Jurnal Kesehatan dan Keselamatan Kerja Indonesia
Volume. 1, Issue 1 November 2025
Page No: 45-58

Worker-Centered Ergonomics: A Narrative Review of Human Factors Engineering and Workplace Interventions

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Received : October 07, 2025
Accepted : November 08, 2025
Published : November 30, 2025

Citation: Tasya, Z., & Budiman. (2025). Worker-Centered Ergonomics: A Narrative Review of Human Factors Engineering and Workplace Interventions. Jurnal Kesehatan dan Keselamatan Kerja Indonesia, 1(1), 45-58.

ABSTRACT: Ergonomic interventions and human factors engineering are essential components of occupational health strategies aimed at reducing musculoskeletal disorders and improving worker productivity. This narrative review explores recent advancements and challenges in implementing ergonomic practices, particularly within manufacturing, construction, and healthcare sectors. Literature was systematically sourced from major databases including PubMed, Scopus, and Web of Science, using keyword-based search strategies and strict inclusion criteria focused on real-world applications. Findings reveal that technologies such as glove-based exoskeletons and sit-stand workstations significantly reduce physical strain and enhance user comfort. Active rest programs and workplace redesigns contribute to improved metabolic health, reduced sedentary behavior, and greater psychological well-being. Additionally, participatory ergonomics and behavior-based training were shown to increase intervention acceptance and organizational compliance. However, widespread implementation is limited by systemic barriers such as cultural resistance, financial constraints, and lack of institutional support. The study recommends a multifaceted, evidence-based approach integrating technology, education, and participatory design to optimize ergonomic outcomes. Long-term evaluation and inclusive policy development are also emphasized to ensure sustainability. These findings reinforce the need for collaborative, adaptive strategies that prioritize worker-centered design to build safer, healthier workplaces.

Keywords: Ergonomic Interventions, Human Factors Engineering, Musculoskeletal Disorders, Participatory Ergonomics, Workplace Redesign, Occupational Health, Exoskeleton Technology.

INTRODUCTION

Human factors engineering and ergonomic interventions have emerged as pivotal domains in the pursuit of healthier, safer, and more productive workplaces, particularly in the manufacturing and construction industries. These sectors are characterized by physically demanding tasks, repetitive movements, and high-risk environments, all of which contribute significantly to the development of work-related musculoskeletal disorders (MSDs). Recent technological advancements, such as

wearable assistive devices and digital ergonomic monitoring systems, have further invigorated the discourse around optimizing human-system interaction in industrial contexts. The centrality of ergonomics in occupational health has been underscored by a growing body of evidence that links ergonomic inadequacies to elevated injury rates, absenteeism, and reduced productivity (Beyan et al., 2020; Hemati et al., 2020).

In light of these challenges, ergonomics research has increasingly focused on worker-centered approaches that prioritize the adaptability, comfort, and engagement of the workforce. The adoption of participatory methods and interdisciplinary strategies—combining organizational change, education, and workspace redesign—has shown promising results in reducing workplace hazards and improving employee satisfaction (Rasmussen et al., 2017). Yet, despite such progress, the implementation of ergonomic interventions is often met with resistance, particularly when they necessitate modifications to established workflows. This resistance reflects deeper organizational and cultural dynamics that complicate the translation of ergonomic principles into practice.

The global burden of MSDs serves as a stark reminder of the need for effective preventive strategies. In heavy industries and construction, workers are frequently exposed to ergonomic risks that exacerbate physical strain and long-term health outcomes. For instance, Mukhopadhyay et al. (2015) highlighted the heightened vulnerability of manual laborers to musculoskeletal injuries, while Aghilinejad et al. (2016) reported that over 40% of occupational compensation claims were linked to such disorders. These findings illuminate the economic and social costs of ergonomic neglect and point to the urgent need for systemic interventions that address the root causes of work-related injuries.

