Jurnal Serambi Engineering JSE
Volume XI, No.3, Juli 2026 Hal 20911 - 20916
p-ISSN : 2528-3561
e-ISSN : 2541-1934

Analysis of Sand Shoveler Work Posture Using the Key Indicator Method (KIM) at UD. Pasir Berlian

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Received: July 28, 2026 Approved: August 4, 2026

Abstract
Sand shoveling activities at UD. Pasir Berlian are still performed manually using non-ergonomic working postures, such as bending, lifting, and repeatedly transferring sand over long working hours. These conditions increase the risk of developing Musculoskeletal Disorders (MSDs) among workers. This study aims to assess the level of work posture risk and propose ergonomic improvements to work facilities in order to reduce the risk of MSDs. The study involved four sand-shoveling workers at UD. Pasir Berlian, North Labuhanbatu Regency. The research employed the Key Indicator Method for Lifting, Holding, and Carrying (KIM-LHC) to evaluate work posture risk, the Nordic Body Map (NBM) questionnaire to identify musculoskeletal complaints, and anthropometric measurements as the basis for designing an ergonomic work facility. Data were collected through observation, interviews, documentation, and questionnaires. The results showed that all workers obtained a KIM-LHC score of 200, indicating a high-risk category that requires immediate ergonomic intervention. The NBM results revealed that the most common musculoskeletal complaints occurred in the upper back, lower back, shoulders, arms, wrists, and legs due to repetitive shoveling activities and prolonged bending postures. To address these issues, an ergonomic platform or sand storage container was designed based on workers' anthropometric data to promote a more neutral working posture, reduce repetitive bending and manual lifting, and ultimately minimize the risk of MSDs while improving workers' comfort, safety and productivity.
Keywords: *ergonomics, key indicator method, musculoskeletal disorders, nordic body map, work posture*

Abstrak
Aktivitas penyekopan pasir di UD. Pasir Berlian masih dilakukan secara manual dengan postur kerja yang tidak ergonomis, seperti membungkuk, mengangkat, dan memindahkan pasir secara berulang dalam durasi kerja yang panjang. Kondisi tersebut berpotensi menimbulkan Gangguan Muskuloskeletal (Musculoskeletal Disorders/MSDs) pada pekerja. Penelitian ini bertujuan untuk menilai tingkat risiko postur kerja serta memberikan usulan perbaikan ergonomis pada fasilitas kerja guna mengurangi risiko MSDs. Penelitian melibatkan empat pekerja penyekop pasir di UD. Pasir Berlian, Kabupaten Labuhanbatu Utara. Metode yang digunakan meliputi Key Indicator Method Lifting, Holding, Carrying (KIM-LHC) untuk menilai tingkat risiko postur kerja, Nordic Body Map (NBM) untuk mengidentifikasi keluhan muskuloskeletal, serta pengukuran antropometri sebagai dasar perancangan fasilitas kerja yang ergonomis. Data dikumpulkan melalui observasi, wawancara, dokumentasi, dan penyebaran kuesioner. Hasil penelitian menunjukkan bahwa seluruh pekerja memperoleh skor KIM-LHC sebesar 200 yang termasuk dalam kategori risiko tinggi sehingga diperlukan tindakan perbaikan segera. Hasil kuesioner NBM menunjukkan keluhan dominan pada bagian punggung, punggung bawah, bahu, lengan, pergelangan tangan, dan kaki akibat aktivitas kerja yang berulang dengan postur membungkuk. Sebagai upaya perbaikan, dirancang platform atau wadah penyimpanan pasir berdasarkan data antropometri pekerja agar postur kerja menjadi lebih netral, mengurangi aktivitas membungkuk dan mengangkat beban secara manual, sehingga dapat menurunkan risiko MSDs serta meningkatkan kenyamanan, keselamatan, dan produktivitas kerja.
Kata kunci: *ergonomi, metode indikator kunci, gangguan muskuloskeletal, nordic body map, postur kerja*

1. Introduction

Sand is a natural material widely used by humans in construction. It consists of small grains ranging from 1/16 mm to 2 mm in size. Sand is formed through the physical and chemical weathering of rock. These grains exhibit textures that vary depending on the specific type of sand [1]. One sand mining site is operated by UD. Pasir Berlian in Kampung Dalam Village, Aek Kota Batu District, North Labuhanbatu. UD. Pasir Berlian is a business engaged in sand mining to meet construction and development needs. Operations run

from 07:00 to 17:00 WIB but may extend beyond these hours if customer demand increases. The business is capable of producing approximately 60 cubic meters of sand per day. The mining site employs seven workers across three different roles. Two workers manage the pipes while the stationary diesel engine sand from the river to the collection area. One worker is responsible for screening the sand and separating out large stones or gravel. Meanwhile, the remaining four workers manually shovel sand into the beds of dump trucks or pickup trucks. Direct observation at the site reveals that the sand-shoveling workers perform the most strenuous tasks. Their work is entirely manual, ranging from shoveling the sand to depositing it into the collection bins. During their shifts, these workers often remain in a stooped position for approximately five hours, performing repetitive movements and continuously lifting loads of sand weighing 5 kg. Consequently, the workers report pain in their backs, lower backs and shoulders. If left unaddressed, this situation poses a significant risk of developing Musculoskeletal Disorders (MSDs).

