

Ergonomic Hazards in the Indian Construction Industry: A Comprehensive Review of Risks, Impacts, and Interventions

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Abstract

Construction workers face global ergonomic risk. In India, these risks are exacerbated by manual labour dependence, inadequate regulatory oversight, and limited worker training and health awareness. Ergonomic issues include manual material handling, repetitive motions, improper postures, and prolonged vibration exposure, leading to musculoskeletal disorders (MSDs) that affect the health, safety, and productivity of workers. This review aims to consolidate knowledge on ergonomic hazards in India's construction sector, identify risks and their effects on workers, and evaluate interventions to mitigate these hazards. A systematic search of PubMed, Scopus, Web of Science, and Google Scholar was conducted for studies published between April 2013 and April 2023. This review includes English-language studies that provide empirical evidence or a sensitive analysis of ergonomic hazards among Indian construction workers. Quality assessment was performed using standardized tools, followed by narrative synthesis. This review found a high prevalence of ergonomic hazards, with over 70% of workers reporting MSD-related symptoms. Key hazards include manual handling of materials, repetitive movements, faulty postures, and prolonged vibration exposure. Contributing factors include socioeconomic conditions, lack of safety training, inadequate personal protective equipment, poor tool and workstation design. Various interventions such as technological solutions, ergonomic training, and organizational strategies are effective in reducing hazards. Ergonomic hazards critically impact health and safety of Indian construction workers and require systemic solutions and immediate interventions. Effective strategies include ergonomic training programmes, ergonomically designed tools, and strict safety regulations. Future research should focus on longitudinal studies and innovative interventions to improve occupational health in the construction industry.

Keywords: Construction Industry, Economic Hazards, India, Musculoskeletal Disorders, Occupational Health, Safety Interventions

Introduction

Worldwide, construction workers are exposed to a range of ergonomic hazards with different levels of risk due to their significant impact on health, safety, and job performance. In India, these hazards are synthesized by the industry's dependence on manual labour, inadequate regulatory control, and lack of worker training and health awareness (1). Ergonomic hazards such as manual material handling, repetitive motions, awkward postures, and prolonged exposure to vibrations place workers at risk for a variety of musculoskeletal disorders (MSDs), which can significantly impair their quality of life and productivity. Despite growing awareness, empirical research on the extent and specifics of these hazards in India is limited (2). A comprehensive synthesis of existing studies is necessary to fill this knowledge gap and to provide a clear path for stakeholders to develop

and implement effective interventions. Ergonomic hazards are prevalent in the construction sector of India and significantly affect a substantial portion of the workforce. Studies suggest that the majority of construction workers in India encounter at least one form of ergonomic hazard during their employment. Researchers have discovered that more than 70% of workers report symptoms associated with musculoskeletal disorders (MSDs), which are directly linked to ergonomic hazards (3). Furthermore, a survey carried out by the Indian Ministry of Labour and Employment in 2021 revealed that ergonomic hazards were prevalent across different regions, indicating the extensive scope of this issue (4). The ergonomic hazards commonly encountered in the Indian construction sector include manual material handling, repetitive movements, working in awkward postures, and prolonged exposure to

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vibration. Manual material handling, recognized as the most prevalent ergonomic hazard, involves lifting, carrying, pushing, and pulling heavy loads, often without the use of machinery. The Majority of construction workers engaged in tasks requiring manual material handling, significantly increasing their risk of lower back injuries and other MSDs. Repetitive movements and working in awkward postures, especially during tasks such as bricklaying and plastering, contribute to a high incidence of upper-extremity and back disorders (5,6). The prevalence and types of ergonomic hazards in the Indian construction industry are influenced by various factors, including socioeconomic conditions, lack of safety training, inadequate use of personal protective equipment, and poor ergonomic design of tools and workstations. Workers' socioeconomic status often forces them to accept hazardous job conditions without proper safety measures. There is a significant lack of safety training and awareness among workers and supervisors, leading to the improper handling of materials and tools. Furthermore, the absence of ergonomically designed tools and workstations exacerbates the risk of ergonomic hazards. Therefore, the following objectives and questions align with the study emphasis on the urgent need to synthesize existing research, evaluate impacts, and propose actionable solutions for addressing ergonomic hazards in India's construction industry. The primary objective of this review is to synthesize existing knowledge on ergonomic hazards in the Indian construction industry and evaluate their risks and impacts on workers' health, safety, and job performance, with a particular focus on musculoskeletal disorders (MSDs). This study aims to examine the factors contributing to the prevalence of these hazards, including socioeconomic conditions, inadequate safety training, and the absence of ergonomic tools and workstations. Additionally, it seeks to assess the effectiveness of existing policies, practices, and interventions designed to mitigate these risks. By identifying research gaps and proposing evidence-based recommendations, this review strives to provide policymakers, health and safety professionals, and industry stakeholders with practical strategies to improve working conditions and protect the well-being of construction workers in India. The guiding

