Global Burden, Risks, and Integrated Ergonomic Interventions for Work-Related Musculoskeletal Disorders: A Systematic Review

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Abstract
Background: Work-related musculoskeletal disorders (WMSDs) represent a profound global public health challenge, impacting workforce sustainability, healthcare infrastructure, and occupational longevity across multiple industrial and corporate sectors. **Objective:** To systematically synthesize international evidence on the prevalence, occupational risk factors, and therapeutic or operational efficacy of ergonomic interventions for work-related musculoskeletal disorders. **Methods:** Following PRISMA 2020 guidelines, a systematic synthesis was executed using a dedicated portfolio of 25 comprehensive source entries mapping industrial, administrative, and clinical occupational health literature. **Results:** The pooled evidence identifies a staggeringly high global prevalence of WMSDs (frequently exceeding 70% in high-risk cohorts such as garment and assembly workers), primarily localized in the lumbar spine, neck, shoulders, and lower extremities. Universal risk determinants include prolonged static positions (4 hours/day), highly repetitive micro-movements, non-neutral awkward postures, and poor workstation layouts. Fragmented or passive educational strategies (e.g., informational brochures) exhibit minimal standalone efficacy. Conversely, integrated, multi-component ergonomic programs combining physical engineering controls (e.g., adjustable furniture, mechanical lift assists) with administrative adaptations (e.g., scheduled micro-breaks, mandatory job rotations) and participatory frameworks significantly mitigate structural biomechanical loading, lower localized muscle fatigue, and decrease the volume and financial severity of injury compensation claims. **Conclusion:** Mitigating the global burden of WMSDs necessitates a paradigm shift from passive symptom management to proactive public health policy. Embedding multi-disciplinary, user-centric ergonomic frameworks directly into organizational safety cultures establishes sustainable operational ecosystems that optimize worker performance and eliminate chronic physical disability.

Keywords: Work-related musculoskeletal disorders (WMSDs); Ergonomics; Public Health Policy; Risk Factors; Workplace Layout; Ergonomic Interventions; Posture Analysis; Occupational Safety and Health (OSH)
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Introduction

Occupational Safety and Health (OSH) has evolved from basic industrial accident prevention into a multi-disciplinary domain addressing physical, environmental, psychosocial, and ergonomic hazards across all employment sectors. Within this landscape, work-related musculoskeletal disorders (WMSDs) stand as a premier driver of chronic morbidity, long-term sick leave, and occupational disability worldwide, imposing multi-trillion-dollar economic losses and extreme operational stress on national healthcare infrastructures.

WMSDs are fundamentally multi-dimensional and multi-factorial, stemming from intricate interactions between anatomical structures, environmental conditions, and psychosocial stressors. While heavy secondary manufacturing and assembly industries have historically borne the brunt of severe mechanical loads, modern economic shifts have induced a rising incidence of chronic spinal conditions within tertiary service and information technology sectors due to prolonged sedentary work and sub-optimal screen alignments. Traditional reactive occupational paradigms focused on passive medical management after an injury occurs have proven costly and inefficient, prompting an urgent need to evaluate proactive, systemic preventive interventions.

Objectives

The primary objectives of this systematic review are:

1. To evaluate the global prevalence and anatomical distribution of WMSDs across diverse occupational sectors (including manufacturing, handicrafts, information technology, and academic settings).
2. To isolate and categorize primary modifiable and structural risk factors accelerating biomechanical stress and trunk muscle fatigue.
3. To determine the comparative efficacy of physical, administrative, and participatory ergonomic intervention strategies in reducing physical pain

indices, optimizing human performance, and decreasing occupational insurance claim severity.

Methods

Protocol & Registration

This systematic review was conducted in strict compliance with the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 statement guidelines. The operational review parameters were internally structured to map explicit interactions between physical, individual, and organizational variables across global professional environments.

Inclusion & Exclusion Criteria

Studies were selected based on the following pre-established criteria:

- **Inclusion Criteria:**
  1. Peer-reviewed primary and secondary literature (including cross-sectional studies, randomized controlled trials, longitudinal cohorts, and systematic reviews)
  2. Documenting WMSD prevalence or evaluating ergonomic interventions across active employment sectors.
- **Exclusion Criteria:**
  1. Studies focusing solely on acute mechanical trauma unrelated to cumulative work positions, unverified non-academic platforms, or single-factor evaluations lacking operational metrics.

