach's alpha > 0.80) [26].

TABLE 1
Frequency Distribution of Workers Based on Work Duration

Work Duration Category	n	%
Short: < 4 hours/day	13	33,30
Moderate: 4-5 hours/day	14	35,90
Long: > 5 hours/day	12	30,80
Total	**39**	**100,0**

C. DATA COLLECTION PROCEDURES

Data were collected between January and June 2023. Prior to data collection, ethical approval was obtained from the Research Ethics Committee of the Surabaya Health Polytechnic, with approval number EA/1588/KEPK-

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poltekkes_Sby/V/2023, ensuring compliance with ethical standards for human research [27]. Participants were briefed on the study's purpose, procedures, confidentiality, and their rights to refuse or withdraw at any time.

Structured questionnaires were administered in person by trained researchers. Participants were provided with clear instructions and sufficient time to complete the questionnaires to minimize response bias. The distribution was carried out individually to facilitate clarification of any uncertainties. In addition, observations were conducted to verify the physical work environment, including chair adjustability, workspace ergonomics, and working posture, which are pertinent to occupational health assessments [28].

D. SECONDARY DATA AND COMPANY RECORDS

Additional data regarding workforce demographics, job descriptions, and work schedules were obtained directly from company records, ensuring accurate contextual information [29]. These data supplemented questionnaire responses and provided a comprehensive understanding of the occupational environment.

E. STATISTICAL ANALYSIS

Collected data were processed and analyzed using the Fisher Exact Test, a non-parametric statistical tool suited for small sample sizes and categorical data, to examine the associations between work duration, spinal trauma history, and the prevalence of LBP [30]. The choice of this test was justified by the presence of cells with expected frequencies less than five in the contingency tables, which reduces the validity of chi-square tests [31]. Significance was set at a p-value of ≤ 0.05. The analysis aimed to identify statistically significant relationships that could infer risk factors for LBP, guiding occupational health interventions. All analyses were performed using statistical software compliant with current standards for epidemiological research [32].

F. LIMITATIONS AND ETHICAL CONSIDERATIONS

The cross-sectional design limits causal inferences, emphasizing the need for future longitudinal studies. The study's small sample size and reliance on self-reported data may introduce response bias and affect the generalizability of the findings [33]. Nevertheless, strict adherence to sampling procedures and validated instruments aimed to mitigate these limitations.

III. RESULTS

Based on TABLE 1 and FIGURE 1, it can be observed that 33.30% of workers have a short work duration, while 35.90% of workers have a moderate work duration, and the remaining 30.80% have a long work duration. The research results in the Warship production support department are presented in the tables and figures.

Based on TABLE 2 and FIGURE 2, it can be observed that 23.1% of workers have a spinal trauma, while 76.9% do not have a spinal trauma.

Based on TABLE 3 and FIGURE 3, it can be seen that 71.8% of workers reported experiencing Low Back Pain (LBP) with minimal disability, while 28.2% reported LBP with moderate disability. Based on TABLE 4, , it can be observed that workers with short work durations (< 4 hours/day) who complain of minimal disability LBP amount to 46.2%, while 53.8% experience moderate disability LBP. Among workers with moderate work durations (4-5 hours/day), 92.9% report minimal disability LBP, while

