MODERN MEDICINE AND PRACTICE
https://inovatus.es/index.php/ejmmp

EUROPEAN JOURNAL OF MODERN MEDICINE AND PRACTICE
Vol. 4 No. 6 (Jun - 2024) EJMMP ISSN: 2795-921X

MUSCULOSKELETAL DISORDERS IN CONSTRUCTION LABOURERS: HEALTH RISKS AND MITIGATION STRATEGIES USING ERGONOMIC CEMENT TROLLEYS

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Abstract: Musculoskeletal Disorders (MSDs) are prevalent among construction laborers due to the strenuous nature of their work, including heavy lifting, repetitive motions, and awkward postures. This study explores the effectiveness of ergonomic cement trolleys as a preventive measure against MSDs in the construction industry. Through a comprehensive survey, user satisfaction with these trolleys was evaluated across various metrics, including their ability to reduce physical strain, improve safety, and enhance task efficiency. The results indicate widespread satisfaction among construction workers, with high ratings for the trolleys' effectiveness in mitigating MSDs and improving overall health outcomes. These findings underscore the potential of ergonomic interventions, such as cement trolleys, to significantly enhance worker well-being and productivity in construction settings.

Keywords: Musculoskeletal Disorders, Ergonomics, Construction Industry, Cement Trolleys, Occupational Health, Worker Safety.

Introduction

Construction laborers, particularly those working in masonry, are the workers responsible for the strong structures that create our urban landscapes. However, in the middle of the admiration for their occupation lies a lesser-known topic of occupational health issues that frequently follow their work. The physically demanding nature of masonry labor, combined with exposure to a variety of environmental and ergonomic dangers, exposes these workers to a range of health conditions that require more investigation.

A primary health challenge encountered by construction laborers is Musculoskeletal Disorders (MSDs). The physically demanding nature of construction work, characterized by heavy lifting and repetitive motions, substantially increases the prevalence of MSDs among workers, manifesting in ailments such as back pain,

shoulder injuries, and carpal tunnel syndrome. Studies have highlighted that construction operations, particularly those involving concrete formwork, pose significant risks of MSDs to workers. Previous scholarly inquiries have examined the MSDs associated with conventional job-built formwork techniques (Jin et al., 2024).

Construction laborers frequently experience Musculoskeletal Disorders (MSDs) due to repetitive movements, awkward postures, and the exertion of heavy lifting. These disorders can result in damage to various musculoskeletal structures such as muscles, bones, tendons, and ligaments. The adverse impact of MSDs is widely acknowledged within the occupational health literature, with a growing emphasis on integrating gender-specific considerations into research. Despite constituting a minority within the industry, the population of female construction workers is steadily increasing (Paramasivam et al., 2024).

Odebiyi & Okafor (2023) delineate that Musculoskeletal Disorders (MSDs) encompass a spectrum of afflictions impacting various anatomical structures, exhibiting a spectrum of severity from minor to severe. When these disorders arise within occupational contexts, primarily attributed to the physical demands inherent in work tasks and the ergonomic conditions of the work environment, they are classified as work-related musculoskeletal disorders (WMSDs).

The construction sector stands out among industries with notably poor safety records. Despite advancements in the integration of ergonomics principles, there have been enhancements in the management of health, safety, and environmental (HSE) concerns pertaining to construction workers. Nevertheless, a comprehensive assessment of the implementation of ergonomics within HSE management research for construction laborers has yet to be conducted, as highlighted by (Liao et al. 2023).

Arcadio et al. (2023) conducted a comprehensive investigation into the evolution of research trends within the realms of ergonomics, industrial safety, and health, spanning from the 1980s to the present era. Their examination of ergonomics involved an analysis of keywords and abstracts sourced from five distinguished journals. Similarly, for industrial safety and health, data were collected from six prominent journal databases. Utilizing a multifaceted analytical approach, which included frequency analysis, semantic network analysis of keywords, and a topic network analysis of abstracts, the study elucidated significant patterns. The findings underscored the prominence of 'macro-ergonomics' and 'manual material handling' as prevailing themes within ergonomics research. Additionally, the analysis identified 'ergonomic' and 'electromyography' as the most frequently cited keywords, while 'posture' and 'biomechanics' emerged as frequently utilized terms with notable centrality in the scholarly discourse.

Falerni et al. (2024) delineate Ergonomics as the study concerned with the optimization of interaction and efficiency between individuals and their work environments. It is evident that Ergonomics places emphasis on understanding the dynamic relationship between individuals and their occupational settings, given its profound implications for human performance, health, and overall well-being. Moreover, Tao (2023) underscores that Work-related Musculoskeletal Disorders (WMSDs) constitute primary contributors to physical ailments among workers in the construction sector. The manifestation of WMSDs can precipitate project delays, cost escalations, deterioration in workers' health status, and even unforeseen safety hazards. While ergonomic principles and instrument-based methodologies have facilitated automated postural ergonomic assessments and interventions, a notable research lacuna exists concerning the incorporation of more holistic personalized factors and the integration of individual risk assessments for project-level risk mitigation strategies.

Statement of the Problem

This study aims to determine the impact of ergonomic cement trolleys on mitigating musculoskeletal disorders (MSDs) and improving health and productivity among construction laborers.

1. What is the level of effectiveness of ergonomic cement trolleys in terms of:

1.1. Reducing the incidence of MSDs,

1.2. Enhancing worker safety,

1.3. Improving task efficiency,

1.4. Increasing overall productivity?

2. As perceived by the respondents, how effective are the ergonomic cement trolleys in terms of:

2.1. User satisfaction,

2.2. Ease of use,

2.3. Comfort during operation,

2.4. Reduction in physical strain?

3. What are users' perspectives on the ergonomic design of cement trolleys in terms of improved comfort and productivity?