The efficacy of ergonomic interventions is well documented in several empirical studies. Worker engagement in ergonomic redesign processes has been correlated with higher job satisfaction and reduced fatigue (Ratzon et al., 2016). In construction settings, introducing job rotation, worksite redesign, and assistive devices has led to demonstrable improvements in worker health and operational efficiency (Comper et al., 2017; Shin & Park, 2017). These outcomes underscore the multifaceted benefits of ergonomics—not only in safeguarding worker health but also in enhancing organizational performance.

Nevertheless, the path to implementing ergonomic solutions is fraught with barriers. A critical obstacle lies in the reluctance of both workers and management to adopt new technologies or procedural changes. Jackie et al. (2019) found that skepticism about cost-efficiency and usability often hampers the adoption of exoskeletons and other wearable supports. Voss et al. (2017) and Plessas & Delgado (2018) further observed that inadequate training and user unfamiliarity can negate the intended benefits of such innovations, sometimes even increasing workload instead of alleviating it. These challenges indicate that ergonomic solutions must be integrated into the organizational culture and supported through comprehensive education and training initiatives.

From a technological perspective, the development of wearable ergonomics, particularly exoskeletons, represents a significant advancement in occupational health. These devices are designed to support the musculoskeletal system by redistributing load and reducing physical

exertion (Jackie et al., 2019; Hemati et al., 2020). Although initial studies suggest that exoskeletons may enhance productivity and reduce fatigue (Wurzelbacher et al., 2020), their long-term impact remains insufficiently explored. The variability in user responses and the contextual specificity of work environments necessitate further research to determine the optimal design and deployment strategies for these technologies (Beyan et al., 2020).

Another persistent challenge involves the customization and integration of ergonomic technologies into diverse occupational settings. The success of these interventions depends heavily on user acceptance, ease of use, and alignment with specific job requirements. As reported by Jackie et al. (2019), perceptions of usefulness varied among surgical teams using exoskeletons, illustrating the nuanced interplay between technology design and real-world application. Moreover, without adequate policy frameworks, investment in supportive infrastructure, and ongoing evaluation mechanisms, the scalability of ergonomic technologies remains uncertain (Carlan et al., 2023; Zare et al., 2020).

Despite these developments, significant research gaps remain. There is limited understanding of the long-term physiological and psychological effects of wearable ergonomic interventions. For example, questions persist regarding the impact of sustained exoskeleton use on muscle development, joint function, and user dependency (Tang & Webb, 2018). Additionally, studies on the psychosocial dimensions of technological integration—such as user perception, motivation, and adaptation—are still emerging (Qureshi et al., 2019; Pérez et al., 2021). Addressing these gaps is crucial for informing evidence-based design and policy decisions.

This narrative review seeks to provide a comprehensive synthesis of current knowledge on the application of human factors engineering and ergonomic interventions in workplace health and productivity. Specifically, it aims to identify effective strategies for preventing MSDs among industrial workers and to examine the facilitators and barriers influencing the implementation of these strategies. In doing so, the review contributes to ongoing efforts to enhance occupational health, reduce injury-related costs, and foster a culture of safety and well-being (Comper et al., 2017; Beyan et al., 2020).

The scope of this review encompasses studies conducted in industrial contexts where ergonomic risk factors are prevalent, including heavy manufacturing, healthcare, and agriculture. The target populations include diverse workforce segments characterized by varying levels of physical demand, technological exposure, and socio-demographic attributes. Particular emphasis is placed on high-risk groups, such as healthcare workers, farmers, and factory laborers, who are disproportionately affected by ergonomic hazards (Guan et al., 2013; Swangnetr et al., 2014). Moreover, the review considers how age, gender, and occupational experience mediate the effectiveness of ergonomic interventions (Rasmussen et al., 2017; Hemati et al., 2020).

While the current literature provides valuable insights, broader representation of under-researched populations and geographies is needed to construct a more holistic understanding of ergonomic intervention outcomes. By synthesizing multidisciplinary findings and highlighting best practices, this review emphasizes the importance of evidence-based, context-sensitive ergonomic strategies.

Ultimately, it seeks to support policymakers, practitioners, and researchers in developing sustainable solutions that align with the evolving demands of modern work environments.