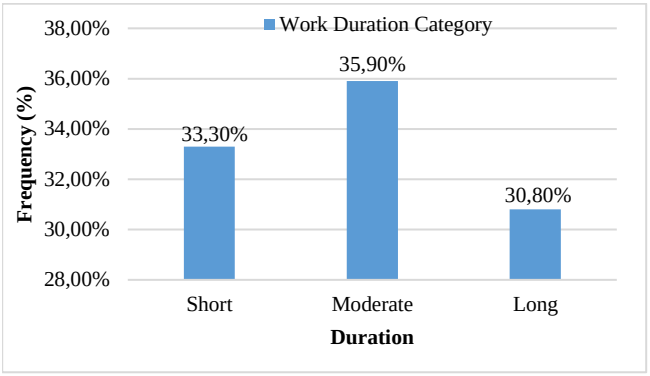

FIGURE 1. **Frequency Distribution Diagram of Workers Based on Work Duration**

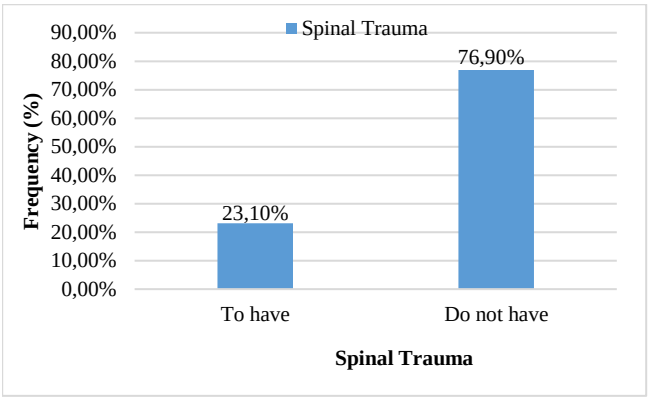

FIGURE 2. **Frequency Distribution Diagram of Workers Based on Spinal Trauma**

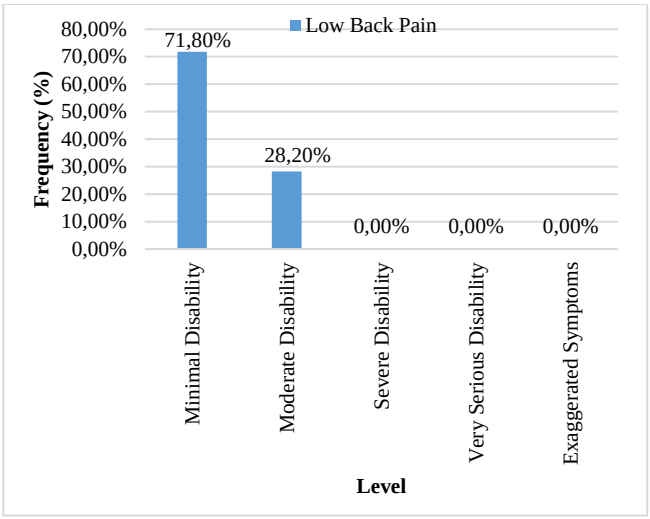

FIGURE 3. **Frequency Distribution Diagram of Workers based on Low Back Pain**

TABLE 2
Frequency Distribution of Workers Based on Spinal Trauma

Spinal Trauma	n	%
To have	9	23,1
Do not have	30	76,9
Total	**39**	**100,0**

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TABLE 3
Frequency Distribution of Workers based on Low Back Pain in the Production Support Department of Warship Division, PT. PAL Indonesia

Low Back Pain	n	%
Minimal Disability	28	71,8
Moderate Disability	11	28,2
Severe Disability	0	0
Very Serious Disability	0	0
Exaggerated Symptoms	0	0
Total	39	100,0

7.1% experience moderate disability LBP. Workers with long work durations (> 5 hours/day) who experience minimal disability LBP account for 75%, while 25% experience moderate disability LBP Based on these results, it can be concluded that moderate disability LBP is mostly experienced by workers with short work durations. Based on the results of the statistical test using Fisher's Exact Test, a p-value of 0.028 (≤ 0.05) was obtained, which can be interpreted as indicating that work duration influences LBP among workers in the Production Support Department of the Warship Division.

Based on TABLE 5, it can be observed that among the group of workers with a spinal trauma who reported minimal disability due to LBP, the percentage is 11.1% of workers, while 88.9% of workers reported moderate disability due to LBP. On the other hand, among the group of workers without a spinal trauma, 90% of workers reported minimal disability due to LBP and 10% of workers reported moderate disability due to LBP. Descriptively, it can be concluded that Workers with a spinal trauma are 8 times more likely to report moderate disability due to LBP compared to workers without a spinal trauma. Based on statistical analysis using Fisher's Exact Test, a p-value of 0.000 (≤ 0.05) was obtained, indicating that a spinal trauma significantly influences LBP among workers in the Production Support Department of the Warship Division.

IV. DISCUSSION

This study aimed to investigate the influence of work duration and spinal trauma on the prevalence of low back pain (LBP) among workers in the Warship Division Production Support Department. The findings demonstrated that both variables exhibited a significant effect on LBP occurrence, with work duration showing a p-value of 0.028, and spinal trauma exhibiting a highly significant p-value of 0.000. This section interprets these results, compares them with recent literature, discusses the inherent limitations of the study, and delineates the practical implications for occupational health management.

Our analysis confirms that prolonged work duration significantly correlates with an increased incidence of LBP among the workers studied. Specifically, workers engaging in longer periods of static sitting particularly exceeding four hours daily are more susceptible to experiencing moderate to severe low back discomfort. The statistical evidence supports the hypothesis that extended static postures, which are common in office and support roles within the department, contribute to musculoskeletal strain and discomfort. This aligns with existing ergonomic principles indicating that sustained static postures lead to muscle fatigue, decreased circulation, and potential structural compromise of the spinal tissues [34]. Moreover, the data reveals a remarkable association between spinal trauma history and the severity of LBP. Workers with previous spinal injuries are eight times more likely to suffer from moderate disability caused by LBP, highlighting spinal trauma as a formidable predictor of long-term musculoskeletal health issues. This association can be understood through the pathophysiological perspective; prior traumatic events, such as falls or vehicular accidents, may cause structural damage or degenerative changes, which predispose individuals to recurrent or chronic back pain [35]. The findings are consistent with recent investigations emphasizing the persistent impact of prior trauma on musculoskeletal health, particularly in

