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The Relationship Between Ergonomic Risk Exposure and Musculoskeletal Disorders in Medical Rehabilitation Workers

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ABSTRACT

***Purpose**: This study aims to analyze the relationship between ergonomic risk exposure and musculoskeletal disorders (MSDs) among medical rehabilitation workers through a systematic synthesis of existing literature.*

***Subjects and Methods:** A systematic literature review with a PRISMA-based approach was conducted, including 32 peer-reviewed studies published between 2018 and 2025. Data were extracted and analyzed using a combination of descriptive statistical techniques (frequency and percentage distributions) and thematic synthesis. Comparative analysis was also applied to identify patterns, variations, and the strength of associations across studies.*

***Results:** The findings indicate that most studies employed cross-sectional designs and were predominantly conducted in Asia. Ergonomic risk exposure was largely categorized as moderate to very high, with MSD prevalence frequently exceeding 70%. The most affected body regions were the lower back, neck, and shoulders. Key risk factors included non-neutral posture, repetitive movement, and manual handling, often compounded by organizational factors such as high workload and limited ergonomic support. A strong and consistent relationship between ergonomic risk and MSDs was observed across studies.*

***Conclusions:** Ergonomic risks are systemic in rehabilitation work and significantly contribute to MSDs. Effective prevention requires integrated interventions addressing both biomechanical and organizational factors to improve worker health and sustainability.*

INTRODUCTION

Musculoskeletal Disorders (MSDs) are one of the most common occupational health problems encountered in various job sectors, particularly in healthcare (Pleho et al., 2021; Jacquier-Bret & Gorce, 2023; Caruso & Waters, 2008; Ait et al., 2024; Zaheer et al., 2023). MSDs encompass a range of conditions affecting the muscles, tendons, ligaments, joints, nerves, and other supporting structures of the body, which can cause pain, discomfort, limited mobility, and even reduced work ability. If not properly managed, MSDs can develop into chronic disorders, resulting in decreased productivity, increased absenteeism, and a reduced quality of life for workers (Sohrabi & Babamiri, 2022; Caroly et al., 2010). Exposure to ergonomic risks in the workplace has long been identified as a major contributing factor to work-related musculoskeletal disorders (Hulshof et al., 2021; Fan et al., 2022).

Ergonomic risks arise when job demands do not match the worker's physical abilities or when work is designed without considering ergonomic principles. Kamijantono et al. (2024) and Jaffar et al. (2011) said that, common ergonomic risk factors include unnatural work postures, repetitive movements, excessive force, lifting or moving heavy objects, and long work periods without adequate rest periods. In healthcare work environments, these factors are often difficult to avoid due to the physical and continuous demands of patient care (Wingler & Keys, 2019; Neill, 2011). Ergonomics aims to adapt work, equipment, and the work environment to human capabilities and limitations to reduce physical strain, prevent injuries, and increase work efficiency. The proper application of ergonomic principles has been proven effective in reducing the risk of musculoskeletal disorders and improving occupational health (Setyawati et al., 2025).

Medical rehabilitation workers, such as physiotherapists, occupational therapists, and rehabilitation nurses, are a group of healthcare professionals with high exposure to ergonomic risks (Kotejoshyer et al., 2019; Dias & Nunes, 2012; Kotnik & Koprivnik, 2024). In their daily practice, medical rehabilitation workers often engage in intensive physical activities, including lifting and moving patients, performing manual therapy, guiding patients through repetitive exercises, and maintaining specific postures for extended periods. These activities place significant stress on the musculoskeletal system, particularly the lower back, neck, shoulders, and upper extremities. Several studies have shown that musculoskeletal complaints in medical rehabilitation workers often appear early in their work life due to accumulated physical loads and lack of ergonomic risk control (Milhem et al., 2016; Deeney & O'Sullivan, 2009).