questions for this review include: What are the common ergonomic hazards faced by Indian construction workers? How do these hazards impact their health, safety, and job performance? What are the key factors driving the prevalence of ergonomic hazards in this sector? How effective are the current interventions in addressing these risks? What research gaps exist in this field, and what future directions should be pursued to enhance occupational health and safety in the Indian construction industry?

Methodology

This review was conducted by searching electronic databases including PubMed, Scopus, Web of Science, and Google Scholar. The search focused on studies published from April 2013 up to April 2023, using a combination of keywords and phrases such as "construction workers," "ergonomic hazards," "India," "influences," "interventions," "occupational health," "risk," "work-related musculoskeletal disorders," and "worker well-being." Additionally, reference lists of identified articles were scrutinized to uncover further relevant studies. The selection criteria of the studies were included in this narrative review based on the following inclusion criteria: (a) quantitative, qualitative, and reviews; case studies providing empirical evidence or insightful analysis; (b) studies focusing exclusively on construction workers in India; articles published in English; and (c) full-text articles accessible through the aforementioned database. The exclusion criteria of this review were: (a) Studies not specific to the construction industry or ergonomic hazards; (b) Research focusing outside the Indian context except interventional study; (c) Editorials, commentary pieces, and unpublished thesis/dissertation (Figure 1). The data extracted from the selected studies included author(s), year of publication, study location within India, sample size, study design, types of ergonomic hazards identified, contributing factors, and interventions evaluated and key findings. This information was synthesized to create a comprehensive narrative that outlines the prevalence of ergonomic hazards, identifies contributing factors, and evaluates the effectiveness of existing interventions. The synthesis also aimed to highlight gaps in research and practice, proposing directions for future studies, and strategies to improve occupational health outcomes. To ensure

the reliability of the literature review, several strategies are employed. First, an independent screening of the identified articles was conducted by two reviewers, who assessed titles and abstracts to determine the relevance of this study. Discrepancies between the reviewers were resolved through discussion and, if necessary, consultation with a third reviewer. Next, the full texts of the articles that met the inclusion criteria were assessed for quality using standardized tools such as the Critical Appraisal Skills Programme (CASP) checklist for observational studies (CASP,

2018) or the Cochrane Risk of Bias Tool for randomized controlled trials (7). This process allowed for the identification of potential sources of bias as well as the assessment of the overall quality and rigour of the research. The data extraction process commenced upon completion of the quality assessment. This involved careful extraction of pertinent information from each study, including the study design, sample size, location, ergonomic hazards identified, contributing factors, intervention evaluated, and key findings gathered wherever available.