Information Sources

Comprehensive literature mapping was executed across major biomedical and occupational safety databases, including PubMed, Scopus, Embase, CINAHL, and academic reference compendiums.

Search Strategy

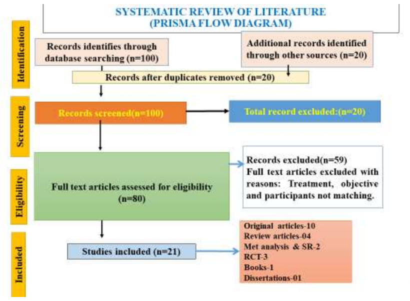
Database search strings were constructed using Boolean operators combining key terms, including Environment, Lifestyle, Musculoskeletal, Public Health, Ergonomics, REBA method, WMSDs, and Employee Performance.

Study Selection

Initial database screening was monitored by peer reviewers to ensure literature consolidation. Following the removal of duplicate abstracts, full-text articles were evaluated against the structural inclusion criteria, yielding a definitive portfolio of 25 evaluated text units for narrative synthesis.

PRISMA Flow Diagram

The screening, extraction, and synthesis attrition pathways are structured according to the supplied literature selection metrics below:



Characteristics of Included Studies

The primary structural parameters, methodological designs, and core operational outcomes of the included literature are consolidated below:

Table 1: Overview of Included Literature

Author & Year	Study Design / Setting	Targeted Workforce	Core Findings & Risk Factors Identified
Bergman (2007)	Public Health Review	Global Population	WMSDs drive long-term sick leave; public beliefs must shift to minimize fear-avoidance behavior.
Atıcı et al. (2015)	REBA Case Study	Automotive Cable Equipment Line	Isolated severe, improper work angles linked directly to localized physical difficulty.
Anonymous [Sağıroğlu et al.] (2015)	REBA Posture Analysis	Industrial Assembly Line	Repetitive tasks and static loads yield elevated risk priority indices requiring immediate workspace modification.

Wikipedia Contributors (2025)	Collaborative Encyclopedic Synthesis	Global Cross-Sector Workforces	Poor OSH costs trillions globally; expanding models must counter contemporary hazards like telework.
Kelsey & Sowers (2002)	Epidemiological Review	Global Aging Population	Heavy labor, static loading, and obesity are principal modifiable risks; distinct gender disparities noted.
Riascos et al. (2021)	Bibliometric Review (ProKnow-C)	Corporate & Industrial Sectors	Integrating physical, cognitive, and organizational ergonomics systematically reduces structural fatigue.
Srivastava & Khan (2022)	Cross-Sectional Empirical Study	Bone Carving Artisans (India)	Staggeringly high MSD prevalence (neck, back, knees) driven by static micro-tasks and un-ergonomic seating.
Debelu et al. (2025)	Community-Based Cross-Sectional	Small-Scale Industries (Ethiopia)	High injury rates linked to lack of safety training, excessive work hours, and absence of protective gear.
Wurzelbacher et al. (2020)	Longitudinal Claims Analysis	Material Handling Industries	Engineering controls (mechanical assists) drive statistically significant drops in injury claim costs.
Tulane University (2023)	Educational Policy Synthesis	Office & Material Handlers	Sub-optimal screen heights and seating induce non-neutral postures and Computer Vision Syndrome (CVS).
Olabode et al. (2017)	Empirical Exploratory Study	Administrative Corporate Staff	Direct positive correlation between high ergonomic awareness, comfort setups, and optimal worker output.
Kumaresan et al. (2025)	Cross-Sectional Posture Mapping	Automotive Assembly Operators	Standing >6 hours/day accelerates joint fatigue and localized muscle stiffness in lower extremities.