METHOD

This narrative review was conducted to explore and synthesize existing literature on the application of human factors engineering and ergonomic interventions in occupational health settings. To ensure comprehensive coverage and academic rigor, the methodology adhered to structured procedures for literature identification, selection, and appraisal, using established databases, defined search strategies, and carefully outlined inclusion and exclusion criteria.

The literature search was primarily carried out using three major academic databases: PubMed, Scopus, and Web of Science. These platforms were selected due to their comprehensive indexing of peer-reviewed articles, including those specifically addressing topics within ergonomics, occupational health, and applied human factors engineering. Each database offered distinct advantages in terms of disciplinary focus and breadth of coverage. PubMed provided access to clinical and biomedical studies, which were particularly useful for examining musculoskeletal health outcomes. Scopus and Web of Science, meanwhile, facilitated the retrieval of multidisciplinary studies, including engineering, health sciences, and applied industrial systems research.

The search strategy combined specific keyword terms and Boolean operators to capture a wide but relevant range of literature. Keywords such as "ergonomics AND human factors," "musculoskeletal disorders AND ergonomic interventions," and "occupational health AND workplace redesign" were frequently used. This strategy allowed the retrieval of articles that explicitly addressed ergonomic intervention outcomes as well as broader human-systems interaction. The search was further refined by limiting the publication dates to studies released within the past 10 to 15 years. This timeframe ensured that the review concentrated on contemporary findings and recent developments, particularly those related to wearable technologies, organizational ergonomics, and participatory interventions in industrial contexts (Jackie et al., 2019; Baker & Jacobs, 2013; Fernández-Gutiérrez et al., 2015).

To maintain methodological consistency, predefined inclusion and exclusion criteria were applied during the selection process. Articles were included if they met the following criteria: (1) they investigated ergonomic interventions or human factors engineering applications; (2) they were conducted in real workplace environments such as factories, construction sites, or healthcare settings; and (3) they adopted empirical research designs such as cohort studies, cross-sectional studies, or randomized controlled trials (RCTs). Studies that examined the impact of ergonomic practices in relation to physical and cognitive health outcomes were also prioritized. This inclusion framework aimed to ensure both relevance and scientific validity, with a strong emphasis on real-world applications and measurable outcomes (Kurowski et al., 2013).

Conversely, several exclusion criteria were established to remove articles that did not align with the objectives of the review. Articles were excluded if they: (1) lacked direct focus on ergonomic or human factors interventions; (2) failed to present empirical data or did not utilize appropriate analytical methods; or (3) were purely theoretical discussions without evidence of implementation or evaluation in occupational contexts. Review articles, editorials, opinion pieces, and conference abstracts were also excluded unless they contained critical empirical findings that met the selection criteria. The rationale behind these criteria was to filter out studies with limited applicability and focus on those contributing concrete findings to the field of ergonomics and occupational health (Sherrod et al., 2013).

The literature selection process began with an initial screening of article titles and abstracts to determine relevance. This phase was critical in eliminating studies that clearly fell outside the scope of the review. The remaining articles underwent full-text review, during which detailed evaluations were conducted against the inclusion and exclusion criteria. The evaluation also considered methodological quality, such as sample size, measurement validity, and analytical rigor. Particular attention was given to studies that implemented interventions within high-risk sectors (e.g., construction, manufacturing, and healthcare) and those that included diverse demographic groups to capture variations in ergonomic impact.

To ensure a robust and unbiased selection, quality appraisal tools were employed throughout the review process. For observational studies and RCTs, standardized checklists were used to assess study quality. These checklists evaluated multiple dimensions, including clarity of research objectives, appropriateness of design, data collection procedures, and validity of outcome measures. For instance, observational studies were assessed using criteria such as representativeness of the study population and adequacy of statistical analysis, while RCTs were evaluated for randomization techniques, control conditions, and blinding procedures. These tools provided a structured framework for ensuring that only high-quality studies were synthesized in the final narrative (Guan et al., 2013; Plessas & Delgado, 2018).