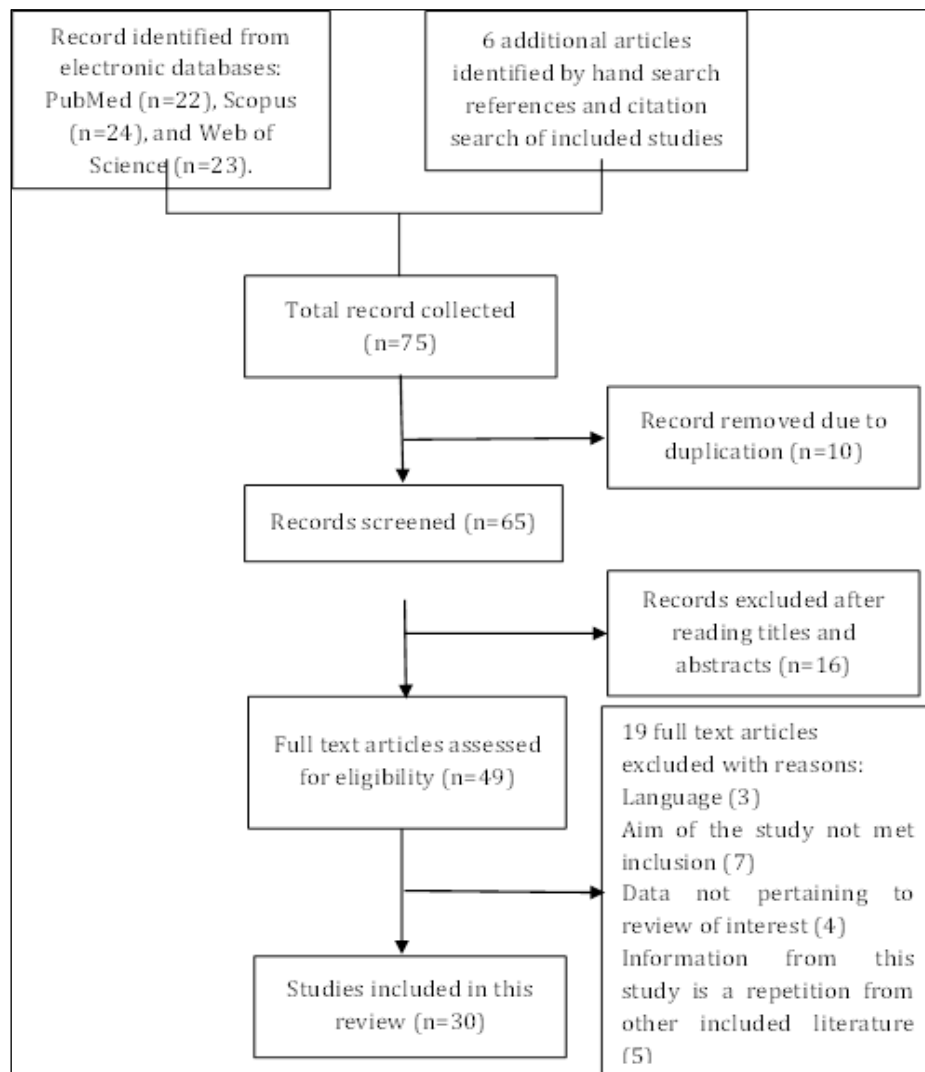


Figure 1: Article-Selection Flowchart

Following data extraction, narrative synthesis was performed to analyse the collected data. This involved the identification of common themes and patterns across the studies as well as the ergonomic Hazards, Prevalence, Influences, and Interventions among Indian construction workers. Table 1 provides a structured overview of the methodology used in conducting the

comprehensive review on ergonomic hazards among Indian construction workers. This methodology ensured a systematic and comprehensive approach to gathering, analyzing, and synthesizing relevant literature, contributing to a nuanced understanding of the topic and its implications for occupational health and safety in the construction sector.

Table 1: Methodology Overview for Narrative Review on Ergonomic Hazards among Indian Construction Workers

Methodology Parameter	Value	Justification
Database	PubMed, Scopus, Web of Science, and Google Scholar	These databases were chosen for their comprehensive coverage of scholarly articles in the fields of medicine, engineering, and social sciences, relevant to the study.
Search Terms Used	"Ergonomic hazards," "construction workers," "India," "occupational health," "work-related musculoskeletal disorders," "prevalence," "influences," "interventions," and "worker well-being."	These search terms were selected to capture a wide range of relevant literature on ergonomic hazards among Indian construction workers.
Time Frame	April 2013 to April 2023	The chosen time frame ensures inclusion of recent studies while also covering a substantial period to capture significant developments in the field.
Inclusion Criteria	(a) quantitative, qualitative, and reviews; case studies providing empirical evidence or insightful analysis; (b) studies focusing exclusively on construction workers in India; articles published in English; and (c) full-text articles accessible through the aforementioned database.	These criteria were established to ensure the inclusion of high-quality studies relevant to the research topic.
Exclusion Criteria	(a) Studies not specific to the construction industry or ergonomic hazards; (b) Research focusing outside the Indian context; (c) Editorials, commentary pieces, and unpublished thesis/dissertation	These criteria were set to maintain the focus of the review on Indian construction workers and relevant ergonomic hazards.
Selection Process	Study location within India, sample size, study design, types of ergonomic hazards identified, contributing factors, and interventions evaluated and key findings.	This process was followed to systematically evaluate and synthesize the selected studies for inclusion in the narrative review.