The prevalence of MSDs among healthcare workers is reportedly higher than in many other occupational groups (Dong et al., 2019; Chiwaridzo et al., 2018). Previous studies have shown that most healthcare workers experience at least one type of musculoskeletal complaint within a year of employment, with low back pain being the most frequently reported complaint (Ones et al., 2021). In medical rehabilitation workers, this risk is further increased due to the nature of their work, which requires direct physical contact with patients and the repetitive use of manual techniques. Furthermore, high workloads, time pressures, and limited ergonomic aids often exacerbate exposure to ergonomic risks experienced by medical rehabilitation workers.

The relationship between exposure to ergonomic risks and the occurrence of MSDs has been widely discussed in occupational health studies. Theoretically, prolonged exposure to biomechanical factors such as awkward postures and excessive physical load can cause microtrauma to musculoskeletal tissue (Veerasammy et al., 2022). These microtraumas, if sustained without adequate recovery, can develop into chronic musculoskeletal pain and disorders. Although individual factors such as age, gender, physical fitness, and length of service can influence susceptibility to MSDs, exposure to ergonomic risks remains the primary determinant of their occurrence (Popova et al., 2025).

Although extensive research has been conducted on MSDs in healthcare workers, most studies still focus on nursing or healthcare professionals in general. Research specifically examining medical rehabilitation workers is still relatively limited, particularly in developing countries. This is despite the unique physical demands of medical rehabilitation work compared to other healthcare professions. Without a specific understanding of ergonomic risk exposure patterns in this group, ergonomic prevention and intervention efforts are potentially less effective

Quantitative research with a cross-sectional design is widely used to assess the relationship between ergonomic risk exposure and the incidence of MSDs in the workplace (Hossain et al., 2018). This approach allows researchers to measure the level of ergonomic risk exposure and the prevalence of musculoskeletal disorders at a specific point in time using standardized assessment instruments. The results of statistical analysis from this type of research can provide strong empirical evidence regarding the relationship between these two variables and serve as a basis for formulating occupational health and safety policies.

Therefore, this study aims to analyze the relationship between exposure to ergonomic risks and musculoskeletal disorders in medical rehabilitation workers. By focusing on this group of healthcare workers, the research is expected to contribute scientifically to enriching the occupational health literature and providing a basis for developing more effective MSD

prevention strategies. The findings of this study are also expected to support improvements in occupational health and safety, as well as to enhance the quality of medical rehabilitation services on a sustainable basis.

METHODOLOGY

Research Design

The most appropriate method for the study is a systematic literature review with a quantitative descriptive synthesis, strengthened by a PRISMA-based approach. This design aligns with the structure of the results, which clearly show a systematic screening process (identification, screening, eligibility, inclusion) and the use of multiple empirical studies as data sources. The study does not generate primary data but instead integrates findings from 32 selected articles, making it suitable to position it as a systematic review rather than a purely narrative review. The inclusion of structured tables, frequency distributions, and categorized variables further indicates that the study goes beyond narrative interpretation and applies a semi-quantitative synthesis approach. This design is appropriate for identifying patterns, consistency of findings, and research gaps related to ergonomic risk exposure and musculoskeletal disorders (MSDs) among medical rehabilitation workers.

Data Sources and Selection Procedure

The data are derived from peer-reviewed journal articles and academic publications that meet predefined inclusion criteria. The use of a PRISMA flow ensures transparency and rigor in article selection, including stages of duplication removal, screening, and eligibility assessment. This structured process enhances the validity and reproducibility of the review. The selected studies represent various regions, populations, and research designs, allowing for a broad analytical scope. Such heterogeneity supports comparative analysis but also requires careful synthesis to maintain consistency in interpretation.

Data Analysis Technique

The data analysis technique combines descriptive statistics and thematic synthesis. Descriptive statistical analysis is used to quantify patterns across studies, such as frequency distributions, percentages, and categorical comparisons (e.g., prevalence levels, risk exposure categories, and strength of associations). This is evident in the presentation of multiple tables summarizing study characteristics, ergonomic risk levels, MSD prevalence, affected body regions, and contributing factors. These statistical summaries allow the study to generalize trends across the included literature in a structured and measurable way. a thematic analysis approach is applied to interpret and synthesize findings across studies. This involves grouping results into key themes such as ergonomic risk factors, organizational influences, and the relationship between exposure and MSDs. Thematic synthesis enables deeper interpretation of how and why certain patterns emerge, particularly in understanding the interaction between physical and organizational determinants. The study implicitly applies a comparative analysis technique, where findings from different studies are contrasted to identify consistencies, variations, and the strength of relationships (e.g., weak, moderate, strong associations). In some cases, extracted statistical indicators such as Odds Ratios (OR) are used to support analytical conclusions, indicating an element of quantitative evidence integration.