In addition to database searches, backward and forward citation tracking was employed to identify additional studies not captured in the initial queries. This process involved reviewing the reference lists of selected articles and using citation indices to locate newer studies that cited foundational or influential works. This iterative approach was particularly useful in identifying emerging technologies, novel applications of human factors principles, and interdisciplinary studies that may not have been indexed under conventional ergonomic keywords.

Throughout the methodology, emphasis was placed on maintaining transparency, reproducibility, and rigor in the review process. Each phase of literature collection and evaluation was documented to provide an audit trail for future researchers. In this regard, the narrative review not only serves to summarize the existing state of knowledge but also lays a foundation for systematic exploration and meta-analytic inquiries in subsequent studies.

By integrating diverse sources of evidence and applying stringent methodological criteria, this review aims to offer a comprehensive and balanced perspective on the current landscape of

ergonomic interventions and human factors engineering. The methodological rigor ensures that the synthesized findings are grounded in credible empirical research, thereby enhancing their relevance for policy development, workplace design, and health promotion strategies in labor-intensive industries.

RESULT AND DISCUSSION

The findings of this narrative review are organized around four core thematic domains that reflect contemporary priorities and empirical insights in human factors engineering and ergonomic interventions: the advancement of wearable technologies, the efficacy of active rest programs, organizational and spatial ergonomic redesign, and global comparative perspectives on ergonomic practices.

In recent years, the integration of wearable ergonomics, particularly glove-based exoskeletons such as Ironhand, has attracted considerable attention in the domain of occupational health. These technologies are specifically designed to reduce upper limb fatigue and lower the risk of work-related musculoskeletal disorders (WMSDs), particularly in occupations involving repetitive or static hand movements. Jackie et al. (2019) demonstrated that exoskeleton usage in surgical environments resulted in significant decreases in perceived physical exertion among healthcare workers, supporting their posture during prolonged static tasks. The study highlighted that muscle fatigue reduction and load redistribution are central outcomes, suggesting that ergonomic wearables can serve as effective preventive tools in physically intensive jobs.

User evaluations also play a critical role in determining the success of such technologies. According to Beyan et al. (2020), workers initially expressed hesitance toward the exoskeleton, reporting unfamiliarity and discomfort. However, following adaptation and regular use, the majority of participants acknowledged improved comfort and reduced physical strain. These subjective experiences affirm the importance of user-centered design in enhancing the long-term acceptance of wearable ergonomic technologies.

Beyond mechanical assistance, workplace wellness can be significantly improved through behavioral interventions such as active rest programs. These initiatives often integrate short bursts of physical activity into daily routines and are supported by a growing body of evidence underscoring their impact on musculoskeletal health. Hemati et al. (2020) found that active rest breaks, when systematically embedded into workplace routines, led to notable reductions in muscular discomfort and fatigue, especially among workers exposed to prolonged sitting or standing. Arias et al. (2023) further supported these conclusions, revealing that participants who engaged in daily exercise-based breaks demonstrated higher alertness and reduced absenteeism.

In addition to reducing discomfort, active health promotion programs have demonstrated broader organizational benefits. Erliana et al. (2023) showed that integrated health promotion—comprising education, physical activity, and injury prevention—resulted in improved mental well-being and increased productivity. These findings indicate that interventions aimed at reinforcing physical health can simultaneously foster psychological resilience and workplace engagement, with

employees reporting greater satisfaction and a perceived sense of support from their organizations. Tang and Webb (2018) emphasized that this sense of empowerment directly contributed to a decline in work-related injuries, reaffirming the dual benefits of such interventions.

Workplace redesign also emerged as a pivotal strategy in improving employee health and optimizing organizational outcomes. Programs such as UP150, which emphasize spatial reorganization and employee mobility, have been shown to significantly impact both physiological and psychological health indicators. Wanyonyi et al. (2015) found that ergonomic workplace modifications—ranging from desk layout changes to the inclusion of activity zones—contributed to improvements in metabolic health, including reduced blood glucose levels and lower risks of cardiovascular conditions. Simultaneously, reduced musculoskeletal complaints were observed, particularly in lower back and shoulder regions, areas commonly affected by sedentary behaviors.