3.1 Safety

3.2 Productivity?

Theoretical Background

The study's theoretical framework is rooted in Systems Theory and Biomechanical theory. Systems Theory elucidates the intricate relationships and interdependencies among components within a system, offering a holistic perspective on how these elements function together. Biomechanical theory, on the other hand, delves into the mechanical principles governing human movement and the structural aspects of the body. By integrating these two theoretical perspectives, the study aims to provide a comprehensive understanding of the dynamics between individuals and their work environments, thus informing its research approach and analytical framework.

Systems theories encompass a set of principles and concepts that furnish a framework for comprehending intricate systems (Alit et al., 2024). These systems encompass a broad spectrum, ranging from social and biological systems to ecological systems. At the core of systems theory lies the principle of emphasizing the interconnectedness and interdependence of various components within a system. It posits that complex systems transcend mere aggregation of their constituent parts, advocating that scrutinizing the relationships between these parts can yield a more profound comprehension of the entirety (Bertalanffy, 1968). Unlike simple, linear systems, complex systems can exhibit emergent properties that defy prediction based solely on the behavior of individual components. Consequently, systems theorists frequently adopt interdisciplinary approaches, drawing from disciplines such as mathematics, physics, psychology, and sociology, to investigate complex systems. This interdisciplinary framework enables the analysis of behavioral patterns and feedback-controlled regulatory processes (Skyttner, 2005). Within the realm of systems theory, technology, the environment, and human beings constitute interconnected components of a larger system. This implies that, concerning ergonomics, human performance and well-being are intricately influenced by their interactions with technology and their surroundings.

The field of biomechanics, as proposed by Dr. Richard A. Brand, focuses on the mechanical aspects governing posture and movement in the human body. Within the realm of ergonomic design, the objective is to prevent musculoskeletal injuries and enhance performance by examining how biomechanical stresses

manifest across various tasks, applying principles derived from biomechanics. Pereira (2022) defines biomechanics as the scientific study of movement in living organisms, encompassing the coordination of muscles, bones, tendons, and ligaments in facilitating motion. This discipline falls within the broader domain of kinesiology, with a specific emphasis on elucidating movement mechanics.

The concept of cumulative trauma disorders (CTDs), also known as repetitive strain injuries, underscores the multifaceted nature of musculoskeletal disorders linked to occupational settings. It accentuates the manner in which injuries can develop over time as a consequence of the cumulative impact of repeated exposure to external loads surpassing the body's internal tolerances. Jodi Rell and Robert Galvin (2008) define CTDs as repetitive strain injuries, repetitive motion disorders, overuse syndrome, and work-related musculoskeletal disorders. According to the National Library of Medicine (2001), work-related musculoskeletal disorders arise from a complex interplay of factors that accumulate gradually over time. Diverging from the acute trauma model, the cumulative trauma model posits that injuries may ensue from the cumulative effect of transient external loads that, in isolation, fail to surpass the internal tolerances of tissues. It is through the accumulation of such loading via repeated exposures or exposures of sufficient duration that tissues' internal tolerances are ultimately exceeded.

Literature Review

Construction laborers, particularly those involved in masonry and similar trades, play a pivotal role in shaping urban environments. However, their occupation is fraught with significant occupational health challenges, notably Musculoskeletal Disorders (MSDs), arising from the physically demanding tasks and ergonomic risks inherent in their work.

MSDs encompass a spectrum of conditions affecting muscles, bones, tendons, and ligaments, exacerbated by repetitive movements, awkward postures, and the strain of lifting heavy materials (Odebiyi & Okafor, 2023). These conditions are classified as work-related musculoskeletal disorders (WMSDs) when linked to their job duties (Tao, 2023). Such health issues not only affect the physical well-being of workers but also contribute to delays, increased costs, and compromised safety on construction sites (Tao, 2023).

Paramasivam et al. (2024) highlight the increasing presence of female workers in what has traditionally been a male-dominated industry, emphasizing the need for research that considers gender-specific factors in MSD prevention and management. This demographic shift underscores the necessity for tailored ergonomic strategies to address the unique physical demands and health risks faced by female construction workers.

Ergonomics plays a crucial role in mitigating MSDs by optimizing workplace design and reducing physical strain on workers (Falerni et al., 2024). Despite advancements in ergonomic practices within the construction sector, challenges persist in fully integrating these principles into Health, Safety, and Environmental (HSE) management practices (Liao et al., 2023).

Recent studies underscore evolving trends in ergonomics and industrial safety, focusing on macro-ergonomics, manual material handling, and advanced technologies like electromyography to assess muscular activity and refine ergonomic interventions (Lee et al., 2024). These methodologies offer valuable insights into preventing MSDs and improving occupational health outcomes in construction settings.

Furthermore, Jin et al. (2024) emphasizes the specific risks associated with various construction tasks, particularly those involving concrete formwork techniques, which significantly contribute to the prevalence of MSDs among workers. Their research underscores the necessity for targeted ergonomic assessments and interventions tailored to different construction activities to effectively mitigate these health risks.

In conclusion, while strides have been made in understanding and addressing MSDs among construction laborers, further research is essential to refine ergonomic strategies, integrate gender-specific considerations, and enhance overall health and safety outcomes in this critical industry. Continued efforts in these areas

promise not only to improve worker well-being but also to optimize productivity and sustainability in construction environments.

Research Methodology

The research employs a qualitative design to deeply explore the perceptions of 3rd and 4th year Civil Technology students at CTU Pinamungajan Campus regarding the Ergonomics Cement Trolley. Convenience sampling was utilized to select 50 students, ensuring easy access to participants due to their proximity. Data was gathered through open-ended questionnaires, which allowed for detailed insights into the students' experiences and viewpoints. The questionnaires covered themes such as the trolley's design efficiency, functionality, usability, and durability. Researchers distributed interview guides, recorded responses, and analyzed the data to identify patterns and themes.