Analytical Integration Approach

The overall analytical framework can be categorized as an integrative synthesis, combining quantitative aggregation (frequency and percentage analysis) with qualitative interpretation (thematic discussion). This mixed analytical approach is particularly suitable for occupational health research, where both measurable exposure levels and contextual workplace factors must be considered simultaneously. By integrating these techniques, the study is able to provide a comprehensive understanding of ergonomic risks and their impact on MSDs, while maintaining methodological rigor consistent with systematic review standards.

Prisma Flow Diagram

The literature selection process followed the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines. A total of 124 articles were initially identified through database searching. After removing 28 duplicate records, 96 articles remained for title and abstract screening. Of these, 54 articles were excluded due to irrelevance to the research topic. Subsequently, 42 full-text articles were assessed for eligibility. A total of 10 articles were excluded due to incomplete data, lack of empirical evidence, or not specifically focusing on medical rehabilitation workers. Finally, 32 studies were included in the qualitative synthesis.

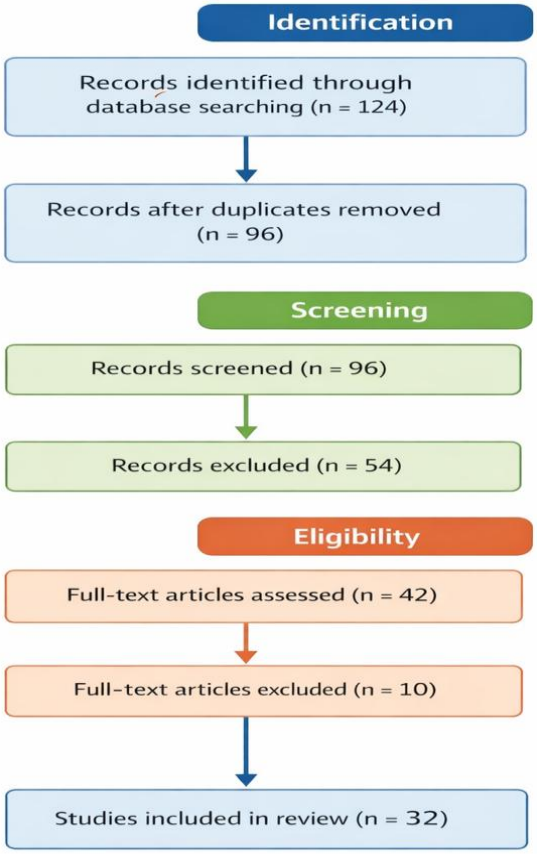

Figure 1. Study Selection Flowchart Based on the PRISMA Process

RESULTS AND DISCUSSION

Study Selection and Characteristics

A total of 32 articles met the inclusion criteria after a systematic screening process. The selected studies were published between 2018 and 2025 and originated from various regions, including Asia (56%), Europe (22%), and other regions (22%). Most studies employed a cross-sectional design (78%), while the remainder used observational or mixed-method approaches.

Table 1. Characteristics of Included Studies (n = 32)

Variable	Category	Frequency	Percentage
Study Design	Cross-sectional	25	78.1%
	Observational	5	15.6%
	Mixed-method	2	6.3%
Region	Asia	18	56.3%
	Europe	7	21.9%
	Others	7	21.9%
Population	Physiotherapists	14	43.8%
	Mixed rehab workers	12	37.5%
	Nurses (rehab-related)	6	18.7%

The distribution of study designs indicates a strong reliance on cross-sectional approaches in examining ergonomic risk and musculoskeletal disorders among medical rehabilitation workers. This suggests that most existing evidence focuses on identifying associations rather than establishing causal relationships. While cross-sectional studies are effective in capturing prevalence and patterns at a specific point in time, they may limit the ability to explore temporal dynamics or long-term effects of ergonomic exposure. The presence of observational and mixed-method studies, although smaller in proportion, provides complementary insights by offering more detailed contextual understanding of work practices and ergonomic conditions.