Psychological health also benefited from participatory redesign efforts. Sherrod et al. (2013) noted that workplace interventions aimed at encouraging movement and social interaction led to increases in self-reported mental wellness and job satisfaction. Employees frequently associated redesigns with a heightened sense of workplace support, an improved sense of autonomy, and increased motivation to maintain health-oriented behaviors. According to Wanyonyi et al. (2015), these results illustrate the psychosocial dividends of investing in worker-centered environmental design.

Complementary findings were presented by Carr et al. (2016), who analyzed the introduction of adjustable sit-stand desks within office environments. The study documented a 14% increase in daily physical activity among employees who adopted the new workstation format. This shift was accompanied by decreased physical complaints, especially in the lumbar region, and enhanced cognitive function, as reported in follow-up surveys. Lin et al. (2017) reinforced these observations, demonstrating that workplace designs that minimize sedentary postures contribute to reductions in musculoskeletal symptoms while increasing concentration and energy levels throughout the workday.

Further, Radas et al. (2013) explored the influence of spatial configurations on spontaneous physical movement. Their study concluded that workspaces allowing easy transitions between workstations and communal areas significantly encouraged incidental movement, helping mitigate the negative health effects of extended sedentary behavior. This evidence supports the notion that ergonomics must encompass not only physical tools and programs but also environmental factors that shape behavior unconsciously.

The effectiveness of ergonomic interventions also varies across geopolitical contexts. In developed countries, such as those under the regulatory frameworks of OSHA and EU-OSHA, the implementation of ergonomic guidelines is supported by both policy and technological infrastructure. These countries typically benefit from well-funded programs, stronger workplace protections, and robust training mechanisms. For instance, Fernández-Gutiérrez et al. (2015) documented reductions in WMSDs following the national adoption of ergonomic mandates in European manufacturing plants, confirming the potential of legislative support to drive compliance and health outcomes. Jakobsen et al. (2016) similarly noted the role of systematic surveillance and follow-up in ensuring the sustainability of ergonomic interventions.

However, the situation is markedly different in developing countries. Implementation efforts are often constrained by limited financial resources, insufficient training, and lack of awareness among both workers and managers. In Kenya, for example, Wanyonyi et al. (2015) reported that while ergonomic devices were introduced in some workplaces, the absence of participatory frameworks and adequate user training significantly limited their impact. These disparities underline the importance of context-sensitive ergonomic models that consider local socio-economic conditions and cultural perceptions of workplace safety.

Moreover, cross-national studies of behavior-based ergonomic training have illuminated significant patterns in worker response and organizational uptake. Chanchai et al. (2016) reported that ergonomics training incorporating behavioral insights—such as self-monitoring, peer modeling, and goal-setting—significantly reduced self-reported MSD symptoms. Importantly, the success of these programs was amplified in environments where leadership commitment and feedback systems were in place. In more industrialized settings, these programs were often augmented with digital feedback tools, providing real-time guidance on posture and motion patterns.

Conversely, in resource-limited settings, ergonomic training has primarily functioned as an awareness tool rather than a catalyst for systemic change. Comper et al. (2017) observed that without follow-up mechanisms and organizational reinforcement, the knowledge gained during training sessions failed to translate into practice. These findings emphasize the necessity of organizational alignment and long-term investment to ensure that training interventions produce measurable health and performance outcomes.

Collectively, the reviewed literature highlights that ergonomic interventions—whether technological, behavioral, or spatial—require integrated support systems, active employee involvement, and context-sensitive design to achieve their full potential. Cross-sectional comparisons between developed and developing countries further reveal that the scalability and efficacy of interventions are highly contingent upon institutional commitment, resource availability, and worker engagement. By grounding ergonomic innovations in participatory frameworks and evidence-based practices, organizations across contexts can improve worker health, boost morale, and foster sustainable productivity.