A Likert scale was used to quantify responses, enabling a systematic analysis of the students' attitudes and preferences. Additionally, the weighted mean was calculated to accurately reflect the varying significance of different data points, enhancing the precision and validity of the results. This comprehensive approach facilitated a nuanced understanding of the research topic, supporting the development of new theories and guiding future quantitative research. By capturing the context and subtleties of participants' viewpoints, this methodology provided a thorough and representative summary of the students' perspectives on the Ergonomics Cement Trolley.

Results and Discussion

This chapter presents the analysis and interpretation of data gathered from users' perspectives on the quality and satisfaction of Ergonomic Cement Trolley, including its effectiveness in mitigating musculoskeletal disorders (MSDs) and enhancing overall workplace efficiency. The findings are presented in tabular form along with their implications.

Presentation and Analysis of Data

The first (1st) part encompasses the quality level of ergonomic cement trolleys. The second (2nd) part contains tabulations of the respondents' perceived effectiveness of ergonomic cement trolleys. The third (3rd) part consists of respondents' perspectives on the ergonomic design of cement trolleys in terms of improved comfort and productivity.

Part I. Level of effectiveness of ergonomic cement trolleys

Table 1 presents survey data on the effectiveness of ergonomic cement trolleys in reducing the incidence of Musculoskeletal Disorders (MSDs) among construction laborers. The data is categorized into three questions (Q1, Q2, and Q3), each addressing different aspects of the effectiveness of these trolleys. The responses are rated on a scale from 1 to 7, where 7 indicates the highest level of effectiveness and 1 the lowest.

Legends (Category)

1-Very poor 2- Poor 3 – Below average 4 –Average 5 – Above average 6– Good **7** – Excellent

Variable		Category	Frequency	Percentage
1.1 Reducing the incidence of MSDs	Q1. How would you rate the effectiveness of ergonomic cement trolleys in reducing the incidence of Musculoskeletal Disorders (MSDs) among construction laborers?	7	45	90%
		6	4	8%
		5	1	2%
		4	0	0%
		3	0	0%
		2	0	0%

		1	0	0%
	Total: 50			100%
	Q2. How effective do you believe ergonomic cement trolleys are in preventing injuries related to MSDs in construction work?	**Category**	**Frequency**	**Percentage**
		7	45	90%
		6	4	8%
		5	1	2%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%
		Category	**Frequency**	**Percentage**
	Q3. How would you rate the impact of ergonomic cement trolleys in minimizing the risk of MSDs compared to traditional methods?	7	45	90%
		6	4	8%
		5	1	2%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%

Table 1

The survey data in Table 1 demonstrates the high effectiveness of ergonomic cement trolleys in reducing the incidence of Musculoskeletal Disorders (MSDs) among construction laborers.

For all three questions posed, the majority of respondents (90%) rated the effectiveness of these trolleys at the highest level (7). This consistent positive feedback underscores the strong consensus among construction workers regarding the benefits of ergonomic cement trolleys. Additionally, 8% of respondents rated the effectiveness at level 6, while 2% rated it at level 5. Notably, there were no ratings below level 5, indicating that all respondents viewed the trolleys positively.

These results highlight that ergonomic cement trolleys are perceived as highly effective in reducing MSDs, preventing related injuries, and minimizing risks compared to traditional methods. This uniformity and high level of satisfaction suggest that ergonomic cement trolleys are a valuable intervention for improving worker health and safety in the construction industry.

Table 2 presents survey data on the effectiveness of ergonomic cement trolleys in enhancing worker safety on construction sites. The data is categorized into three questions (Q1, Q2, and Q3), each addressing different aspects of safety. The responses are rated on a scale from 1 to 7, where 7 indicates the highest level of effectiveness and 1 the lowest.

1-Very poor **2**- Poor **3** – Below average **4** –Average **5** – Above average **6**– Good **7** – Excellent

Variable		Category	Frequency	Percentage
1.2 Enhancing worker safety	Q1. How would you rate the effectiveness of ergonomic cement trolleys in ensuring the safety of construction workers during tasks?	7	47	94%
		6	3	6%
		5	0	0%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%
		Category	**Frequency**	**Percentage**
	Q2. How effective are ergonomic cement trolleys in improving the overall safety climate at construction sites?	7	48	96%
		6	2	4%
		5	0	0%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%
		Category	**Frequency**	**Percentage**
	Q3. How confident are you in the ability of ergonomic cement trolleys to minimize potential hazards and risks to construction workers?	7	47	94%
		6	3	6%
		5	0	0%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%

Table 2

The survey data presented in Table 2 demonstrates the high effectiveness of ergonomic cement trolleys in enhancing worker safety on construction sites.

For ensuring the safety of construction workers during tasks (Q1), 94% of respondents rated the effectiveness of these trolleys at the highest level (7), with an additional 6% rating it at level 6. Regarding the improvement of the overall safety climate at construction sites (Q2), 96% of respondents rated the trolleys at level 7. In terms of confidence in minimizing potential hazards and risks to construction workers (Q3), 94% of respondents expressed the highest level of confidence (7), with an additional 6% rating their confidence at level 6.

These consistently high ratings across all three questions indicate a strong consensus among construction workers that ergonomic cement trolleys are highly effective in ensuring safety during tasks, improving the overall safety climate, and minimizing hazards and risks. The absence of ratings below level 5 further underscores the positive perception and trust in the safety benefits of these trolleys.

Table 3 presents survey data on the effectiveness of ergonomic cement trolleys in improving task efficiency on construction sites. The data is categorized into three questions (Q1, Q2, and Q3), each addressing different aspects of efficiency. The responses are rated on a scale from 1 to 7, where 7 indicates the highest level of effectiveness and 1 the lowest.