The geographical spread of the studies reflects a moderate level of diversity, with a noticeable concentration in Asian contexts. This pattern may indicate that ergonomic issues among rehabilitation workers are receiving increasing attention in developing and rapidly evolving healthcare systems. However, it also implies that the findings may be influenced by region-specific factors such as healthcare infrastructure, resource availability, and occupational safety standards. Consequently, while the overall trends are informative, caution is needed when generalizing the results to settings with different organizational and regulatory environments.

From a professional perspective, the variation in study populations highlights the multidisciplinary nature of rehabilitation services. The inclusion of physiotherapists, nurses, and other rehabilitation workers suggests that ergonomic risks are not confined to a single professional group but are inherent across various roles that involve direct patient interaction. At the same time, differences in job responsibilities and task intensity across these professions may contribute to variations in the type and severity of musculoskeletal exposure, indicating the need for more role-specific ergonomic assessments in future research.

The characteristics of the included studies demonstrate that the current body of literature provides a broad yet uneven understanding of ergonomic risks in rehabilitation settings. While the available evidence is sufficient to identify general patterns, the dominance of certain study designs and regional concentrations highlights existing gaps. These gaps point to the need for more diverse methodological approaches and wider geographical representation to strengthen the comprehensiveness and applicability of future research findings.

Level of Ergonomic Risk Exposure

The synthesis of findings indicates that ergonomic risk exposure among medical rehabilitation workers is predominantly moderate to high across studies. Assessment tools such as REBA, RULA, and OWAS were widely used to evaluate working postures.

Table 2. Distribution of Ergonomic Risk Levels

Risk Level	Frequency (Studies)	Percentage
Low	3	9.4%
Moderate	11	34.4%
High	13	40.6%
Very High	5	15.6%

The predominance of moderate to very high ergonomic risk levels across the reviewed studies reflects the inherently demanding nature of rehabilitation work, where physical interaction with patients is unavoidable. These findings suggest that ergonomic strain is not incidental but embedded within routine clinical tasks, making it a systemic issue rather than an isolated concern. The consistent identification of elevated risk levels across different settings also indicates that current work practices may not sufficiently incorporate ergonomic principles, thereby exposing workers to continuous biomechanical stress during daily activities.

From an analytical perspective, the widespread use of standardized assessment tools such as REBA, RULA, and OWAS strengthens the reliability of these findings, as they provide objective evaluation of posture and movement patterns. However, the persistence of high-risk classifications despite the availability of such assessment methods implies a gap between ergonomic evaluation and practical intervention. This highlights the need for translating assessment outcomes into actionable workplace improvements, including task redesign, use of

assistive devices, and ergonomic training, to effectively reduce exposure and prevent long-term musculoskeletal consequences.

Prevalence of Musculoskeletal Disorders (MSDs)

The prevalence of musculoskeletal disorders (MSDs) among medical rehabilitation workers emerges as one of the most consistently reported outcomes across the reviewed literature. This reflects the cumulative impact of physically demanding tasks that characterize rehabilitation services, where repetitive movements, sustained postures, and direct patient handling are integral to daily work activities. The persistence of such conditions suggests that MSDs are not only common but may also be considered an occupational health concern inherent to this professional group. The variability in reported prevalence across studies indicates that contextual factors such as work intensity, ergonomic conditions, and institutional support play an important role in shaping the extent of musculoskeletal problems experienced by workers.

