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ERGONOMIC IMPACT OF LIFTING ACTIVITIES ON LOW BACK PAIN IN MALANG'S SANITARY WARE INDUSTRY

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ABSTRACT

Background: Low back pain (LBP) is a common musculoskeletal disorder linked to repetitive ergonomic tasks, resulting in discomfort and reduced productivity. In Malang's sanitary ware industry, workers frequently perform lifting and carrying tasks**.** Workers involved in lifting activities are particularly vulnerable to these risks. **Objective:** This research sought to address gaps in knowledge about the relationship between ergonomic factors and LBP severity among this occupational setting. **Methods:** Observational-analytic study was conducted on August-October 2022 using a cross-sectional survey of workers in Malang's sanitary ware industry, with the size of the research sample were 42 participants. Data were collected through questionnaires and analyzed using the Somers' D correlation test in SPSS. Ethical clearance was obtained, and participants provided informed consent. **Results:** The analysis demonstrated a significant relationship between lifting activities and LBP complaints. The correlation strength indicated a weak association, but most workers reported moderate LBP severity, highlighting ergonomic challenges in the workplace ($p = 0.032$, $r = 0.315$). **Conclusion:** This study underscores the ergonomic impact of lifting activities on LBP among industrial workers. The findings highlight the necessity of ergonomic interventions to mitigate LBP risks. Future studies should focus on implementing and evaluating long-term ergonomic strategies to improve occupational health outcomes in similar industries.

BACKGROUND

Low back pain (LBP) is the leading cause of years lived with disability worldwide and its absolute burden is projected to rise further, driven in part by ageing populations and persistent exposure to occupational risks[1]. Within workplaces, modifiable ergonomic hazards, such as manual materials handling (MMH), frequent or heavy lifting, sustained trunk flexion/rotation, and non-neutral postures, are consistently implicated in the etiology and persistence of LBP[2]. Large population-based data indicate that workers who routinely handle heavy loads report substantially higher LBP prevalence than those who do not, underscoring MMH as a priority for prevention[3].

In low- and middle-income settings, industrial sectors that rely on manual handling, such as metal casting, ceramics and sanitary ware, embed repetitive lifting and carrying into daily production cycles. These tasks often co-occur with squatting, stooping and awkward reaches across poorly fitted workstations, amplifying cumulative spinal load and the risk of pain-related disability[2–4]. Indonesia mirrors these global patterns: recent national evidence shows a high 12-month prevalence of LBP among working-age adults, with modifiable lifestyle and work-related factors (e.g., lifting, prolonged static postures) contributing meaningfully to risk[5]. Moreover, pragmatic trials in Indonesian small-industry contexts demonstrate that targeted ergonomic modifications and participatory approaches can reduce musculoskeletal complaints

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and fatigue, suggesting clear translational potential for manufacturing workplaces[4].

Malang's sanitary-ware industry is representative of labor-intensive production environments in which workers frequently perform short-cycle lifting of moulds and finished goods. Yet, local empirical data quantifying the relationship between lifting exposures and LBP severity remain limited. The present study addresses this gap by examining the association between lifting activities and LBP complaints among sanitary-ware workers in Malang. By focusing on an exposure that is both measurable and modifiable, the findings aim to inform feasible ergonomic controls and monitoring strategies for similar industries in Indonesia and comparable settings[1–5].

METHODS

This study employed an observational-analytic method with a cross-sectional approach to examine the relationship between lifting and carrying activities and low back pain complaints in the sanitary ware industry center in Malang City. The research was conducted in Karangbesuki Village, Malang City, during November 2022. Ethical clearance for the study was obtained from the Health Research Ethics Committee at Universitas Muhammadiyah Malang, with the approval number No.E.5.a/236/KEPK-UMM/XI/2022.

The study population consisted of all active workers in the Karangbesuki sanitary ware industry center who met the inclusion criteria. A total sampling technique was used to recruit participants, with inclusion criteria being: (1) workers at the Karangbesuki sanitary ware industry center in Malang City, (2) workers involved in lifting and carrying activities, and (3) workers willing to participate in the study. The independent variable in this study was lifting and carrying activities, while the dependent variable was LBP complaints. LBP severity was categorized into four levels: no symptoms, mild, moderate, and severe. These categories were defined based on self-reported pain intensity and its impact on daily work activities. Data on LBP complaints were collected on August-October 2022 using a structured, self-administered questionnaire adapted from commonly used musculoskeletal symptom assessments. Participants were asked to report the intensity of low back pain experienced during the past month. This methodology was designed to comprehensively analyze the ergonomic risks associated with traditional labor practices in this specific occupational setting.