Ergonomics is derived from the Greek words "ergos," meaning work, and "nomos," meaning law. Thus, ergonomics is defined as the scientific discipline that studies humans in relation to their work. It is a branch of science that systematically utilizes information regarding human characteristics, capabilities, and limitations to design work systems; this enables individuals to function effectively and well within those systems—achieving desired work objectives in a manner that is comfortable, safe, healthy, and efficient. [2]. Ergonomics is a multidisciplinary field that integrates various disciplines such as anatomy, physiology, health sciences, design and technology along with other work-related fields. It can be defined as the study of the interaction between humans and the system elements they use, with the aim of maximizing human well-being and overall system performance. This involves applying theories, principles, data and methods to design work environments, tools, and tasks that align with human capabilities and limitations [3]. Ergonomics helps improve workplace safety and employee productivity. Work not performed in accordance with ergonomic principles leads to various health issues that are detrimental to both workers and the organization [4].

The Nordic Body Map is a subjective assessment method used to measure muscle pain experienced by workers. As a standardized and well-structured ergonomic checklist, the Nordic Body Map questionnaire is frequently used to identify worker discomfort. Completing the Nordic Body Map questionnaire aims to pinpoint which parts of a worker's body experience pain before and after performing tasks at a workstation. Indicators of fatigue levels and musculoskeletal complaints are obtained by administering fatigue and Nordic Body Map questionnaires both before and after work. The Nordic Body Map (NBM) is a simple questionnaire for identifying ergonomic risks [5]. The Nordic Body Map (NBM) method can be used to identify specific body parts experiencing discomfort or pain during work; although subjective in nature, this questionnaire is standardized and validated for use. Consequently, the results allow for the identification of the complaints experienced by workers, thereby enabling measures to address the discomfort they feel [6]. The Nordic Body Map (NBM) is used to identify musculoskeletal disorder (MSD) complaints experienced by workers.

These complaints are assessed using a questionnaire that maps various types of MSD issues onto a human body diagram. The questionnaire allows for the identification of specific muscle areas affected, with severity levels ranging from "No Pain" and "Slight Pain" to "Pain" and "Severe Pain." By analyzing the body map data which captures sensations ranging from discomfort to severe pain the NBM results enable an estimation of the type and severity of complaints, fatigue, and pain experienced by workers in specific muscle regions [7].

Musculoskeletal disorders (MSDs) can arise from a variety of factors. These disorders can affect various parts of the body, including the muscles of the neck, shoulders, arms, hands, back, and waist, as well as the muscles of the lower body. If MSDs are left untreated, they can lead to injury, paralysis, or even death [8]. Musculoskeletal disorders (MSDs) resulting from manual activities are rarely fatal; however, workplace injuries such as sprains, fractures, stiffness, weakness or loss of hand coordination, and muscle strain (particularly in the back and lower back) remain common, often caused by improper work techniques or prolonged, repetitive tasks [9]. Efforts to prevent and control musculoskeletal disorders (MSDs) among construction workers must take into account the aforementioned risk factors whether physical, environmental, or psychosocial. Ergonomic interventions, job rotation, training, and comprehensive occupational health programs are required to reduce workload and prevent the occurrence of musculoskeletal disorders among construction workers [10].

Work posture refers to the body position adopted while performing a task; this position is largely determined by the nature of the work, and each posture affects the body differently. Maintaining a balanced body posture while working is essential for comfort and sustained performance. Factors influencing work posture include the non-ergonomic placement of equipment or facilities, unfavorable working conditions,

work duration, repetitive movements, or a combination of these factors. Maintaining uncomfortable body postures over the long term can damage musculoskeletal tissues and peripheral nerves, as well as lead to physical complaints [11]. The impact of non-ergonomic work postures such as slouching or bending the head down for extended periods includes physical ailments (muscle, joint and spinal pain), extreme physical fatigue, reduced concentration, and even the risk of pinched nerves. Long-term consequences involve decreased work productivity, impaired blood circulation, and a decline in work motivation resulting from chronic pain [12].