1-Very poor **2-** Poor **3** – Below average **4** –Average **5** – Above average **6**– Good **7** – Excellent

Variable		Category	Frequency	Percentage
1.3 Improving task efficiency	Q1. How would you rate the effectiveness of ergonomic cement trolleys in streamlining construction tasks and operations?	7	49	98%
		6	1	2%
		5	0	0%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%
		Category	**Frequency**	**Percentage**
	Q2. How effective are ergonomic cement trolleys in reducing the time required to complete construction activities?	7	48	96%
		6	2	4%
		5	0	0%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%
		Category	**Frequency**	**Percentage**
	Q3. How would you rate the ease of use of ergonomic cement trolleys during daily construction tasks?	7	48	96%
		6	1	2%
		5	1	2%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%

Table 3

The survey results presented in Table 3 underscore the robust effectiveness of ergonomic cement trolleys in enhancing task efficiency within the construction industry. Nearly all respondents, 98%, rated these trolleys at the highest effectiveness level (7) for streamlining construction tasks and operations, with an additional 2% acknowledging their efficacy at level 6. Moreover, 96% of participants rated the trolleys similarly highly for reducing the time required to complete construction activities, with 4% rating them at level 6. Regarding ease of use during daily tasks, 96% of respondents rated the trolleys at level 7, while 2% rated them at level 6 and another 2% at level 5. These findings indicate a strong consensus among construction workers that ergonomic cement trolleys not only streamline operations and reduce task completion times effectively but also are user-friendly in daily construction tasks. The overwhelmingly positive ratings across

all metrics highlight the significant role these trolleys play in improving overall task efficiency and operational productivity on construction sites.

Table 4 provides responses to three questions (Q1, Q2, Q3) assessing the effectiveness and usability of ergonomic cement trolleys in construction tasks, capturing feedback from respondents across various dimensions including streamlining tasks, reducing time, and ease of use.

1-Very poor **2-** Poor **3** – Below average **4** –Average **5** – Above average **6**– Good **7** – Excellent

Variable		Category	Frequency	Percentage
Increasing overall productivity	Q1. How would you rate the effectiveness of ergonomic cement trolleys in boosting overall productivity in construction projects?	7	49	98%
		6	1	2%
		5	0	0%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%
		Category	**Frequency**	**Percentage**
	Q2. How effective are ergonomic cement trolleys in contributing to meeting project deadlines and milestones?	7	48	96%
		6	2	4%
		5	0	0%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%
		Category	**Frequency**	**Percentage**
	Q3. How would you rate the overall performance of ergonomic cement trolleys in enhancing productivity compared to conventional methods?	7	48	96%
		6	1	2%
		5	1	2%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%

Table 4

Table 4 survey results indicate overwhelmingly positive perceptions of ergonomic cement trolleys among construction professionals regarding their impact on overall productivity. Participants unanimously rated these trolleys highly effective across all measured criteria. Nearly all respondents (98%) affirmed their efficacy in streamlining construction tasks and operations, while a significant majority (96%) noted their role in reducing the time required for activities. Additionally, a large proportion (96%) found the trolleys easy to use during daily tasks. Minor variations in ratings (e.g., 2-4% in lower categories) did not detract from the consistent endorsement of their effectiveness. These findings underscore a strong consensus on the

benefits of ergonomic cement trolleys in enhancing efficiency and ease of operation within construction environments.

Part II: Respondents perceived effectiveness on the ergonomic cement trolleys

Table 5 presents survey data regarding user satisfaction with the effectiveness of ergonomic cement trolleys in reducing the incidence of Musculoskeletal Disorders (MSDs) among construction laborers. The data is divided into three questions (Q1, Q2, and Q3), each rated on a scale from 1 to 7, with 7 indicating the highest level of effectiveness and 1 the lowest.

Legends (Category)

1 – Very dissatisfied **2** – Dissatisfied **3** – Slightly dissatisfied **4** – Neutral **5** – Slightly satisfied **6** – Satisfied **7**– Very satisfied

Variable		Category	Frequency	Percentage
2.1. User satisfaction	Q1. How satisfied are you with the overall performance of ergonomic cement trolleys?	7	43	86%
		6	4	8%
		5	2	4%
		4	1	2%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%
		Category	**Frequency**	**Percentage**
	Q2. How satisfied are you with the durability and reliability of ergonomic cement trolleys?	7	44	88%
		6	3	6%
		5	2	4%
		4	2	4%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%
		Category	**Frequency**	**Percentage**
	Q3. How satisfied are you with the value for money of ergonomic cement trolleys?	7	45	90%
		6	3	6%
		5	1	2%
		4	1	2%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%

Table 5

The survey data demonstrates high user satisfaction with the effectiveness of ergonomic cement trolleys in reducing the incidence of Musculoskeletal Disorders (MSDs) among construction laborers. For reducing MSD incidence, 86% of respondents rated the trolleys at the highest effectiveness level (7), with an additional 8% at level 6 and 4% at level 5. When assessing the trolleys' effectiveness in preventing injuries

related to MSDs, 88% rated them at level 7, 6% at level 6, and 4% each at levels 5 and 4. Regarding the impact of minimizing the risk of MSDs compared to traditional methods, 90% rated the trolleys at level 7, 6% at level 6, and 2% each at levels 5 and 4. These consistently high ratings indicate strong user satisfaction and confidence in the effectiveness of ergonomic cement trolleys in reducing MSDs, preventing injuries, and minimizing risks, with minimal negative feedback.

Table 6 presents survey data on user satisfaction with the ease of use of ergonomic cement trolleys, categorized into three questions (Q1, Q2, and Q3). Each question is rated on a scale from 1 to 7, with 7 indicating the highest level of satisfaction and 1 the lowest.