Results

The results of the literature review were interpreted and discussed in the context of the existing body of knowledge on Ergonomic Hazards among Indian Construction Workers. In this literature review, the results discuss the types of ergonomic hazards identified, contributing factors, and interventions evaluated, and the key findings are discussed. Table 2 provides a summary of the ergonomic risks recognized within India's construction sector, alongside the associated research deficiencies. The table delineates the prevalent hazards confronting Indian construction labourers, such as incorrect posture, discomfort in muscles and joints, occupational stress, lower back ache (LBA),

shoulder discomfort, wrist and elbow discomfort, neck strain, repetitive movements, awkward stances, and extended exposure to vibrations. Furthermore, Table 2 illuminates the existing gaps in research concerning the comprehension and management of these ergonomic complexities. These research voids encompass issues like insufficient training, inadequate provision of safety equipment, flawed workplace layout, stress-related aspects, communication discrepancies, administrative challenges, environmental threats, and risks associated with machinery usage (Figure 2). Through the identification of these ergonomic hazards and research gaps, the table emerges as a beneficial reference for researchers, policymakers, and

stakeholders within the construction industry. Addressing these gaps through focused research and targeted interventions has the potential to substantially enhance occupational health and

safety standards for Indian construction workers, consequently bolstering their well-being and efficiency.

Table 2: Ergonomic Hazards and Research Gaps in the Indian Construction Industry

Ergonomic Hazard	Research Gap
Manual Material Handling	Lack of longitudinal studies to assess the long-term impact of manual material handling on musculoskeletal health.
Repetitive Motions	Limited research on innovative interventions to reduce repetitive motions and associated musculoskeletal disorders.
Awkward Postures	Insufficient data on the prevalence and impact of awkward postures, especially in specific construction tasks.
Prolonged Exposure to Vibrations	Lack of studies examining the cumulative effects of prolonged vibration exposure on worker health.
Lack of Safety Training and Awareness	Research gap in evaluating the effectiveness of safety training programs in mitigating ergonomic hazards.
Socioeconomic Influences	Limited understanding of how socioeconomic factors influence the adoption of ergonomic practices in construction.
Inadequate Use of Personal Protective Equipment (PPE)	Research gap in assessing the barriers to the consistent use of PPE and its role in preventing ergonomic injuries.
Poor Ergonomic Design of Tools and Workstations	Lack of studies evaluating the impact of ergonomic tool and workstation design on reducing musculoskeletal disorders.

Table 3 reveals a wide range of ergonomic hazards identified across various studies, highlighting poor posture; musculoskeletal disorders (MSDs) including lower back pain (LBP); shoulder, wrist, and elbow pain; and occupational stress as prevalent issues among construction workers. These conditions are prevalent across different types of construction

work, from marble and granite processing to surface mine work, indicating sector-wide issues. Key findings suggest a significant need for ergonomic interventions, with recommendations pointing towards comprehensive ergonomic programs that incorporate engineering, administrative, and work practice controls to enhance worker safety and prevent injuries.

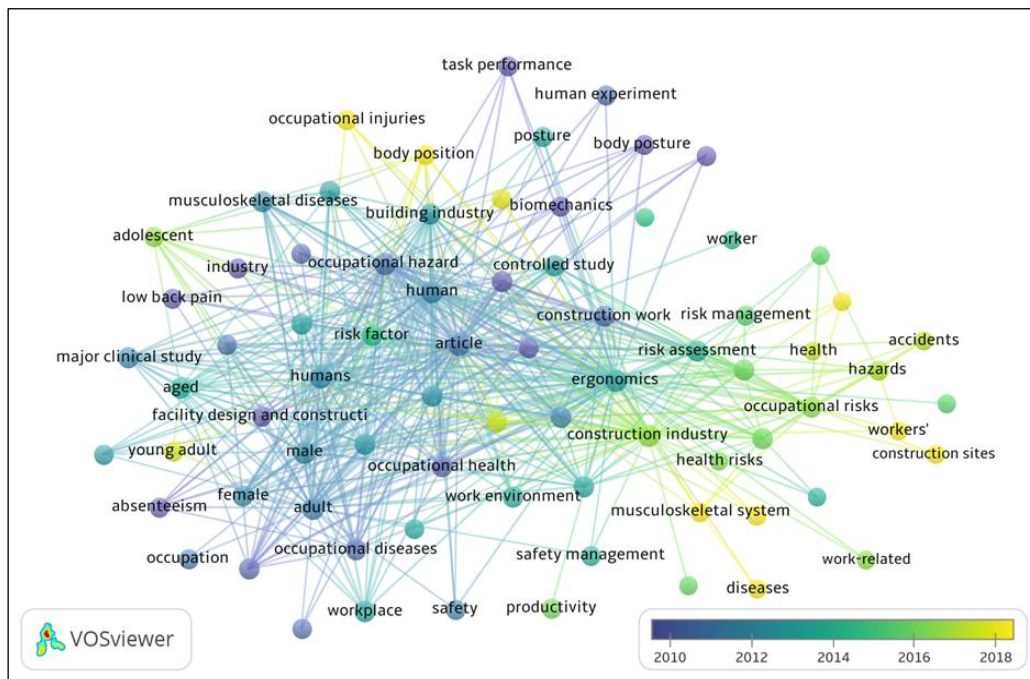


Figure 2: Overlay Visualization of Bibliometric Analysis

Table 3: Types of Ergonomic Hazards Identified in the Indian Construction Industry