The synthesis of evidence from this narrative review reinforces the critical role of ergonomic interventions and human factors engineering in shaping occupational health and organizational effectiveness. The discussion draws connections between empirical findings and systemic workplace dynamics, demonstrating that well-designed ergonomic strategies are not only beneficial for workers' physical well-being but also serve as enablers of corporate health and safety policy compliance and productivity.

A key insight from the reviewed literature is the alignment between ergonomic intervention outcomes and occupational health and safety (OHS) policies. In contexts such as healthcare environments in Kenya, ergonomic interventions have been found to elevate managerial awareness of musculoskeletal risks, thereby encouraging improved workplace safety regulations (Wanyonyi et al., 2015). This dynamic mirrors findings from Guan et al. (2013), who documented how global discourse on MSDs can stimulate national policy reforms, particularly in agricultural sectors where

ergonomic risks are often under-regulated. These findings illustrate the policy feedback loop in which successful ergonomic interventions contribute to the evolution of workplace health regulations and, in turn, reinforce broader institutional frameworks for worker protection.

Participatory ergonomic approaches have emerged as especially effective in enhancing compliance with OHS policies. Jakobsen et al. (2016) emphasized that involving workers in the co-design and implementation of ergonomic solutions significantly improves both the uptake and sustainability of such initiatives. Worker participation builds a shared sense of responsibility and ownership, which reduces resistance to change and aligns organizational behavior with safety objectives. By embedding ergonomic thinking into the organizational culture, companies can foster environments that promote health-conscious practices and inclusive decision-making.

Despite this potential, systemic barriers frequently undermine the successful deployment of ergonomic interventions. Cultural, financial, and structural factors form a triad of constraints that prevent many organizations from fully realizing the benefits of ergonomics.

Cultural resistance often originates from a lack of ergonomic literacy among both employees and management. Jackie et al. (2019) observed that limited awareness of the benefits of ergonomic changes, compounded by reluctance to abandon familiar work routines, inhibits the adoption of innovative solutions. This resistance is particularly salient in hierarchical or risk-averse organizations where new approaches are perceived as disruptive rather than supportive. Moreover, when workers are excluded from the decision-making process, their disengagement further weakens the effectiveness of interventions, underscoring the importance of inclusive workplace strategies.

Financial constraints also present formidable obstacles. Although ergonomic tools such as exoskeletons or height-adjustable desks offer substantial long-term benefits, the upfront investment can be prohibitive for resource-constrained organizations. Jakobsen et al. (2016) reported that the high costs of ergonomic equipment and insufficient financial planning often deter hospital administrations from adopting such tools, even when their potential to reduce work-related injuries is well established. Organizations driven by short-term financial performance may deprioritize long-term investments in worker health, despite mounting evidence that ergonomic improvements can yield significant returns through reduced absenteeism and enhanced productivity.

Structural limitations compound these challenges. Beyan et al. (2020) highlighted that many institutions lack formalized procedures or infrastructural readiness to support ergonomic innovations. Without comprehensive evaluation frameworks, interdepartmental coordination, or dedicated ergonomic roles, even well-intentioned interventions risk failure. In such contexts, isolated ergonomic efforts may struggle to achieve systemic change, and fragmented implementation may lead to inconsistent results. A holistic strategy, integrating risk assessment, education, and policy design, is essential to embed ergonomics within the operational fabric of organizations.

Addressing these barriers requires a multi-pronged response rooted in evidence-based practices and institutional commitment. First, worker participation remains a cornerstone of sustainable ergonomic interventions. Jakobsen et al. (2016) found that when workers are engaged in the design,

piloting, and feedback loops of ergonomic solutions, they are more likely to adopt new practices and advocate for their peers. This engagement promotes not only compliance but also adaptation, enabling interventions to be tailored to specific occupational contexts.