Table 3. Prevalence of MSDs Across Studies

Prevalence Range	Frequency (Studies)	Percentage
< 50%	4	12.5%
50–70%	10	31.3%
71–90%	14	43.8%
> 90%	4	12.5%

The distribution of prevalence rates demonstrates that musculoskeletal disorders represent a widespread and significant issue rather than an isolated phenomenon. The concentration of studies reporting higher prevalence levels suggests that a large proportion of rehabilitation workers are affected by these conditions, potentially influencing their functional capacity and long-term work sustainability. This pattern highlights the need for greater attention to preventive strategies, as persistent exposure without adequate intervention may lead to chronic health outcomes and reduced workforce productivity. Moreover, the observed variation across studies reinforces the importance of considering both individual and organizational determinants when addressing MSDs, as effective solutions are likely to require a combination of ergonomic, behavioral, and systemic approaches.

Affected Body Regions

The distribution of musculoskeletal disorders across different body regions provides important insight into how physical demands in rehabilitation work affect specific parts of the body. This pattern reflects the nature of daily tasks performed by medical rehabilitation workers, which often require coordinated movements, sustained postures, and direct physical interaction with patients. Such activities place uneven mechanical loads on the body, leading to varying levels of strain across different anatomical regions. Understanding these distribution patterns is essential for identifying priority areas for ergonomic intervention and for designing targeted prevention strategies.

Table 4. Most Affected Body Regions

Body Region	Average Prevalence (%)	Rank
Lower back	58–72%	1
Neck	45–60%	2
Shoulders	48–65%	3
Upper limbs (arms/wrists)	35–55%	4
Lower limbs	20–35%	5

The observed pattern of affected body regions highlights the cumulative impact of repetitive and physically intensive tasks on areas that are most involved in patient handling and posture maintenance. This concentration of strain suggests that certain body regions are more vulnerable due to their continuous engagement in load-bearing and movement-intensive activities. The consistency of these findings across studies reinforces the need for focused ergonomic improvements that address specific physical demands rather than adopting a generalized approach. Targeted interventions, such as posture correction, assistive devices, and task

modification, are therefore crucial in reducing strain on the most affected regions and improving overall occupational health outcomes.

Ergonomic Risk Factors Identified

The identification of ergonomic risk factors is a critical step in understanding the underlying causes of musculoskeletal disorders among medical rehabilitation workers. These risk factors reflect the interaction between physical job demands and the human body, particularly in work environments that require continuous movement, force application, and patient interaction. Rather than occurring in isolation, ergonomic risks often emerge as a combination of multiple exposures that accumulate over time, increasing the likelihood of strain and injury. Therefore, examining these factors collectively provides a more comprehensive picture of occupational health risks in rehabilitation settings.

In addition to physical demands, the presence of ergonomic risk factors is also influenced by how work is organized and executed. Variations in task design, workflow structure, and availability of support systems can either mitigate or intensify these risks. For example, inadequate staffing or inefficient task allocation may force workers to perform physically demanding activities more frequently or without sufficient recovery time. This highlights that ergonomic risk is not solely a biomechanical issue but also closely linked to organizational and environmental conditions within healthcare facilities.

The synthesis of literature further indicates that certain risk factors tend to co-occur, creating compounded effects on the musculoskeletal system. Repetitive movements combined with awkward postures or high workload, for instance, can significantly amplify physical stress. This interaction suggests that addressing a single factor in isolation may not be sufficient to reduce overall risk. Instead, a multidimensional approach is required to effectively identify and manage the range of ergonomic exposures present in rehabilitation work.

Table 5. Key Ergonomic Risk Factors

Risk Factor	Frequency (Studies)	Percentage
Non-neutral posture	29	90.6%
Repetitive movement	26	81.3%
Manual handling	24	75.0%
Prolonged static posture	22	68.8%
High workload	20	62.5%

The overall pattern of identified risk factors demonstrates that musculoskeletal strain among rehabilitation workers is driven by both task-related and systemic conditions. The dominance of posture-related and movement-related risks indicates that the physical execution of work plays a central role in shaping health outcomes. At the same time, the presence of workload as a contributing factor suggests that organizational pressures, such as time constraints and patient volume, further intensify these physical demands. This combination creates a work environment where the body is continuously subjected to stress without adequate opportunities for recovery.