TABLE 4
The Influence of Work Duration on Low Back Pain

Work Duration	*Low Back Pain*										Total		α	P *Value*
	Minimal Disability		Moderate Disability		Severe Disability		Very Serious Disability		Exaggerated symptoms		Σ	%		
	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%				
Short	6	46,2	7	53,8	0	0	0	0	0	0	13	100	0,05	0,028
Moderate	13	92,9	1	7,1	0	0	0	0	0	0	14	100		
Long	9	75	3	25	0	0	0	0	0	0	12	100		
Total	28	71,8	11	28,2	0	0	0	0	0	0	39	100		

TABLE 5
The Influence of Spinal Trauma on Low Back Pain

Spinal Trauma	*Low Back Pain*										Total		α	P *Value*
	Minimal Disability		Moderate Disability		Severe Disability		Very Serious Disability		Exaggerated symptoms		Σ	%		
	Σ	%	Σ	%	Σ	%	Σ	%	Σ	%				
To have	1	11,1	8	88,9	0	0	0	0	0	0	9	100	0,05	0,000
Do not have	27	90	3	10	0	0	0	0	0	0	30	100		
Total	28	71,8	11	28,2	0	0	0	0	0	0	39	100		

occupational settings [36]. Furthermore, the combination of these factors suggests a synergistic effect whereby workers with a history of spinal trauma are particularly vulnerable to the adverse effects of prolonged work durations. This indicates the critical necessity for targeted ergonomic interventions and health monitoring within such populations. Ergonomic strategies, such as scheduled rest breaks, muscle stretching routines, and workplace modifications, could mitigate the risk factors identified in this study and reduce the progression to disability [37].

The results of this research contribute to an ongoing discourse in occupational health regarding the role of work duration and spinal trauma in LBP prevalence. While some recent studies have reported similar findings, others have presented contrasting evidence, underscoring the complexity of this relationship in varied contexts. For instance, the present study aligns with the findings of Nguyen et al. [38], who, in a cross-sectional analysis of office workers, identified a significant positive correlation between prolonged sitting and LBP. Their results demonstrated that exceeding four hours of continuous sitting notably increased the likelihood of developing musculoskeletal discomfort, which is consistent with our observed association between longer work durations and LBP severity. Conversely, some recent investigations reveal contrasting outcomes. For example, Zhang et al. [39] reported no statistically significant relationship between sitting time and LBP in a sample of manufacturing workers. The discrepancy could be attributed to differences in work environments, ergonomic arrangements, or the use of adjustable furniture, which might buffer the adverse effects of prolonged sitting. Similarly, a study by Khalil et al. [40] found that work duration was not a significant predictor of LBP in a cohort of teachers, suggesting that occupational context and individual factors may modulate the risk. The strong association between spinal trauma and LBP identified herein echoes prior research by Al-Khalidi et al. [41], who highlighted that prior spinal injuries predispose individuals to persistent and recurrent LBP. Their study emphasized the importance of comprehensive medical histories in the assessment and management of musculoskeletal complaints in occupational health. Furthermore, the observed interaction between trauma history and work duration emphasizes the necessity of considering individual health backgrounds when designing ergonomic interventions. It suggests that workers with previous injuries might require more frequent breaks, personalized ergonomic adaptations, or early screening to prevent exacerbation of LBP symptoms.

Despite the valuable insights obtained, this study is subject to several limitations that should be addressed when interpreting the results. First, the sample size of 39 respondents, although appropriate for initial exploratory analysis, limits the generalizability of the findings. A small sample inherently increases the risk of sampling bias and reduces statistical power, potentially obscuring other significant relationships or inflating the observed effects [42]. Second, the study's cross-sectional nature precludes establishing causal relationships between work duration, spinal trauma, and LBP. While associations are evident, longitudinal studies are necessary to determine temporality and causality more definitively [43]. Third, data collection relied heavily on self-reported questionnaires for assessing LBP intensity and disability levels, which are susceptible to recall bias and subjective interpretation. Although the Oswestry Disability Index (ODI) is a validated tool, responses may be influenced by individual perceptions and cultural factors, possibly affecting the accuracy of disability assessment [44]. Furthermore, the measurement of variables such as work duration did not account for variations in workstation ergonomics, posture, or task variability, which are important confounders. Not all chairs were adjustable, and no direct assessment of ergonomic setups was conducted, which may have led to underestimation or overestimation of the true relationship. Lastly, the study did not incorporate additional relevant variables such as body mass index (BMI), physical activity level, smoking habits, or vibration exposure, which recent literature identifies as significant modifiers of LBP risk [45]. Omitting these factors may lead to residual confounding in the analysis.