RESULTS

Table 1. Characteristics of Lifting and Carrying Activities and Low Back Pain Symptoms (n=42)

Variable	Category	n (%)
Low Back Pain Severity	No symptoms	5 (11.9)
	Moderate	31 (73.8)
	Severe	6 (14.3)
Number of items handled	<10 items	14 (33.3)
	≥10 items	28 (66.7)
Weight of items lifted	<30 kg	12 (28.6)
	≥30 kg	30 (71.4)
Distance of item movement	<10 m	13 (31.0)
	≥10 m	29 (69.0)
Duration of lifting/carrying	<5 minutes	18 (42.9)
	≥5 minutes	24 (57.1)
Body position	Ergonomic	10 (23.8)
	Non-ergonomic	32 (76.2)
Years of employment	<5 years	8 (19.0)
	≥5 years	34 (81.0)
Daily working hours	≤8 hours/day	30 (71.4)
	>8 hours/day	12 (28.6)

Table 2. Somers' D Test on the Association Between Lifting and Carrying Activities and Low Back Pain Symptoms

Directional Measures									
Ordinal by Ordinal	**No symptoms**		**Mild**		**Moderate**		**Severe**		**Total**
	n	**%**	**n**	**%**	**n**	**%**	**n**	**%**	
<5 years	5	11,90	0	0	3	7,10	0	0	8
≥5 years	0	0	0	0	28	66,70	6	14,30	34
	5	11,90	0	0	31	73,80	6	14,30	42

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Table 1 presents the distribution of lifting and carrying activity characteristics and low back pain severity among workers. Most respondents reported moderate low back pain symptoms. The majority of workers handled ≥10 items per task, lifted loads ≥30 kg, transported items over distances ≥10 meters, and worked in non-ergonomic postures. Most participants also had employment duration of ≥5 years and performed lifting activities for ≥5 minutes per task.

Table 2 present the Somers' d analysis confirmed a statistically significant ordinal association between lifting/carrying exposure and LBP severity (Symmetric Somers' d = 0.323, p = 0.032). Both directional measures (lifting-dependent: d = 0.333; LBP-dependent: d = 0.315) demonstrated consistent moderate positive monotonicity, supporting a clinically meaningful exposure-response gradient across the study population.

DISCUSSION

This study identifies a statistically significant, positive monotonic association between lifting–carrying exposure and low back pain (LBP) symptoms (Somers' d ≈ 0.32; p = 0.032). Although the effect size is modest, the association is consistent across multiple exposure indicators, including the number of items handled, load weight, duration of lifting bouts, daily working hours, body posture, and employment tenure. The predominance of moderate LBP symptoms (73.8%) suggests clinically meaningful functional impairment at the workforce level, supporting the occupational relevance of these findings despite the limited magnitude of correlation.

From a biomechanical and pathophysiological standpoint, the observed pattern reflects cumulative lumbar loading arising from the interaction of load magnitude, exposure duration, and posture. Increased compressive and shear forces at the lumbar spine, particularly at the L4–L5 segment, occur when heavier loads, greater horizontal reach, vertical displacement, trunk asymmetry, and suboptimal coupling are combined with prolonged exposure and inadequate recovery intervals[2,3,6–8]. The gradients observed across posture categories and years of employment further support a cumulative dose mechanism, whereby repeated non-neutral postures and high-frequency manual handling constrain tissue perfusion and recovery, thereby potentiating nociceptive signaling and symptom persistence[2,6,9].

These findings are concordant with contemporary evidence identifying heavy and frequent lifting and non-neutral trunk postures as established risk factors for chronic or persistent LBP[2,3]. They also align with interventional literature demonstrating that ergonomic modifications, such as participatory ergonomics, workstation height optimization, and structured micro-breaks, can reduce musculoskeletal symptoms and disability days without necessarily reducing nominal load weight, by altering exposure profiles related to posture, reach, and time-on-task[6–8,10–12]. At the population level, Global Burden of Disease 2021 estimates continue to attribute a substantial proportion of LBP burden to occupational ergonomic risks[1], underscoring the public health significance of targeted workplace interventions suggested by the present findings.