These findings also point to the need for integrated ergonomic interventions that go beyond individual behavior. While improving posture and movement techniques is important, it must be supported by structural changes such as redesigning tasks, optimizing workflow, and providing appropriate assistive equipment. Without addressing these broader conditions, efforts to reduce ergonomic risk may have limited effectiveness. The evidence suggests that sustainable improvements in occupational health require alignment between individual practices and organizational support systems.

The consistency of these risk factors across multiple studies reinforces their relevance as key targets for intervention. The repeated identification of similar factors in different contexts indicates that they are fundamental characteristics of rehabilitation work rather than context-specific issues. This strengthens the argument for developing standardized ergonomic guidelines tailored to rehabilitation settings. By addressing these core risk factors, healthcare organizations can reduce the incidence of musculoskeletal disorders and improve both worker well-being and service quality.

Relationship Between Ergonomic Risk and MSDs

The relationship between ergonomic risk exposure and musculoskeletal disorders represents a central focus in occupational health research, particularly in physically demanding professions such as medical rehabilitation. This relationship reflects how repeated exposure to unfavorable working conditions translates into measurable health outcomes over time. Rather than being incidental, musculoskeletal complaints are often the result of continuous interaction between biomechanical stressors and the body's adaptive limits. Understanding the strength of this relationship is essential to determine whether ergonomic risks function as primary determinants of MSDs or merely as contributing factors among other influences.

From a theoretical perspective, this association is grounded in biomechanical and physiological mechanisms. Prolonged exposure to awkward postures, repetitive movements, and forceful exertions can lead to cumulative tissue damage, muscle fatigue, and joint strain. When such exposures exceed the body's capacity for recovery, they increase the likelihood of both acute discomfort and chronic musculoskeletal conditions. Therefore, examining how consistently this relationship appears across studies helps to validate the role of ergonomic risk as a key explanatory factor in the development of MSDs.

Table 6. Strength of Association

Strength of Relationship	Frequency (Studies)	Percentage
Weak	3	9.4%
Moderate	10	31.3%
Strong	19	59.3%

The overall pattern of findings indicates that the relationship between ergonomic risk exposure and musculoskeletal disorders is not only consistent but also substantively meaningful across different study contexts. The predominance of stronger associations suggests that ergonomic factors play a decisive role in shaping health outcomes among rehabilitation workers. This implies that reducing exposure to these risks could lead to measurable improvements in musculoskeletal health, making ergonomic intervention a critical component of occupational health strategies. The variation in the strength of relationships observed across studies highlights the influence of contextual and methodological factors. Differences in measurement tools, sample characteristics, and workplace environments may affect how strongly ergonomic risks are linked to MSDs. This suggests that while the overall relationship is robust, its magnitude may depend on specific conditions within each setting. Consequently, effective intervention strategies should not adopt a one-size-fits-all approach but instead consider the unique combination of physical and organizational factors present in each work environment.

Organizational Factors Influencing MSDs

Organizational factors are a key determinant of the emergence of musculoskeletal disorders (MSDs) in the workplace. Unlike individual or biomechanical factors, organizational factors are more related to how work systems are designed, managed, and implemented by institutions or companies. This includes work policies, time management, provision of facilities, and support for occupational safety and health. In the context of occupational ergonomics, organizations play a strategic role in creating a safe and healthy work environment. An imbalance between job demands and worker capacity, for example, can increase physical stress, which impacts the risk of MSDs. Therefore, an organizational approach is crucial in prevention efforts, as it can intervene on risk factors systemically, not just at the individual level.

Various studies have shown that organizational factors are often latent but have a cumulative impact on worker health. Long-term, suboptimal working conditions can worsen work posture, increase fatigue, and ultimately trigger musculoskeletal disorders. Therefore, identifying organizational factors is a crucial first step in designing effective intervention strategies. Based on a literature review, a number of organizational factors have been identified as key contributors to the occurrence of MSDs. These factors were then analyzed based on their frequency of occurrence across various studies to provide an overview of their level of significance within the broader research context.