Second, the adoption of multifaceted ergonomic approaches yields superior outcomes compared to singular interventions. Beyan et al. (2020) advocated for integrated strategies that encompass environmental design, training, behavioral reinforcement, and organizational restructuring. Ergonomic initiatives that are narrowly focused—such as standalone workshops or isolated technology upgrades—often fail to address the complex interactions between physical, cognitive, and organizational factors contributing to MSD risk. By contrast, comprehensive programs are more resilient to variability in work tasks and workforce characteristics, thus maximizing their reach and effectiveness.

Ongoing monitoring and evaluation also play a critical role in maintaining the effectiveness of ergonomic programs. As Radas et al. (2013) observed, longitudinal tracking of sedentary behavior in university workers enabled iterative improvements to workspace layout and health promotion activities. Such adaptive frameworks ensure that ergonomic interventions remain responsive to emerging needs and changing organizational dynamics. They also facilitate evidence accumulation, enabling organizations to make data-driven decisions and refine interventions over time.

Technological integration offers additional promise. As noted in studies by Jackie et al. (2019) and Lin et al. (2017), innovations such as wearable devices, sit-stand desks, and automation systems can significantly reduce physical load and promote worker comfort. However, technological adoption must be complemented by user education and systemic support to prevent underutilization. If workers do not understand the intended benefits or feel that new devices disrupt workflow, the potential of these tools may be unrealized. Technology should thus be embedded within broader ergonomic frameworks that include feedback, support, and adaptation mechanisms.

Furthermore, education and continuous training are indispensable for sustaining ergonomic awareness and behavior change. Tonelli et al. (2014) found that regular educational sessions on ergonomic principles and tool usage significantly improved compliance and proactive behavior among workers. Training must go beyond one-time sessions and be reinforced through visual cues, peer mentorship, and managerial support. Creating a culture of lifelong learning in ergonomics encourages self-monitoring and iterative improvement, essential attributes for effective risk management in dynamic work environments.

Despite the wealth of evidence supporting ergonomic interventions, several limitations in the existing literature warrant attention. Many studies are conducted in high-resource settings, limiting the generalizability of findings to under-resourced contexts. Additionally, short-term follow-up periods are common, leaving questions about the durability of ergonomic benefits over time. Future research should prioritize longitudinal studies in diverse settings and focus on understanding the psychosocial dimensions of ergonomic adoption, including trust, motivation, and perceived autonomy. Such insights will deepen our understanding of the human side of human factors engineering, ensuring that interventions are not only technically sound but also socially sustainable.

The complex interplay of workplace systems, cultural norms, and economic constraints necessitates a nuanced approach to ergonomic intervention design and implementation. By situating ergonomic practices within broader organizational and policy ecosystems, practitioners and researchers can unlock their full potential to safeguard worker health, empower employee agency, and enhance organizational resilience in an evolving labor landscape.

CONCLUSION

This narrative review highlights the significance of human factors engineering and ergonomic interventions as foundational strategies for enhancing worker health, safety, and productivity across industrial settings. The findings underscore the efficacy of wearable technologies such as exoskeletons, active rest programs, and office redesigns in reducing musculoskeletal strain, promoting physical activity, and improving psychological well-being. Furthermore, comparative insights revealed that participatory, multifaceted approaches yield superior outcomes, especially when integrated into supportive policy environments. Despite these promising outcomes, systemic barriers—including cultural resistance, financial constraints, and structural inefficiencies—continue to hinder widespread adoption.

The urgency of addressing work-related musculoskeletal disorders calls for policy-driven action that prioritizes preventive strategies and invests in long-term ergonomic solutions. Organizations must implement participatory frameworks, allocate sufficient resources for ergonomic innovation, and embed ergonomic principles into their structural policies. Additionally, continuous training and evaluation mechanisms should be institutionalized to adapt interventions over time and maintain effectiveness.

Future research should focus on longitudinal studies across diverse occupational settings, particularly in low-resource environments, to better understand the psychosocial dynamics of ergonomic adoption. There is also a pressing need to explore adaptive technologies and inclusive policy models that align with various worker demographics and workplace structures. Emphasizing worker-centered ergonomic strategies remains a vital pathway to overcoming health and safety challenges in modern workplaces.

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