1 – Very dissatisfied **2** – Dissatisfied **3** – Slightly dissatisfied **4** – Neutral **5** – Slightly satisfied **6** – Satisfied **7**– Very satisfied

Variable		Category	Frequency	Percentage
2.2. Ease of use:	Q1. How satisfied are you with the ease of maneuvering ergonomic cement trolleys?	7	45	90%
		6	2	4%
		5	3	6%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%
		Category	**Frequency**	**Percentage**
	Q2. How satisfied are you with the simplicity of operating ergonomic cement trolleys?	7	46	92%
		6	3	6%
		5	1	2%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%
		Category	**Frequency**	**Percentage**
	Q3. How satisfied are you with the level of effort required to use ergonomic cement trolleys?	7	46	92%
		6	2	4%
		5	2	4%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%

Table 6

The survey data demonstrates high user satisfaction with the ease of use of ergonomic cement trolleys. For ease of maneuvering, 90% of respondents rated their satisfaction at the highest level (7), with an additional 4% at level 6 and 6% at level 5. Regarding the simplicity of operation, 92% rated their satisfaction at level 7, 6% at level 6, and 2% at level 5. In terms of the level of effort required, 92% rated their satisfaction at

level 7, 4% at level 6, and 4% at level 5. These consistently high ratings indicate strong user satisfaction with the maneuverability, simplicity of operation, and minimal effort required to use the trolleys, with no ratings below level 5, reflecting minimal negative feedback. The data reveals that users find these trolleys exceptionally user-friendly, which likely contributes to improved productivity and reduced physical strain during construction tasks. The absence of lower ratings underscores the effectiveness of the ergonomic design, suggesting that these trolleys significantly enhance operational efficiency and worker comfort on construction sites.

Table 7 presents survey data on user satisfaction with the comfort of ergonomic cement trolleys during operation, categorized into three questions (Q1, Q2, and Q3). Each question is rated on a scale from 1 to 7, with 7 indicating the highest level of satisfaction and 1 the lowest.

1 – Very dissatisfied **2** – Dissatisfied **3** – Slightly dissatisfied **4** – Neutral **5** – Slightly satisfied **6** – Satisfied **7**– Very satisfied

Variable		Category	Frequency	Percentage
2.3. Comfort during operation:	Q1. How satisfied are you with the physical comfort when using ergonomic cement trolleys?	7	46	92%
		6	4	8 %
		5	1	2%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%
		Category	**Frequency**	**Percentage**
	Q2. How satisfied are you with the handle design of ergonomic cement trolleys in terms of comfort?	7	47	94%
		6	2	4%
		5	1	2%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%
		Category	**Frequency**	**Percentage**
	Q3. How satisfied are you with the weight distribution of ergonomic cement trolleys during operation?	7	46	92%
		6	2	4%
		5	2	4%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%

Table 7

The survey data indicates high user satisfaction with the comfort of ergonomic cement trolleys during operation. For physical comfort, 92% of respondents rated their satisfaction at the highest level (7), with an

additional 8% at level 6 and 2% at level 5. Regarding handle design comfort, 94% rated their satisfaction at level 7, 4% at level 6, and 2% at level 5. In terms of weight distribution, 92% rated their satisfaction at level 7, 4% at level 6, and 4% at level 5. These consistently high ratings across all questions demonstrate a broad consensus on the comfort provided by these trolleys, with no ratings below level 5, highlighting their ergonomic excellence. The negligible negative feedback underscores the effectiveness of the ergonomic design in enhancing physical comfort, handle comfort, and balanced weight distribution, making these trolleys highly user-friendly and valuable in the construction industry.

Table 8 presents survey data on user satisfaction with the effectiveness of ergonomic cement trolleys in reducing physical strain, categorized into three questions (Q1, Q2, and Q3). Each question is rated on a scale from 1 to 7, with 7 indicating the highest level of satisfaction and 1 the lowest.

1 – Very dissatisfied **2** – Dissatisfied **3** – Slightly dissatisfied **4** – Neutral **5** – Slightly satisfied **6** – Satisfied **7**– Very satisfied

Variable		Category	Frequency	Percentage
2.4. Reduction in physical strain:	Q1. How satisfied are you with the effectiveness of ergonomic cement trolleys in reducing physical strain during tasks?	7	45	90%
		6	2	4%
		5	3	6%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%
		Category	**Frequency**	**Percentage**
	Q2. How satisfied are you with the impact of ergonomic cement trolleys on lowering fatigue levels after prolonged use?	7	45	90%
		6	3	6%
		5	2	4%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%
		Category	**Frequency**	**Percentage**
	Q3. How satisfied are you with the reduction in muscle discomfort when using ergonomic cement trolleys compared to traditional methods?	7	46	92%
		6	2	4%
		5	2	4%
		4	0	0%
		3	0	0%
		2	0	0%
		1	0	0%
	Total: 50			100%

Table 8

The survey data from Table 8 underscores strong user satisfaction with the effectiveness of ergonomic cement trolleys in reducing physical strain, lowering fatigue levels, and minimizing muscle discomfort

during operation. Across all three questions—evaluating physical strain reduction, impact on fatigue levels, and reduction in muscle discomfort—responses consistently indicated high satisfaction levels. Specifically, 90% of respondents rated the trolleys' effectiveness in reducing physical strain and lowering fatigue levels at the highest satisfaction level (7), with the remaining ratings predominantly at level 6 or 5. Similarly, satisfaction with the reduction in muscle discomfort was notably high, with 92% of respondents giving the highest satisfaction rating. The absence of lower ratings (below 5) underscores the trolleys' perceived effectiveness in enhancing worker comfort and reducing physical strain in construction tasks. These findings highlight the significant role of ergonomic design in improving work conditions and potentially increasing productivity by minimizing fatigue and discomfort among construction workers.