Table 7. Organizational Contributing Factors

Factor	Frequency (Studies)	Percentage
High workload	25	78.1%
Lack of ergonomic equipment	23	71.9%
Limited rest time	21	65.6%
Lack of training	19	59.4%

Based on the literature compiled, it is clear that organizational factors play a significant role in influencing the occurrence of MSDs. The high prevalence of these factors across various studies demonstrates consistent findings, indicating that this problem is systemic and not limited to a specific sector or type of work. The identified organizational factors illustrate the interrelationship between workload, facility availability, work time management, and aspects of employee competency development. The combination of these factors reflects how job design and organizational policies can directly and indirectly impact workers' long-term physical condition.

These findings also indicate that MSD prevention efforts cannot be achieved solely through individual approaches, such as work posture education, but must be supported by organizational-level changes. Interventions such as improving work systems, providing adequate facilities, and strengthening training programs are relevant steps to reduce this risk. Therefore, it is crucial for organizations to adopt a more holistic approach to occupational health management. Integrating policies, work practices, and employee support can be key to reducing the incidence of MSDs and sustainably improving workforce productivity and well-being.

Discussion

Evidence Landscape and Research Orientation

The body of evidence synthesized in this study reflects a field that is still largely oriented toward identifying patterns rather than explaining underlying mechanisms in depth. The dominance of certain research designs suggests that current knowledge is built primarily on observational snapshots, which are useful for establishing the scale of the problem but less effective in uncovering causal pathways (Imai et al., 2011; Neale, 2021; Hendren et al., 2023). This indicates that while the issue of ergonomic risk and MSDs is well-documented, there remains a gap in understanding how these risks evolve over time and how interventions may alter long-term outcomes. The concentration of studies within particular regions highlights an imbalance in global research representation. This uneven distribution suggests that the understanding of ergonomic challenges may be shaped by specific healthcare contexts, potentially limiting broader applicability. It also implies that differences in institutional capacity, technological support, and occupational health policies may influence both the occurrence of risks and the way they are studied. As a result, expanding research into more diverse settings would contribute to a more comprehensive and globally relevant evidence base.

Systemic Nature of Ergonomic Exposure

The findings collectively point to ergonomic exposure as an embedded feature of rehabilitation work rather than an occasional or situational issue. The nature of clinical tasks, which inherently involve physical interaction and patient support, creates an environment where biomechanical strain is continuously present. This suggests that ergonomic risks are structurally integrated into work processes, making them difficult to eliminate without fundamental changes to how tasks are designed and executed. This systemic characteristic also indicates that risk exposure is not solely determined by individual behavior or technique. Instead, it is shaped by broader work systems, including workflow organization, patient load, and resource availability. Consequently, efforts to reduce ergonomic strain must address these structural dimensions rather than focusing exclusively on individual-level adjustments. Without such systemic changes, improvements are likely to be limited and difficult to sustain.

MSDs as a Persistent Occupational Outcome

The consistently high occurrence of musculoskeletal disorders across studies underscores their role as a persistent and widespread occupational outcome in rehabilitation settings (Kidner et al.,

2009). Rather than being sporadic incidents, these conditions appear to reflect ongoing exposure to cumulative physical stress. This persistence suggests that existing preventive measures may not be sufficiently effective or consistently implemented across different work environments. The variation in reported prevalence indicates that MSDs are influenced by a combination of factors that extend beyond direct physical exposure. Differences in organizational support, workload distribution, and access to ergonomic resources may all contribute to how these conditions manifest. This reinforces the idea that MSDs should be understood as the result of interacting determinants, requiring interventions that address both physical and contextual dimensions simultaneously.

Targeted Vulnerability and Physical Load Distribution

The pattern of musculoskeletal impact across specific body regions highlights how physical demands are distributed unevenly within rehabilitation work (Al-Khiami et al., 2025). Certain areas of the body are repeatedly engaged in tasks that involve lifting, stabilizing, or maintaining posture, leading to concentrated exposure over time. This suggests that vulnerability is closely linked to the functional roles these body regions play in daily work activities. This uneven distribution also has implications for intervention design. General ergonomic improvements may not adequately address the specific areas most at risk, emphasizing the importance of targeted strategies. Interventions that focus on task-specific mechanics and body positioning are likely to be more effective in reducing localized strain (Sousa et al., 2023). Such an approach recognizes that occupational risk is not uniform and must be managed with precision.