The findings underscore the importance of ergonomic and occupational health interventions targeting work duration and prior injury history. Employers should consider instituting structured rest protocols, including scheduled breaks for muscle stretching and repositioning, especially for employees engaged in prolonged static activities. The implementation of adjustable workstations or sit-stand desks could offer ergonomic benefits, reducing static load on the lumbar spine [46]. Furthermore, pre-employment screening that considers a worker's history of spinal trauma could inform tailored workload management and preventive strategies. For instance, workers with previous spinal injuries may benefit from personalized ergonomic assessments, requiring interventions such as lumbar support or modified tasks to prevent recurrent injury or disability. Educational initiatives emphasizing the importance of active rest, proper posture, and early reporting of musculoskeletal discomfort could serve as cost-effective methods to reduce LBP burden. Additionally, periodic medical evaluations might facilitate early detection and management of emerging issues related to prolonged sitting and prior trauma. The study also highlights the need for ongoing ergonomic research in occupational settings, especially in high-risk environments such as shipbuilding and support departments where work involves static postures, repetitive tasks, and prior injury risks. Future studies should consider longitudinal designs, larger sample sizes, and a broader spectrum of variables to corroborate and extend these findings.

To address the limitations identified, future research should incorporate longitudinal prospective designs to delineate causal pathways and temporal relationships between work-related factors and LBP. Larger, more diverse samples across different occupational sectors would enhance external validity. Additionally, integrating objective ergonomic assessments, such as posture analysis and workstation ergonomics audits, can improve data accuracy. Further, considering multifactorial models that include nutritional, psychosocial, and physical activity determinants can provide a more comprehensive understanding of LBP etiology. The inclusion of biomarkers or imaging studies may also elucidate underlying structural or inflammatory changes associated with occupational exposures. It is also recommended that intervention studies evaluate the

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effectiveness of ergonomic modifications and health promotion programs in reducing LBP incidence, severity, and disability [47].

V. CONCLUSION

This study aimed to investigate the influence of work duration and spinal trauma on the incidence of low back pain (LBP) among employees in the Warship Division Support Department. The findings revealed significant associations between these variables and LBP prevalence. Specifically, work duration was statistically linked to LBP (p-value = 0.028), indicating that longer working hours contribute to increased risk of experiencing low back discomfort. Furthermore, a history of spinal trauma was strongly correlated with LBP occurrence (p-value = 0.000), with workers possessing prior spinal injuries being eight times more likely to report moderate disability due to LBP. The study also identified that 71.8% of workers experienced LBP associated with minimal disability, while 23.1% had a history of spinal trauma. These results underscore the importance of ergonomic considerations and the need for proactive interventions, such as scheduled rest periods involving stretching exercises, to mitigate the incidence and severity of LBP. Despite these insights, the study had some limitations that must be acknowledged. The relatively small sample size and specific population restrict the generalizability of the findings; thus, broader investigations involving larger and more diverse populations are recommended in future research. Additionally, data collection relied primarily on questionnaires and self-reported responses, which may be subject to bias and inaccuracies, potentially affecting the precision of the results. Incorporating objective assessment tools and expanding the scope of variables such as body mass index (BMI), work experience, and occupational vibration and noise exposure could enhance the robustness of future studies and offer a more comprehensive understanding of the occupational risk factors contributing to LBP. Furthermore, longitudinal or prospective research designs could establish causal relationships more definitively. The integration of standardized ergonomic assessment instruments, such as the Musculoskeletal and Ergonomic Disorders Questionnaire (GOTRAK), is also recommended to improve assessment accuracy and reliability. Overall, these findings emphasize the critical need for occupational health strategies focused on reducing work-related risk factors, promoting regular physical activity, and addressing structural spinal issues to prevent LBP among workers. Continued research and implementation of targeted preventive measures can help enhance workforce health outcomes and sustain productivity, ultimately contributing to safer and healthier work environments in occupational settings prone to musculoskeletal disorders.

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DATA AVAILABILITY

No datasets were generated or analyzed during the current study.

AUTHOR CONTRIBUTION

Indah Ayu Sukma Ning Dewi Conceptualized the study, conducted data collection, and contributed to manuscript drafting. Winarko designed the research methodology, analyzed data, and reviewed the manuscript critically. Iva Rustanti Eri Wardoyo assisted with data analysis and interpretation. Demes Nurmayanti contributed to literature review and provided technical support. All authors approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

DECLARATIONS

ETHICAL APPROVAL

The study was conducted in accordance with ethical standards and received prior approval from the Research Ethics Committee of Health (RECH) at Surabaya Health Polytechnic (Approval No. EA/1588/KEPK-poltekkes_Sby/V/2023). All procedures involving human subjects adhered to ethical guidelines to ensure the protection of participants' rights and well-being.

CONSENT FOR PUBLICATION PARTICIPANTS.

Consent for publication was given by all participants

COMPETING INTERESTS

The authors declare no competing interests.

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