Author	Location	Study Design	Sample Size	Types of Construction work	Ergonomic Hazard Identified	Key Findings
Revansiddappa <i>et al.</i> , (8)	India	Review	50.	Marble and granite	Poor Posture	Recommended for ergonomic intervention to prevent ergonomic hazards
Chakraborty <i>et al.</i> , (9)	India	Cross sectional	268	Construction with sub occupational group	LBA, Shoulder and wrist pain, Occupational stress	Workers with higher occupational stress and MSDs reported lower quality of life due to poor working conditions
Gopireddy <i>et al.</i> , (10)	Chennai	Cross-sectional community-based study	300	Construction with sub occupational group	LBA, Shoulder, wrist and elbow, neck pain	The risk of developing ergonomic hazard was higher for laborers and those who have been working for more than 11 years.
Mohan (11)	India	Review	-	Construction with sub occupational group	Muscle joint pain	This study suggests a comprehensive ergonomics program that includes engineering, administrative, and work practice controls to prevent injuries and enhance worker safety
Ratri <i>et al.</i> , (12)	India	Survey	-	Construction with sub occupational group	LBA, Shoulder, wrist and elbow, neck pain	The study found that mason helpers face the highest risk of musculoskeletal injuries due to their work, and masons and carpenters are also significantly affected by manual material handling tasks.

Jeripotula <i>et al.</i> , (13)	India	Epidemiological	500	Surface mine worker	LBA, Shoulder, wrist and elbow, neck pain	This study found that 44.23% of surface mine workers in India reported injuries related to their muscles and bones, especially in the lower back, over a year
Gangopadhyay <i>et al.</i> , (14)	India	Case series	-	Carpenter	Muscle joint pain	The proper implementation of ergonomic interventions can ultimately prevent ergonomic hazards and improve the economy of the nation.
Thayyil <i>et al.</i> , (15)	Kozhikode	Cross sectional	410	Construction workers	Joint pain	The study found that construction workers in India face higher risks of ergonomic hazards and health issues, such as tuberculosis, malaria, jaundice, and typhoid, compared to the general population.
Anagha <i>et al.</i> , (16)	Ernakulam	Review	-	Construction workers	Musculoskeletal disorders	Construction workers often get hurt or feel pain because they perform the same movements repeatedly, work in faulty positions, or use too much force.
Chellappa <i>et al.</i> , (17)	India	Systematic review	-	Construction workers	Musculoskeletal disorders	The research mainly focused on safety management, safety climate, and safety performance, highlighting the need for better safety practices in

							Indian construction
Pratik Jasani (18)	K. Surendra Nagar	cross-sectional	312	Construction workers	Musculoskeletal disorders	Most construction workers in Surendranagar city, Gujarat, India, do not have enough knowledge about work-related hazards and how to prevent them	
Chatterjee <i>et al.</i> , (19)	West Bengal	cross-sectional	164	Construction labourers	Musculoskeletal problem	The study suggests that ergonomic interventions, like better work-rest schedules and equipment design, could help reduce the workers' stress and improve their quality of life	
Gourab <i>et al.</i> , (20)	West Bengal	Review	-	Construction workers	Musculoskeletal disorders	Musculoskeletal disorders, such as back pain and shoulder strain, are common due to poor working postures and manual handling	

Table 4 describes several factors that contribute to ergonomic hazards, including improper training, lack of safety gear, faulty posture, stress, communication gaps, and administrative and environmental issues. These factors focus on systemic problems within the industry, such as a lack of safety culture, inadequate protective

measures, and poor workplace design, all of which increase the risk of ergonomic injuries. The findings highlight the importance of addressing these key factors through improved safety management practices, ergonomic training, and the adoption of appropriate safety gear.