Not all exposure indicators followed a strictly linear pattern, particularly with respect to movement distance. Short-distance tasks with high repetition or extreme vertical handling occasionally demonstrated a higher symptom burden than longer carries. This observation is biomechanically plausible and has been reported previously, as high-frequency lifting and handling at floor level or above shoulder height markedly increase lumbar loading even over short transport distances[6,9,13–15]. Inter-study variability may further reflect differences in task composition, co-exposures (e.g., heat stress, whole-body vibration), and psychosocial factors (e.g., high job demands, low decision latitude) that interact with biomechanical load to influence symptom expression[2,16–18].

Collectively, these findings support a hierarchy-of-controls approach that prioritizes reduction of cumulative lumbar load rather than focusing solely on nominal load weight. From an engineering perspective, interventions should emphasize improved grasp quality, staging materials within the power zone (approximately knuckle-to-elbow height), minimizing horizontal reach and trunk asymmetry, and employing mechanical or team-based assistance for heavier loads[13–15,19]. Administrative controls, including limits on high-cycle lifting duration, task rotation across dissimilar physical demands, and implementation of short active-rest breaks, may further reduce cumulative exposure and facilitate tissue recovery[6–8,11,12]. Worker-centered measures, such as task-specific coaching aligned with redesigned workstations and early reporting with graded activity, can mitigate

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progression and prevent deconditioning[16–18]. Ongoing surveillance linking exposure metrics with health outcomes is essential; emerging approaches using wearable inertial sensors offer feasible options for objective assessment of posture and lifting frequency in industrial settings[9,20–22].

This study has several strengths, including clearly specified lifting exposures, convergent indicators of manual handling demands, and the use of an ordinal association statistic appropriate for symptom severity. Nevertheless, limitations should be acknowledged. The cross-sectional design precludes causal inference; the sample size was modest (n = 42); exposure assessment relied on self-reported and coarse categorical measures; and potential confounders (e.g., age, body mass index, smoking status, psychosocial factors) were not controlled. The single-site context also limits generalizability.

Future research should adopt prospective or stepped-wedge designs to evaluate integrated engineering and administrative interventions[7,8,10,12], incorporate objective exposure measurement to refine dose–response relationships for load, reach, and frequency[9,20–22], and explicitly examine effect modification by psychosocial demands, heat stress, and vibration exposure[16–18]. Linking ergonomic exposure reduction to productivity and economic outcomes will be critical to sustaining implementation in sanitary ware and comparable labor-intensive industries[1–3,10,12].

CONCLUSION

This study demonstrates a statistically significant association between lifting and carrying activities and low back pain (LBP) severity among workers in the sanitary ware industry. Although the correlation strength was weak, the predominance of moderate LBP symptoms indicates a clinically and occupationally meaningful impact on worker function and productivity.

These findings underscore the importance of ergonomic risk factors, particularly cumulative exposure related to load handling, posture, and task duration, in the development of LBP in industrial settings. The results support the need for preventive ergonomic interventions aimed at reducing cumulative biomechanical load rather than focusing solely on load weight.

Given the cross-sectional design and limited sample size, causal inference cannot be established. Nevertheless, this study provides relevant evidence to inform targeted ergonomic strategies and highlights the need for future research to evaluate the effectiveness of long-term ergonomic interventions in improving occupational health outcomes in similar industries.

ETHICAL APPROVAL

Ethical clearance for the study was obtained from the Health Research Ethics Committee at Universitas Muhammadiyah Malang, with the approval number No.E.5.a/236/KEPK-UMM/XI/2022.

CONFLICTS OF INTEREST

The authors declare no conflicts of interest. We have no financial or personal relationships that could inappropriately influence the work reported in this paper.

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AUTHOR CONTRIBUTIONS

Rubayat Indradi: conceived and defined the research topic and title; selected the study site; led the literature review, discussion, and conclusion; coordinated the project and served as corresponding author.

Marinda Rahman: designed the methodology; developed sampling tools and procedures; performed data processing/analysis; contributed to the literature review.

Febri Endra Budi Setyawan: drafted the manuscript; expanded the Introduction and Discussion sections; contributed to the literature review and manuscript editing.

All authors reviewed and approved the final version of the manuscript.

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