Interconnected Risk Structure

The analysis of ergonomic risk factors reveals that they operate as an interconnected system rather than as independent variables. Multiple exposures often occur simultaneously, creating a cumulative effect that amplifies overall risk. This interconnectedness suggests that addressing a single factor in isolation may not significantly reduce the burden of musculoskeletal strain. The interaction between physical and organizational factors further complicates the risk structure. High workload, for example, may intensify the impact of poor posture or repetitive movement by increasing frequency and reducing recovery time. This indicates that effective risk management requires a comprehensive approach that integrates physical, organizational, and behavioral considerations into a unified strategy.

Strength and Consistency of the Relationship

The strong and recurring association between ergonomic exposure and musculoskeletal outcomes reinforces the central role of workplace conditions in shaping worker health. This relationship demonstrates that ergonomic risk is not merely a contributing factor but a significant determinant of musculoskeletal well-being in rehabilitation contexts. The consistency of this pattern across studies strengthens confidence in its validity and highlights the importance of prioritizing ergonomic interventions. At the same time, variations in the strength of this relationship suggest that its impact is influenced by contextual factors. Differences in workplace design, employee characteristics, and measurement approaches may all affect how strongly ergonomic risks translate into health outcomes (Migliore et al., 2021). This variability underscores the need for context-sensitive interventions that are tailored to specific work environments rather than relying on standardized solutions alone.

Organizational Context as a Determining Layer

The influence of organizational factors introduces an additional layer of complexity in understanding musculoskeletal disorders (Huang et al., 2003). Workplace policies, resource allocation, and management practices shape the conditions under which tasks are performed, thereby influencing the level of risk exposure. This highlights that organizational decisions play a critical role in either mitigating or exacerbating ergonomic challenges. These factors often operate indirectly but have cumulative effects over time. Inadequate rest periods, limited access to equipment, and insufficient training can gradually increase physical strain, even when individual tasks appear manageable. This suggests that effective prevention requires a shift from reactive to

proactive strategies, where organizations actively design work systems that prioritize long-term worker health.

Implications for Integrated Intervention

The synthesis of findings points to the necessity of adopting an integrated approach to managing ergonomic risks and musculoskeletal disorders. Interventions that focus solely on individual behavior are unlikely to achieve substantial or lasting improvements without support from organizational structures. Instead, a coordinated strategy that aligns worker practices with institutional policies is required (Molenveld et al., 2020). Such an approach involves not only improving physical work conditions but also fostering a culture that values occupational health and safety. By integrating ergonomic considerations into daily operations, training programs, and strategic planning, organizations can create a more sustainable framework for risk reduction. Ultimately, the effectiveness of intervention efforts depends on the extent to which they address the multifaceted nature of the problem, combining technical solutions with systemic change.

CONCLUSION

In conclusion, the synthesis of 32 studies demonstrates that medical rehabilitation workers are consistently exposed to moderate to very high ergonomic risks, which are strongly associated with a high prevalence of musculoskeletal disorders, particularly affecting the lower back, neck, and shoulders. These risks are not isolated but arise from a combination of biomechanical demands such as non-neutral postures, repetitive movements, and manual handling and organizational conditions, including high workload, limited resources, and insufficient ergonomic support. The findings confirm that ergonomic exposure is a systemic and inherent aspect of rehabilitation work, with musculoskeletal disorders representing a persistent occupational outcome rather than occasional incidents. Moreover, the strong and consistent relationship between ergonomic risk and MSDs underscores the critical role of workplace conditions in shaping worker health. Therefore, effective prevention requires a comprehensive and integrated approach that combines task-level ergonomic improvements with organizational interventions, ensuring that both physical and systemic factors are addressed to enhance worker well-being and sustain long-term productivity.

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