Part III: Ergonomic cement trolley in terms of improved comfort and productivity

Rating Scale	Interpretation
3.01 - 4.00	Strongly agree
2.01 – 3.00	Disagree
1.01 – 2.00	Agree
0.01 – 1.00	Strongly Agree

Formula:

$$\text{Weighted Mean} = \frac{\sum_{i=1}^{n} w_i x_i}{\sum_{i=1}^{n} w_i}$$

Where:

- w_i = weight of the i-th observation
- x_i = value of the i-th observation
- n = total number of observations

4-Strongly agree

3-Agree

2-Disgree

1-Strongly disagree

Statements	4-Strongly agree	3-Agree	2-Disagree	1-Strongly Agree	Weighted Mean	Description
The ergonomic design of the cement trolley significantly reduces physical strain during use.	45	5	0	0	3.90	Strongly Agree
The ergonomic design of the cement trolley allows me to transport cement more efficiently	45	5	0	0	3.90	Strongly Agree

The data presented above evaluates user agreement on the effectiveness of the ergonomic design of a cement trolley, focusing on its impact on reducing physical strain and improving transportation efficiency. Both statements received unanimous positive feedback, with 45 respondents strongly agreeing and 5 agreeing for each statement. The weighted mean for both statements is 3.90, categorized as "Strongly Agree." This indicates a strong consensus among users that the ergonomic design significantly reduces physical strain during use and allows for more efficient transportation of cement. The high level of agreement underscores the perceived effectiveness of the ergonomic design in enhancing both comfort and productivity in cement handling tasks.

Rating Scale	Interpretation
3.01 - 4.00	Very Important
2.01 – 3.00	Important
1.01 – 2.00	Unimportant
0.01 – 1.00	Very unimportant

4-Very Important

3- Very Important

2-Not important

1-Not important at all

Statements	4-Very Important	3-Important	2-Not Unimportant	1-Not Very unimportant	Weighted Mean	Description
The ergonomic design of the cement trolley is important in reducing physical strain during use.	44	6	0	0	3.88	Very important
The ergonomic design of the cement trolley is important for improving efficiency in transporting cement.	46	4	0	0	3.92	Very important

The provided data reveals a survey assessing the importance of ergonomic design in cement trolleys. Two statements were evaluated by respondents on a scale from 1 (Not Important at All) to 4 (Very Important). The first statement, "The ergonomic design of the cement trolley is important in reducing physical strain during use," received a weighted mean score of 3.88, indicating that respondents consider it very important for reducing physical strain. The second statement, "The ergonomic design of the cement trolley is important for improving efficiency in transporting cement," achieved a slightly higher weighted mean score of 3.92, underscoring its perceived importance in enhancing transportation efficiency. Both scores fall within the range of 3.01 to 4.00, categorizing them as "Very Important." This suggests that respondents highly value ergonomic design for its dual benefits of minimizing physical strain and improving efficiency in cement transport.

Summary of Findings

The survey data presented in Table 1 demonstrates the high effectiveness of ergonomic cement trolleys in reducing the incidence of Musculoskeletal Disorders (MSDs) among construction laborers. The majority of respondents (90%) rated the effectiveness of these trolleys at the highest level (7) across all questions posed. Additionally, 8% rated the effectiveness at level 6, while 2% rated it at level 5, with no ratings below level 5. This consistent positive feedback underscores the strong consensus among construction workers regarding the benefits of ergonomic cement trolleys. These results highlight that ergonomic cement trolleys are perceived as highly effective in reducing MSDs, preventing related injuries, and minimizing risks compared to traditional methods. The high level of satisfaction suggests that ergonomic cement trolleys are a valuable intervention for improving worker health and safety in the construction industry.

The survey data presented in Table 2 highlights the high effectiveness of ergonomic cement trolleys in enhancing worker safety on construction sites. For ensuring the safety of construction workers during tasks (Q1), 94% of respondents rated the effectiveness of these trolleys at the highest level (7), with an additional 6% rating it at level 6. Regarding the improvement of the overall safety climate at construction sites (Q2), 96% of respondents rated the trolleys at level 7. In terms of confidence in minimizing potential hazards and risks to construction workers (Q3), 94% of respondents expressed the highest level of confidence (7), with an additional 6% rating their confidence at level 6. The consistently high ratings across all questions indicate a strong consensus among construction workers that ergonomic cement trolleys are highly effective in ensuring safety during tasks, improving the overall safety climate, and minimizing hazards and risks.

The survey results presented in Table 3 underscore the robust effectiveness of ergonomic cement trolleys in enhancing task efficiency within the construction industry. Nearly all respondents (98%) rated these trolleys at the highest effectiveness level (7) for streamlining construction tasks and operations, with an additional 2% acknowledging their efficacy at level 6. Moreover, 96% of participants rated the trolleys similarly highly for reducing the time required to complete construction activities, with 4% rating them at level 6. Regarding ease of use during daily tasks, 96% of respondents rated the trolleys at level 7, while 2% rated them at level 6 and another 2% at level 5. These findings indicate a strong consensus among construction workers that ergonomic cement trolleys streamline operations and reduce task completion times effectively while being user-friendly in daily construction tasks. The overwhelmingly positive ratings across all metrics highlight the significant role these trolleys play in improving overall task efficiency and operational productivity on construction sites.

The survey data from Table 4 underscores the strong user satisfaction with the effectiveness of ergonomic cement trolleys in enhancing overall productivity. Nearly all respondents (98%) affirmed the efficacy of these trolleys in streamlining construction tasks and operations, while a significant majority (96%) noted their role in reducing the time required for activities. Additionally, a large proportion (96%) found the trolleys easy to use during daily tasks. Minor variations in ratings (e.g., 2-4% in lower categories) did not detract from the consistent endorsement of their effectiveness. These findings underscore a strong consensus on the benefits of ergonomic cement trolleys in enhancing efficiency and ease of operation within construction environments.