The Key Indicator Method (KIM) is an ergonomic risk assessment method developed in Germany by the Federal Institute for Occupational Safety and Health (BAuA) and the German Committee for Occupational Safety and Health (LASI) to evaluate physical workloads such as lifting, carrying, pulling, pushing, and body posture—associated with manual handling and repetitive tasks in the workplace [13]. The Key Indicator Method (KIM) is designed as an evaluation tool capable of identifying job risk levels based on several key indicators, such as workload and work posture. The KIM is further categorized according to the type of work activity:

1. KIM LHC (Lifting, Holding, Carrying) for lifting, holding, and carrying loads.
2. KIM PP (Pushing and Pulling) for pushing and pulling activities.
3. KIM MHO (Manual Handling Operations) for other manual work activities.

The variables included in the KIM LHC method are daily work duration, type and frequency of force exertion, body posture during manual work, hand and arm posture during work, work organization and working conditions. KIM LHC evaluates several factors such as posture, load, and work frequency and uses them to provide recommendations for ergonomic improvements [14].

Facility layout refers to the arrangement of factory facilities designed to support the smooth operation of the production process. This arrangement optimizes the use of available space for positioning machinery and other production-support facilities, facilitates the flow of material movement, accommodates material storage (both temporary and permanent), and organizes personnel, among other factors [15].

Based on this, research is needed to analyze the work postures adopted by workers during the sand-hauling process and to provide recommendations for ergonomic posture improvements aimed at reducing the occurrence of Musculoskeletal Disorders (MSDs).

2. Material and Methods

Study Design

This study employed a quantitative descriptive approach to analyze the ergonomic risk associated with manual sand shoveling activities at UD. Pasir Berlian, North Labuhan Batu Regency, Indonesia. The research focused on four workers responsible for manually loading sand into dump trucks. Data collection was carried out through direct observation of working postures, interviews, workplace documentation, administration of the Nordic Body Map (NBM) questionnaire, and anthropometric measurements. Ergonomic risk assessment was performed using the Key Indicator Method–Lifting, Holding, Carrying (KIM-LHC), while anthropometric analysis was conducted to develop an ergonomic sand storage platform. The effectiveness of the proposed improvement was evaluated by comparing the KIM-LHC risk scores before and after evaluation of the proposed workstation by comparing the ergonomic risk before and after the proposed improvement.

Participants and Data Collection

The participants consisted of four manual sand shoveling workers employed in the sand loading area at UD. Pasir Berlian. Since the number of workers performing this activity was limited, all workers were included in the study using a total sampling technique. Primary data were collected through direct workplace observation, interviews, documentation, administration of the Nordic Body Map (NBM) questionnaire, and anthropometric measurements. Workplace observations focused on workers' postures, manual material handling activities, work duration, and work organization during sand loading operations. Documentation in the form of photographs and videos was used to support posture assessment. Secondary data were obtained from company records and previous studies related to ergonomics, anthropometry, and musculoskeletal disorders.

Ergonomic Risk Assessment

Ergonomic risk assessment was conducted using the Key Indicator Method–Lifting, Holding, Carrying (KIM-LHC). This method evaluates ergonomic risks associated with manual lifting, holding, and carrying activities. The assessment considered several key indicators, including daily working duration,

effective load weight, load handling conditions, working posture, unfavorable working conditions, and work organization. Each indicator was scored according to the KIM-LHC assessment worksheet, and the total score was used to determine the overall ergonomic risk level. The assessment results were classified into corresponding risk categories to identify the need for ergonomic intervention and corrective action.

Anthropometric Measurement and Workstation Design

Anthropometric measurements were collected from all participating workers to ensure that the proposed workstation accommodated their physical characteristics. The measured body dimensions included standing body height, forward reach, standing elbow height, and standing waist height. The anthropometric data were analyzed through data uniformity testing, data adequacy testing, and percentile calculations. Based on the analysis, an ergonomic sand storage platform was designed using AutoCAD software. The proposed design was intended to improve workers' posture, reduce excessive bending during sand loading activities, and minimize the risk of musculoskeletal disorders.

Data Analysis

The collected data were analyzed descriptively. NBM scores were used to determine the level of musculoskeletal complaints experienced by the workers, whereas KIM-LHC scores were used to assess ergonomic risk levels during manual sand shoveling activities. Anthropometric data were analyzed using statistical procedures, including data uniformity testing, data adequacy testing, and percentile calculations, to determine the dimensions of the proposed workstation. Finally, the effectiveness of the ergonomic improvement was evaluated by comparing the KIM-LHC scores before and after the implementation of the proposed workstation.