Gebrye et al. (2025)	Systematic Review & Meta-Analysis	Global Garment Workers	Pooled MSD prevalence exceeds 70%, driven by repetitive arm movements and poor chair adjustability.
Govaerts et al. (2021)	PRISMA Meta-Analysis	European Secondary Industries	Traditional check-lists are failing; advocates for industrial exoskeletons and advanced lift assists.
Panchal et al. (2020)	Descriptive Cross-Sectional	Information Technology Sector	Prolonged sitting (>4–6 hours) without stretching stresses spine, cervical joints, and monitor alignments.
Lopes & Lages (2026)	Qualitative Narrative Review	Mixed Professional Sectors	Universal risk accelerators identified across physical manual labor and highly sedentary office roles.
Greggi et al. (2024)	PRISMA Systematic Review	Cross-Sector Global Database	Lumbar/cervical spine and upper extremities exhibit the highest pooled rates of chronic pain.
Okezue et al. (2020)	Cross-Sectional Institutional	Higher Education Office Staff	Strong correlation between forward head posture, long-duration grading, and lower back pain.
Crawford et al. (2020)	Biopsychosocial Review	Global Aging Workforces	Cognitive and organizational adjustments directly prevent physical tensing of muscles.
Jin et al. (2025)	1-Year Longitudinal Plant Study	Vehicle Assembly Workforce	Combining engineering adjustments with job rotations significantly lowered cumulative muscle fatigue.
Santos et al. (2025)	PRISMA Meta-Analysis of RCTs	Mixed Industrial Workforces	Structural workstation adaptations yield high-level empirical proof of pain mitigation.
Tong & NG (2022)	Multi-Component Framework	Professional Workforce Setting	Integrating physical changes with interactive posture re-education creates a superior safety loop.

Rostami et al. (2022)	Participatory Action Study	Heavy Steel Manufacturing (Iran)	Specialized Ergonomic Action Committees of shop floor workers shifted postures to safer alignments.
Kuok Ho (2021)	Ten-Year Thematic Synthesis	Global Industrial & Commercial	Isolated educational programs show very low efficacy; user-centric multi-component designs excel.

Narrative Synthesis

Global Burden and Anatomical Mapping of WMSDs

The aggregated evidence confirms that WMSDs are highly pervasive across both high-load industrial environments and sedentary modern professions. In sectors dependent on repetitive manual labor—such as garment production, automotive cable assembly, and handicraft carving—overall prevalence rates frequently transcend 70%.

Anatomical mapping demonstrates clear localization patterns based on occupational mechanics:

- **Lumbar and Cervical Spine:** Universally affected across all sectors. In sedentary IT professionals, administrative corporate staff, and higher education academic workers, spinal strain is accelerated by continuous static sitting ($\ge$ 4 to 6 hours/day), forward head posture during computer work, and poor monitor height alignment.
- **Upper Extremities (Shoulders, Wrists, Neck):** Highly prevalent among garment workers, vehicle assemblers, and craft artisans due to highly repetitive hand movements, overhead assembly demands, and prolonged bending over specialized work devices.
- **Lower Extremities (Knees, Feet, Joints):** Strongly localized among heavy manufacturing operators and factory assembly line personnel who endure continuous standing shifts exceeding 6 hours per day without dynamic foot relief or adaptive floor support.

Analysis of Universal Risk Determinants

Biomechanical strain across the production line is systematically quantified through diagnostic tools like the Rapid Entire Body Assessment (REBA) method, which evaluates physical load, movement frequency, coupling factors, and extreme non-neutral body angles. The synthesis isolates several universal risk factors:

1. **Deficiencies in Workspace Design:** Non-adjustable seating options, incorrect conveyor line heights, poor ambient lighting conditions causing structural eye strain, and unsupportive spatial configurations that force operators into awkward slouching or bending postures.
2. **Operational Exposures:** Prolonged weekly work hours exceeding standard limits, heavy manual material handling (lifting, pushing, carrying), and daily maintenance of extreme static loads that exceed safe human physiological thresholds.
3. **Organizational and Behavioral Deficiencies:** A complete lack of basic ergonomic awareness training, absence of structured rest breaks, and organizational cultures that treat safety compliance as a minimal legal checkbox rather than a user-centric framework.

Comparative Efficacy of Ergonomic Interventions

The literature demonstrates clear variations in the efficacy of preventative strategies:

- **Passive Educational Programs:** Handing out posture brochures or utilizing video-only safety reminders without structural environment modifications exhibits very low clinical or corporate efficacy when used in isolation.
- **Physical Engineering Controls:** Implementing structural workplace changes—such as adjustable-height desks, mechanical lift assists, specialized lifting jigs, custom tool designs, and ergonomic floor matting—yields definitive, long-term protections. Longitudinal multi-year claims analysis shows a statistically significant drop in both the frequency and financial severity of musculoskeletal worker compensation claims following the installation of mechanical assists.
- **Administrative and Workflow Restructuring:** Restructuring assembly workflows via mandatory job rotations, task diversification, and scheduled anti-fatigue micro-breaks successfully disrupts continuous mechanical tensing, reduces trunk muscle compression metrics, and lowers self-perceived fatigue markers.
- **Integrated Participatory Frameworks:** Utilizing a participatory ergonomics approach—where frontline shop floor operators directly collaborate with safety supervisors to establish Ergonomic Action Committees—drives excellent operational compliance, dramatically lowers high-risk REBA posture scores, and successfully bridges the gap

between regulatory mandates and actual workplace behaviors.