Table 4: Contributing Factors to Ergonomic Hazards in the Indian Construction Industry

Authors	Contributing Factors	Description of Factors
Sasmita <i>et al.</i> , (21)	Improper training, safety gear, Faulty posture, Stress, Communication gap	A lack of proper training and information on safety measures can result in workplace accidents. Many workers fail to use protective gear, such as helmets and gloves, which increases their risk of injury. In addition, working in a faulty posture can cause injuries. Long hours and inadequate time with the family can leave workers feeling stressed or fatigued, negatively impacting their safety at work. Poor communication between workers and

Ishwarya <i>et al.</i> , (22)	Administrative, Environmental, Health related, Miscellaneous	management can exacerbate workplace hazards. The number of breaks, overtime, stress from deadlines, labourers doing the same job, and unhealthy habits contribute to stress. Environmental risks include site lighting, air quality, temperature, and noise level. The health-related factors included age, sex, disease, and vital signs. Machinery risks include tool type, machinery size, protective measures, and skills/experience.
Subbiah <i>et al.</i> , (23)	Personal Protective Equipment, Unsafe gangways for loading and unloading, Workers' negligence	PPE usage is lacking, leading to unsafe construction site conditions. Unsafe loading and unloading systems, inadequate bar bending sheds, workers' negligence in checking electrical wires, and owners' or builders' failure to inspect drilling equipment all contribute to the risk.
Mohana <i>et al.</i> , (24)	Faulty posture, Inadequate workplace design, Management support is crucial, Communication issues	Occupational accidents and injuries can arise from various risks, such as improper posture, repetitive motions, exposure to extreme temperatures, contact stress, and inadequate workplace design. These factors can lead to issues like back pain, prolonged static postures, and handling heavy materials. Furthermore, communication problems within organizations can exacerbate ergonomic problems, emphasizing the need for better management control, ergonomic design, and training.
Shabin <i>et al.</i> , (25)	Faulty postures, Repeated motion, over exposure to vibration, Static loading, working in extreme temperature	Construction workers are prone to musculoskeletal strain due to faulty posture, repetitive motions, and exposure to vibrations and extreme temperatures.
Vigneshkumar <i>et al.</i> , (26)	Identification of ergonomic hazards, Poor accident reporting methods	Identifying hazards and steps is challenging due to users' difficulty in accuracy, increased by India's poor safety culture, inadequate reporting methods, and lack of safety regulation enforcement.

Table 5 shows case studies of various interventions aimed at mitigating ergonomic hazards, ranging from technological solutions such as smartphone-based posture monitoring and wearable sensors to organizational strategies such as enhanced communication and management control. The effectiveness of these interventions varies, with technologies such as

wearable sensors and ergonomic tools being highly effective in reducing MSDs and improving worker safety. However, the key findings also emphasize the importance of comprehensive approaches that combine technology with organizational and training interventions to effectively address the multifaceted nature of ergonomic hazards

Table 5: Studies on Ergonomic Hazard Prevention and Management in the Construction Industry

Authors	Study design	Sample Size	Focus Intervention	Key findings
Nath <i>et al.</i> , (27)	Experimental	Not specify	This study focuses on using smartphones to monitor the body postures of construction workers	This study found that smartphones can be used to measure how much of construction workers

			construction workers to find out if they are at risk of injury from their work positions.	bend their bodies, which can help spot risky work postures.
Rahman <i>et al.</i> , (28)	Review	-	This review focuses on how new technologies can help make construction work safer by reducing the risk of injuries related to the way people work, like muscle and joint injury.	Researchers found that new tools like wearable sensors, virtual reality, and robots can help keep construction workers safe by spotting dangers and reducing hard physical work.
Abdul-Tharim <i>et al.</i> , (29)	Review	-	Key interventions include better communication and management control, appropriate ergonomic design, and organization training and education.	This research found that good communication and management are important to make sure workers are safe and comfortable at work
Sousa <i>et al.</i> , (30)	Review	-	It reviews research on understanding, analyzing, and modeling construction accidents, as well as managing occupational safety and health risks.	The research suggests that planning safety measures early, during the design stage of a project, can prevent many accidents
Uddin <i>et al.</i> , (31)	Descriptive	287	The main focus of the intervention in this study is to understand how well construction workers can spot different safety risks, like things that could fall or cause burns, and to find ways to help them get better at noticing these dangers.	On average, workers recognized about 47% of the safety risks from falling, electrical shocks, moving objects, and heat, but less than 10% of the risks from pressure, chemicals, and radiation.
Yan <i>et al.</i> , (32)	Experimental	5	The study used a personalized mobile health (mHealth) system with Wearable Inertial Measurement Units (WIMUs) to track the workers' trunk posture and provide alerts for excessive bending.	The study found that using a health system with sensors to track and give feedback on workers' bending postures can help prevent back problems.