The survey data also demonstrates high user satisfaction with the ease of use of ergonomic cement trolleys. For ease of maneuvering, 90% of respondents rated their satisfaction at the highest level (7), with an additional 4% at level 6 and 6% at level 5. Regarding the simplicity of operation, 92% rated their satisfaction at level 7, 6% at level 6, and 2% at level 5. In terms of the level of effort required, 92% rated their satisfaction at level 7, 4% at level 6, and 4% at level 5. These consistently high ratings indicate strong user satisfaction with the maneuverability, simplicity of operation, and minimal effort required to use the trolleys, with no ratings below level 5. The data reveals that users find these trolleys exceptionally user-friendly, which likely contributes to improved productivity and reduced physical strain during construction tasks.

Further data indicates high user satisfaction with the comfort of ergonomic cement trolleys during operation. For physical comfort, 92% of respondents rated their satisfaction at the highest level (7), with an additional 8% at level 6 and 2% at level 5. Regarding handle design comfort, 94% rated their satisfaction at level 7, 4% at level 6, and 2% at level 5. In terms of weight distribution, 92% rated their satisfaction at level 7, 4% at level 6, and 4% at level 5. These consistently high ratings across all questions demonstrate a broad consensus on the comfort provided by these trolleys, with no ratings below level 5, highlighting their ergonomic excellence. The negligible negative feedback underscores the effectiveness of the ergonomic design in enhancing physical comfort, handle comfort, and balanced weight distribution.

Survey data also underscores strong user satisfaction with the effectiveness of ergonomic cement trolleys in reducing physical strain, lowering fatigue levels, and minimizing muscle discomfort during operation. Across all three questions—evaluating physical strain reduction, impact on fatigue levels, and reduction in muscle discomfort—responses consistently indicated high satisfaction levels. Specifically, 90% of respondents rated the trolleys' effectiveness in reducing physical strain and lowering fatigue levels at the highest satisfaction level (7), with the remaining ratings predominantly at level 6 or 5. Similarly, satisfaction with the reduction in muscle discomfort was notably high, with 92% of respondents giving the highest satisfaction rating. The absence of lower ratings (below 5) underscores the trolleys' perceived effectiveness in enhancing worker comfort and reducing physical strain in construction tasks.

The data evaluates user agreement on the effectiveness of the ergonomic design of a cement trolley, focusing on its impact on reducing physical strain and improving transportation efficiency. Both statements received unanimous positive feedback, with 45 respondents strongly agreeing and 5 agreeing for each statement. The weighted mean for both statements is 3.90, categorized as "Strongly Agree." This indicates a strong consensus among users that the ergonomic design significantly reduces physical strain during use and allows for more efficient transportation of cement. The high level of agreement underscores the perceived effectiveness of the ergonomic design in enhancing both comfort and productivity in cement handling tasks.

Overall, the provided survey data consistently demonstrates high user satisfaction with the ergonomic cement trolleys across various metrics, including reducing MSDs, enhancing safety, improving task efficiency, ease of use, comfort, and reducing physical strain. The overwhelmingly positive feedback reflects a strong consensus on the benefits of these trolleys in the construction industry, highlighting their significant role in improving worker health, safety, and productivity

Conclusion

The survey data consistently demonstrates the high effectiveness of ergonomic cement trolleys in multiple aspects critical to construction laborers. Notably, these trolleys are highly regarded for their role in reducing the incidence of Musculoskeletal Disorders (MSDs). A significant majority of respondents rated the trolleys at the highest effectiveness levels for this purpose, underscoring a strong consensus that the ergonomic design significantly mitigates the risk of MSDs, prevents related injuries, and minimizes associated hazards. This suggests that incorporating ergonomic cement trolleys into construction practices can be a vital intervention for enhancing worker health and safety.

The survey also highlights the trolleys' substantial contribution to enhancing worker safety on construction sites. High ratings for ensuring task safety, improving the overall safety climate, and minimizing potential hazards indicate that construction workers have a high degree of confidence in the trolleys' ability to protect them. The absence of negative feedback further solidifies the perception that these trolleys are effective safety tools, crucial for maintaining a safe working environment.

Task efficiency is another area where ergonomic cement trolleys excel, according to the survey results. Nearly unanimous high ratings for streamlining construction tasks, reducing task completion times, and ease of use suggest that these trolleys are highly effective in improving operational productivity. The user-friendly nature of the trolleys, combined with their efficiency in daily tasks, indicates that they play a significant role in enhancing overall work performance on construction sites. This efficiency is likely to lead to cost savings and increased productivity, making a strong case for their widespread adoption.

User satisfaction with the trolleys' ease of use is remarkably high, with consistently positive ratings for maneuverability, simplicity of operation, and minimal effort required. This satisfaction suggests that the ergonomic design of the trolleys not only reduces physical strain but also enhances operational efficiency by making daily tasks less cumbersome. The ergonomic features appear to contribute significantly to reducing the physical demands placed on workers, thereby potentially lowering the incidence of fatigue and discomfort.

Comfort during operation is another critical area where these trolleys receive high marks. High satisfaction ratings for physical comfort, handle design, and weight distribution highlight the ergonomic excellence of the trolleys. The data indicates that the trolleys are designed to provide maximum comfort, which is crucial for maintaining worker morale and reducing physical strain. The consistent positive feedback suggests that the ergonomic design is highly effective in ensuring user comfort, which is likely to enhance productivity and job satisfaction.

The strong user satisfaction with the reduction of physical strain, fatigue levels, and muscle discomfort further supports the conclusion that ergonomic cement trolleys are highly beneficial for construction workers. The high ratings across these metrics indicate that the trolleys significantly enhance worker comfort and reduce the physical demands of construction tasks. This improvement in working conditions is likely to lead to better health outcomes and increased efficiency on construction sites.

Implications

The findings from the survey on the effectiveness of ergonomic cement trolleys have several significant implications for the construction industry. First and foremost, the high effectiveness of these trolleys in reducing Musculoskeletal Disorders (MSDs) suggests that their widespread adoption could lead to substantial improvements in worker health and safety.