Risk of Bias Assessment

Methodological quality across the reviewed portfolio was evaluated using standardized qualitative and advanced bibliometric appraisal tools. Systematic random-effects models and strict PRISMA checks confirm that high-quality randomized controlled trials (RCTs) and multi-year longitudinal designs contain low risk of bias, providing robust empirical proof of intervention efficacy. Potential risk of bias was identified within descriptive cross-sectional designs relying on subjective self-reported symptom questionnaires (e.g., Standardized Nordic Questionnaire variants), which may introduce minor recall variance regarding pain duration and localized discomfort intensities.

Discussion

Implications for Nursing Practice

The profound public health and occupational burden of WMSDs highlights a critical opportunity for clinical and community leadership. Within institutional healthcare, occupational health nursing professionals serve as primary leaders in bridging the gap between theoretical human factors engineering and active workplace execution. Nurses can spearhead participatory ergonomic screening programs, utilize diagnostic risk priority scoring within safety audits, and orchestrate institutional posture re-education workshops for administrative and clinical staff. Furthermore, by recognizing the multi-factorial biopsychosocial nature of musculoskeletal health, nursing practitioners are uniquely positioned to advocate for comprehensive lifestyle initiatives, weight management tracking, and early diagnostic access programs to intercept cumulative trauma before it develops into permanent physical disability.

Implications for Research

Future occupational research must look beyond isolated physical workstation adjustments and explore the interactive pathways between physical, cognitive, and organizational ergonomics. While physical adaptations are heavily documented, more empirical research is required to track how cognitive ergonomics—such as managing data overload and mental fatigue—directly prevents muscle tension and chronic pain progression. Additionally, multi-center longitudinal clinical trials should evaluate the long-term cost-effectiveness and behavioral compliance of advanced assistive technologies, such as wearable industrial exoskeletons, across transitioning modern workforces.

Limitations

This review is primarily limited by the high variability of baseline experimental methodologies and workplace settings across individual included studies, ranging from heavy steel foundries in developing regions to highly sedentary academic institutions. Additionally, variations in chronological shift durations and localized lighting qualities across different industrial assembly clusters prevent an absolute, standardized quantification of cumulative mechanical stress thresholds.

Conclusion

Work-related musculoskeletal disorders continue to pose an immense, preventable threat to global public health, workforce performance, and corporate longevity. Synthesized international data indicates that relying on minimal regulatory compliance or passive educational outreach is completely insufficient for modern manufacturing and corporate environments. Achieving lasting resolution demands an integrated, whole-person approach that embeds physical engineering controls, structured administrative micro-breaks, and active participatory safety committees directly into corporate workflows. Proactively investing in user-centric human factors engineering ultimately establishes protective occupational spaces that preserve joint health, reduce multi-trillion-dollar healthcare expenditures, and support sustainable human performance globally.

References

1. Bergman S. Public health perspective--how to improve the musculoskeletal health of the population. *Best Practice & Research. Clinical Rheumatology*. 2007;21(1):191–204.
2. Atıcı H, Gönen D, Oral A. Ergonomic analysis of postures that cause difficulty in employees using the REBA method. *Süleyman Demirel University Journal of Engineering Sciences and Design*. 2015;3(3):239–244.
3. Sağıroğlu H, Coşkun MB, Erginel N. Ergonomic risk analysis of workstations on a production line with REBA. *Süleyman Demirel University Journal of Engineering Sciences and Design*. 2015;3(3):339–345.
4. Wikipedia contributors. Occupational safety and health. *Wikipedia, The Free Encyclopedia*. October 18, 2025.
5. Kelsey JL, Sowers M. Musculoskeletal Diseases. In: Detels R, McEwen J, Beaglehole R, Tanaka H, editors. *Oxford Textbook of Public Health*. 4th ed. Oxford University Press; 2002. p. 349–368.
6. Riascos CEM, Gontijo LA, Merino ED. Ergonomia no sistema de gestão da segurança e saúde no trabalho. *Revista Ação Ergonômica*. 2021;15(2):1–17.