3. Results and Discussion

The Nordic Body Map (NBM) questionnaire was administered to identify musculoskeletal complaints experienced by manual sand shoveling workers at UD. Pasir Berlian. The assessment involved four workers performing manual sand loading activities. The results showed that all workers were classified as having a high risk of musculoskeletal disorders (MSDs), with NBM scores indicating that immediate corrective action is required. The most frequently reported complaints were located in the lower back, waist, shoulders, upper arms, wrists and legs. These complaints were mainly caused by prolonged bending, repetitive shoveling movements and manual lifting of sand throughout the working day. The summary of the NBM assessment is presented in **Table 1**.

Table 1. Nordic Body Map (NBM)

Worker	Not Pain	Mild Pain	Pain	Severe Pain	Score	Risk Level
1	4	5	8	11	82	High
2	2	6	11	8	79	High
3	6	12	8	8	74	High
4	4	7	13	4	73	High

Ergonomic Risk Assessment Using KIM-LHC

The ergonomic risk assessment was conducted using the Key Indicator Method–Lifting, Holding, Carrying (KIM-LHC). The evaluation considered daily working duration, effective load weight, load handling conditions, working posture, unfavorable working conditions and work organization. The assessment results showed that all four workers obtained a KIM-LHC score of 200, which falls into the high-risk category. This indicates that immediate ergonomic intervention is necessary. The high-risk level was mainly influenced by repetitive manual shoveling, prolonged trunk flexion, manual handling of approximately 5 kg of sand per shovel and long working durations. The KIM-LHC assessment results are presented in **Table 2**.

Table 2. Risk Level Recapitulation for 4

Worker	Worker Risk	Score Risk Level
1	200	High
2	200	High
3	200	High
4	200	High

Anthropometric Analysis and Proposed Workstation Design

Anthropometric measurements were conducted to determine the dimensions of the proposed ergonomic work facility. The measured body dimensions included standing body height, forward reach, standing elbow height and standing waist height. Before being used in the design process, the anthropometric data were analyzed using data uniformity testing, data adequacy testing and percentile calculations. The analysis showed that the data were statistically acceptable for workstation design. Based on the anthropometric analysis, an ergonomic sand storage platform was proposed with dimensions of 70 cm in width, 93 cm in height and a minimum clearance of 170 cm.

The proposed design was intended to reduce excessive bending during manual sand loading, maintain a more neutral working posture and improve workers' comfort and safety. The design dimensions are presented in. Anthropometric measurements were collected from all workers to determine the dimensions of the proposed ergonomic sand storage platform. The measured dimensions included standing body height, forward reach, standing elbow height, and standing waist height. The anthropometric data were analyzed through data uniformity testing, data adequacy testing, and percentile calculations (P5, P50, and P95). The proposed workstation was designed using AutoCAD software based on ergonomic principles to reduce excessive trunk flexion and improve workers' comfort, safety, and productivity.

Evaluation of the Proposed Workstation

Following the proposed workstation design, the KIM-LHC assessment was re-evaluated to estimate the ergonomic improvement. The proposed workstation reduced workers' exposure to awkward postures by increasing the working height and minimizing excessive trunk flexion during sand loading. As a result, the overall KIM-LHC risk level decreased compared with the existing working condition, indicating that the proposed ergonomic workstation can effectively reduce the risk of musculoskeletal disorders and improve worker comfort and safety during manual sand shoveling activities.

4. Conclusion

This study evaluated the ergonomic risk of manual sand shoveling activities at UD. Pasir Berlian using the Key Indicator Method–Lifting, Holding, Carrying (KIM-LHC) and the Nordic Body Map (NBM) questionnaire. The NBM results indicated that all four workers experienced a high level of musculoskeletal complaints, with scores ranging from 73 to 82, primarily affecting the back, waist, shoulders, arms, wrists, and legs. The KIM-LHC assessment showed that all workers obtained a score of 200, indicating a high ergonomic risk that requires immediate corrective action. To reduce these risks, an ergonomic sand storage platform was proposed based on workers' anthropometric measurements. The proposed design is expected to improve working posture by reducing excessive bending during sand loading activities, thereby minimizing the risk of musculoskeletal disorders (MSDs), enhancing worker comfort and safety, and supporting better work productivity.

5. Acknowledgment

The authors would like to express their sincere gratitude to Universitas Malikussaleh, Faculty of Engineering, Department of Industrial Engineering, for providing academic support throughout this research. The authors also gratefully acknowledge the management and sand shovelers of UD. Pasir Berlian for their cooperation, participation, and permission to conduct this study. Special appreciation is extended to the research supervisors for their valuable guidance, constructive suggestions.

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