Yan <i>et al.</i> , (33)	Experimental	6	They trained a computer to recognize bad postures by looking at the shapes and movements of the workers' bodies with the help of camera.	The study suggests that this camera system could help keep workers safe by pointing out when they're in a posture that could lead to injury.
van Heerden <i>et al.</i> , (34)	Survey	100	This study examines why companies in South Africa that build things want to use health and safety rules.	The study found that the biggest reasons for construction companies to focus on health and safety are to handle dangers, follow safety laws, and because they think keeping workers safe is very important
Choi (35)	Survey	58 construction company	It focused on evaluating the use of trade-specific hand tools, body positions during work, and manual material handling activities that contribute to ergonomic risks.	Most construction companies care about worker safety and have safety programs, but few have specific programs for ergonomic safety.
Smallwood <i>et al.</i> , (36)	Interview	84	Workers were asked specific questions about how they use their bodies at work, where they feel pain, and when this pain happens	Workers reported that their lower and upper back hurt the most frequently. The main ergonomic problems identified were climbing and descending, and handling heavy materials
Kamar <i>et al.</i> , (37)	Descriptive	Not specify	This study focused to create a new way to understand and manage the costs of keeping workers safe and healthy on construction sites from the beginning to the end of a project	The study found that current models for figuring out safety costs in construction are based on manufacturing and don't work well for construction, so they need to be better.

Discussion

A comprehensive review of ergonomic hazards in the Indian construction industry presents a critical examination of existing risks, impacts, and interventions essential for mitigating these hazards. The synthesis of findings from the literature underscores the significant prevalence of ergonomic hazards and their strong effects on workers' health, safety, and job performance. This discussion explores the implications of these findings, evaluates the review methods, compares them with other studies, acknowledges the limitations, and offers recommendations for future research and practice. Globally, advanced economies often adopt stringent ergonomic standards, prioritize worker training, and utilize advanced tools and machinery to minimize ergonomic risks. In contrast, the Indian construction industry heavily relies on manual labor, with limited access to ergonomically designed tools and technologies. While global best practices emphasize proactive ergonomic assessments, India faces challenges such as inadequate regulatory enforcement, lack of worker training, and minimal awareness about ergonomics among both workers and employers. However, there are areas where India aligns with global practices, such as recognizing musculoskeletal disorders (MSDs) as a significant occupational health concern and the growing acknowledgment of the need for ergonomic interventions. By comparing India's practices to global standards, this review can identify actionable lessons and propose tailored strategies to bridge the gap, ensuring that India's workforce benefits from the advancements seen in more developed construction industries. This comparative perspective enhances the relevance of findings and supports the development of context-specific interventions to improve workplace safety and productivity. India's construction industry faces significant ergonomic challenges despite the existence of policies like the Factories Act (1948), the BOCW Act (1996), and the National Policy on Safety, Health, and Environment (2009). These frameworks provide general safety guidelines but lack specific ergonomic standards, leading to persistent hazards such as manual material handling and awkward postures. Weak enforcement, limited awareness, inadequate monitoring, and

fragmented coverage, particularly for informal workers, exacerbate these risks. Unlike global best practices that emphasize proactive measures and ergonomic assessments, Indian policies remain reactive and poorly implemented. To address these gaps, there is a need for stronger enforcement, detailed ergonomic guidelines, worker-focused training programs, and the inclusion of informal workers in safety measures. By integrating these improvements, India can enhance workplace safety and reduce the prevalence of musculoskeletal disorders (MSDs) in the construction sector. Despite awareness of these hazards, the implementation of ergonomic practices in Indian construction remains inadequate. Many companies struggle to invest in ergonomic equipment and design due to cost concerns and a lack of understanding of their long-term benefits. Additionally, the informal nature of the construction sector and prevalence of subcontracting make it challenging to implement consistent ergonomic standards across all worksites. Addressing these limitations requires concerted efforts from government agencies, industry stakeholders, and construction companies to prioritize worker well-being and embed ergonomic considerations into the core of the construction processes (5). The identified ergonomic hazards, including manual material handling, repetitive motions, faulty postures, and prolonged exposure to vibrations, highlight the urgent need for targeted intervention. These hazards are not isolated incidents but common across the sector, affecting a vast majority of the workforce and leading to a range of musculoskeletal disorders (MSDs). The correlation between ergonomic hazards and high incidence of MSDs suggests that addressing these hazards can significantly enhance the quality of life and productivity of construction workers (9). To enhance the applicability of the proposed interventions, we have included examples of successful case studies and interventions in similar settings. For example, an Indian study on ergonomic interventions in marble and granite industries emphasized the importance of systematic ergonomic risk assessments using tools such as REBA and RULA to address work-related musculoskeletal disorders (WRMSDs) (8). This method can be adapted to the construction sector, which faces similar ergonomic challenges.