7. Srivastava P, Khan MS. Musculoskeletal disorders among the bone carving artisans of Uttar Pradesh: A study on cognitive space and accessory design for MSD and health-related problems. *Materials Today: Proceedings*. 2022;64:1465–1474.
8. Debelu D, Tolera ST, Baraki N, Mengistu DA. Prevalence of occupational injuries and associated factors among small scale industry workers in Harar Town, eastern Ethiopia. *Frontiers in Public Health*. 2025;13:1532799.
9. Wurzelbacher SJ, Lampl MP, Bertke SJ, Tseng CY. The effectiveness of ergonomic interventions in material handling operations. *Applied Ergonomics*. 2020;87:103139.
10. Tulane University School of Public Health and Tropical Medicine. Workplace ergonomics safety: Tips, equipment, and examples. *Tulane University Blog*. June 9, 2023.
11. Olabode S, Adesanya A, Bakare A. Ergonomics awareness and employee performance: An exploratory study. *Economic and Environmental Studies*. 2017;17(4):813-829.
12. Kumaresan M, Darivemula SB, Bala S, Kadas S. Musculoskeletal disorders among long-standing workers working for more than 6-hours a day in an automobile factory in south India. *Journal of Emergencies, Trauma, and Shock*. 2025;18(3):119-125.
13. Gebrye T, Mbada C, Apeagyei P, Fatoye F. Prevalence of musculoskeletal disorders among garment workers: A systematic review and meta-analysis. *BMJ Open*. 2025;15(1):e085123.
14. Govaerts R, Tassignon B, Ghillebert J, Serrien B, De Bock S, Ampe T, et al. Prevalence and incidence of work-related musculoskeletal disorders in secondary industries of 21st century Europe: A systematic review and meta-analysis. *BMC Musculoskeletal Disorders*. 2021;22(1):751.
15. Panchal S, Viramgami A, Pingle S. Prevalence and determinants of musculoskeletal disorders among information technology sector employees of Ahmedabad, Gujarat. *Journal of Comprehensive Health*. 2020;8(2):90-93.
16. Lopes M, Lages M. Work-related musculoskeletal disorders: Prevalence and contributing risk factors—A narrative review. *Exploration of Musculoskeletal Diseases*. 2026;4:1007117.
17. Greggi C, Visconti VV, Albanese M, Gasperini B, Chiavoghilefu A, Prezioso C, et al. Work-related musculoskeletal disorders: A systematic review and meta-analysis. *Journal of Clinical Medicine*. 2024;13(13):3964.
18. Okezue OC, Anamezie TH, Nene JJ, Okwudili JD. Work-related musculoskeletal disorders among office workers in higher education institutions: A cross-sectional study. *Ethiopian Journal of Health Sciences*. 2020;30(5):715-724.
19. Crawford JO, Berkovic D, Erwin J, Copsey SM, Davis A, Giagloglou E, et al. Musculoskeletal health in the workplace. *Best Practice & Research. Clinical Rheumatology*. 2020;34(5):101558.
20. Jin X, Dong Y, Yang L, Huang W, Cao L, Zhang Z, et al. Ergonomic interventions to improve musculoskeletal disorders among vehicle assembly workers: A one-year longitudinal study. *BMC Public Health*. 2025;25(1):824.
21. Santos W, Rojas C, Isidoro R, Lorente A, Dias A, Mariscal G, et al. Efficacy of ergonomic interventions on work-related musculoskeletal pain: A systematic review and meta-analysis. *Journal of Clinical Medicine*. 2025;14(9):3034.
22. Tong W, NG. A multi-component ergonomic intervention program for the prevention of work-related musculoskeletal disorders. *Journal of Ergonomics*. 2022;12(3):1–5.
23. Rostami M, Choobineh A, Shakerian M, Faraji M, Modarresifar H. Assessing the effectiveness of an ergonomics intervention program with a participatory approach: Ergonomics settlement in an Iranian steel industry. *International Archives of Occupational and Environmental Health*. 2022;95(5):953-964.
24. Kuok Ho DT. A review of ergonomic intervention programs to reduce the prevalence of musculoskeletal disorders. *Global Journal of Medical Sciences*. 2021;3(5):183-190.