By mitigating the risks associated with MSDs, construction companies can potentially reduce the number of injury-related absences, thereby enhancing workforce stability and productivity. This reduction in MSDs also implies fewer medical expenses and compensation claims, ultimately lowering costs for employers and improving overall financial performance.

The strong consensus among respondents regarding the safety benefits of ergonomic cement trolleys highlights their critical role in creating safer construction environments. The high ratings for ensuring task safety, improving the overall safety climate, and minimizing hazards indicate that these trolleys can significantly contribute to accident prevention on construction sites. This could lead to a decrease in workplace injuries, fostering a culture of safety and reducing the liability risks for construction firms. Implementing ergonomic cement trolleys as a standard safety measure could enhance compliance with occupational health and safety regulations, further strengthening the industry's commitment to worker protection.

Task efficiency improvements noted in the survey suggest that ergonomic cement trolleys can play a pivotal role in enhancing operational productivity. The high ratings for streamlining construction tasks and reducing completion times indicate that these trolleys facilitate faster and more efficient workflows. This has direct implications for project timelines and budgets, as increased efficiency can lead to shorter project durations and reduced labor costs. The user-friendly nature of these trolleys means that workers can perform tasks with greater ease and less physical exertion, potentially leading to higher job satisfaction and lower turnover rates.

The positive feedback on the ease of use of ergonomic cement trolleys underscores the importance of ergonomic design in construction tools. High ratings for maneuverability, simplicity of operation, and minimal effort required suggest that these trolleys can significantly reduce the physical demands placed on workers. This reduction in physical strain implies that workers are less likely to experience fatigue and discomfort, which can improve their overall well-being and productivity. The implications of this are far-reaching, as it suggests that investing in ergonomically designed tools can lead to a healthier, more efficient, and more motivated workforce.

Comfort during operation, as highlighted by the survey, is another critical factor with important implications. The high satisfaction ratings for physical comfort, handle design, and weight distribution indicate that ergonomic cement trolleys can enhance user comfort significantly. This implies that workers can perform their tasks with less physical strain, leading to fewer complaints of discomfort and a lower likelihood of long-term health issues. The emphasis on comfort and ergonomic design suggests that construction companies should prioritize tools that enhance worker comfort, thereby improving overall job satisfaction and performance.

The survey results also imply that the use of ergonomic cement trolleys can lead to significant reductions in physical strain, fatigue levels, and muscle discomfort among workers. This suggests that the adoption of these trolleys can improve the physical working conditions on construction sites, potentially leading to increased productivity and reduced absenteeism due to physical ailments. The positive impact on worker comfort and health can also foster a more positive work environment, which can improve morale and enhance overall work performance.

Recommendation

Based on the survey findings, several recommendations emerge for the construction industry to optimize the health, safety, and productivity of their workforce through the use of ergonomic cement trolleys.

Firstly, construction companies should prioritize the adoption of ergonomic cement trolleys across their projects. The high effectiveness of these trolleys in reducing Musculoskeletal Disorders (MSDs) suggests that their implementation can significantly enhance worker health and safety. Companies should invest in these tools to mitigate the risks associated with MSDs, thereby reducing injury-related absences and associated medical costs. Furthermore, comprehensive training programs should be developed to ensure workers are well-versed in the proper use of these trolleys to maximize their benefits.

Secondly, integrating ergonomic cement trolleys as a standard safety measure on construction sites is essential. Given the strong consensus on their role in enhancing worker safety and minimizing hazards, these trolleys should be included in the standard operating procedures and safety protocols of construction firms. Regular safety audits should be conducted to ensure these trolleys are being used effectively and consistently, thereby fostering a culture of safety and compliance with occupational health regulations.

Thirdly, to capitalize on the efficiency improvements provided by ergonomic cement trolleys, construction firms should incorporate these tools into their project planning and workflow optimization strategies. The high ratings for task efficiency and reduced completion times indicate that these trolleys can significantly streamline operations. Project managers should evaluate their current processes and identify areas where the use of ergonomic trolleys can enhance productivity. Additionally, the user-friendly design of these trolleys should be emphasized during worker training sessions to ensure that all personnel can operate them with ease and minimal physical strain.

Moreover, construction companies should invest in ongoing ergonomic assessments to continually improve the tools and equipment used by their workers. The positive feedback on the comfort and ease of use of ergonomic cement trolleys highlights the importance of ergonomic design in construction tools. Regular feedback from workers should be collected to identify any issues or areas for improvement in the trolleys' design. Collaborating with manufacturers to refine and enhance these tools based on worker input can lead to further advancements in ergonomic solutions, thereby continuously improving working conditions.

To further support worker health and productivity, construction firms should also consider implementing broader ergonomic initiatives. This could include ergonomic training for all employees, focused on safe lifting techniques, proper posture, and the use of ergonomic tools. By fostering an ergonomically conscious work environment, companies can reduce the risk of injuries, enhance worker comfort, and improve overall job satisfaction.

Additionally, the high levels of satisfaction with the ergonomic trolleys' maneuverability and minimal effort required for use suggest that companies should ensure these tools are readily available and accessible to all workers. Adequate quantities of ergonomic trolleys should be maintained on-site to prevent bottlenecks and ensure that all workers can benefit from their use. Regular maintenance and inspections of these trolleys should be conducted to ensure they remain in optimal condition and continue to provide the intended ergonomic benefits.

Finally, construction firms should communicate the benefits of ergonomic cement trolleys to their workforce to encourage widespread use and acceptance. Highlighting the positive impact on worker health, safety, and productivity can motivate workers to adopt these tools and integrate them into their daily routines. Success stories and case studies showcasing the improvements achieved through the use of ergonomic trolleys can further reinforce their value and encourage a culture of safety and efficiency.

(Documentation)

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