Moreover, designing and evaluating ergonomic interventions in informal sectors have demonstrated that low-cost solutions can effectively reduce WRMSDs and boost productivity, suggesting potential benefits for construction workers (14). Additionally, a case study of construction workers in Pune highlighted the poor conditions faced by labourers, underscoring the need for tailored ergonomic interventions to improve their quality of life (38). Integrating these insights provides more effective recommendations for ergonomic interventions in the Indian construction workforce. Moreover, the factors contributing to these hazards, such as inadequate training, lack of safety gear, and poor workplace design, pinpoint systemic issues within the construction industry. These findings call for a holistic approach to occupational health and safety that goes beyond immediate interventions to address the underlying socioeconomic and organizational factors contributing to the risk of ergonomic hazards (22). One potential solution is to develop comprehensive training programs for construction workers that educate them on proper ergonomics and safe work practices. A multifaceted approach is essential to mitigate ergonomic hazards in the Indian construction industry. This includes comprehensive training programs for workers on proper lifting techniques, use of ergonomic tools, and identification of early signs of musculoskeletal issues. Collaboration with regulatory bodies to establish ergonomic standards can significantly improve workplace safety and reduce the incidence of work-related injuries (9). By integrating ergonomic principles into every aspect of the construction process from material handling to equipment design, the industry can create a safer and more sustainable work environment for all workers involved. It is crucial for stakeholders to recognize the long-term benefits of ergonomic interventions in terms of worker health, productivity, and overall cost savings from reduced injury rates. The methodology employed in this review, involving a systematic search across multiple databases and rigorous selection criteria, ensured a comprehensive synthesis of existing literature on the subject. The use of standardized tools for quality assessment and the narrative synthesis approach facilitated robust analysis of the data.

However, dependence on published studies in English may have excluded relevant research conducted in other languages or unpublished studies, potentially limiting the scope of this review. Comparatively, the prevalence and types of ergonomic hazards identified in this review align with the findings from other regions, highlighting the global nature of these issues in the construction industry. For instance, studies conducted in countries such as the United States and China have also reported high rates of MSDs among construction workers, which are attributed to similar ergonomic hazards. This consistency across different contexts underscores the universal challenges faced by construction workers and the need for global efforts to improve the occupational health and safety standards. This review highlights significant ergonomic hazards in the Indian construction industry but has limitations that must be addressed. The exclusive focus on Indian studies limits the generalizability of findings to other contexts, while reliance on English-language publications and potential publication bias may exclude relevant research and underreport less prominent findings. Additionally, the varied quality and methodologies of included studies could affect the reliability of synthesized evidence. Future research should prioritize longitudinal studies on the long-term impacts of ergonomic hazards and the sustained efficacy of interventions, along with interventional studies exploring innovative technologies and strategies. Expanding research to include informal workers, small-scale sites, and regional language studies would provide a more comprehensive understanding of ergonomic risks. Cross-country comparisons can identify transferable global practices, while qualitative methods like worker interviews could offer deeper insights. Practical recommendations include engaging stakeholders in designing and implementing ergonomic interventions, strengthening academia-industry-government collaboration, and developing robust safety guidelines and monitoring systems to enhance workplace safety and productivity.

Conclusion

This study revealed a significant prevalence of ergonomic hazards in the Indian construction industry, underscoring the systemic issues within the sector. Despite known risks, the adoption of

comprehensive ergonomic practices is constrained by cost concerns, the sector's informal nature, and subcontracting practices. This review emphasizes the necessity of a multi-pronged approach, including worker education, implementation of ergonomic standards, and integration of ergonomic principles throughout construction processes, to effectively mitigate these hazards. The collaboration of the government, industry stakeholders, and construction companies is important in prioritizing worker safety and realizing the long-term benefits of ergonomic interventions. This joint effort can significantly enhance occupational health and safety standards, ensuring a safer work environment for construction workers.

Abbreviations

CASP: Critical Appraisal Skills Programme, LBA: Lower Back Ache, MSD: Musculoskeletal Disorders, PPE: Personal Protective Equipment.

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Conflicts of Interest

The authors declare no conflicts of interest.

Ethical Approval

The study was conducted after obtaining ethical clearance from the Institutional Ethical Committee of Integral University, Lucknow, India

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