Preventia: The Indonesian Journal of Public Health
ISSN: 2528-2999 (Print): 2528-3006 (Online)
DOI: 10.17977/um044v10i12025p58-73

Improving Worker Health and Productivity: A Systematic Review of Participatory Ergonomics in Construction

Agung Raharjo*, Januar Ariyanto, Farahul Jannah
Universitas Pembangunan Nasional Veteran Jakarta, Jl, RS Fatmawati, Jakarta, 1245, Indonesia
*Authors correspondence, agungraharjo@upnvj.ac.id

ARTICLE INFO

ORCHID ID
Author 1: http://orcid.org/0009-0007-7982-1029
Author 2: http://orcid.org/0000-0002-9163-8784
Author 3: http://orcid.org/0009-0005-7441-3611

Article History:
Paperreceived: 18-06-2025
revised: 27-06-2025
accepted: 29-06-2025

Keywords:
Participatory ergonomics; MSDS; construction; health outcomes

ABSTRACT

The construction industry is recognized to be physically demanding and is characterized by a range of occupational safety and health issues, including musculoskeletal disorders (MSDs) arising from repetitive movements, prolonged static postures, and physically strenuous working conditions. Participatory ergonomic interventions in which workers are involved in the formulation of the problems have been recommended as effective interventions to increase productivity and health in industries. The objective of this literature review is to explore the effects of participatory ergonomics on health outcome and productivity measures in construction. The review followed the PRISMA 2020 guidelines and included nine studies which examined various ergonomic intervention approaches. Results indicated positive improvement in the reduction of MSDs and fatigue when there was high worker engagement. However, some studies reported limited effects on overall health or productivity. In conclusion, while participatory ergonomics shows potential, its long-term effectiveness depends on worker engagement, intervention design, and consistent implementation, indicating the necessity of a common language for outcome measure and long-term follow-up in future studies.

1. Introduction

Construction work is one of the risky jobs in the world, and workers are exposed to various health and safety hazards including musculoskeletal disorders (MSDs). MSDs account for a high proportion of injuries mainly due to the repetitive lifting of heavy loads, awkward posture, and exposure to prolonged and intense physical work. Studies have consistently demonstrated that constructions workers have significantly higher prevalence of MSDs as compared to workers in other industry sectors, emphasizing the paramount need for effective intervention measures to mitigate the impact of these (Mishra et al., 2024; Reddy et al., 2016). Apart from MSDs, fatigue and physical strain lead the risk of workplace accidents, underscoring the essential requirements for through safety intervention in construction setting (Ibrahim et al., 2023).

To address these problems, one way to ensure health and safety of workers is to implement participatory ergonomic (PE) interventions. These interventions emphasize the active involvement of workers in the identification of ergonomic risks and the formulation of customized solutions to mitigate them. Changing workstations, introducing ergonomic tools, and teaching people how to prevent injury are all components of participatory ergonomics provided it has involvement of workers during the process (Burgess-Limerick, 2018; Van Der Molen et al., 2005). Participatory ergonomic interventions have been shown in a number of studies to provide health benefits such as reduced musculoskeletal pain and increased overall worker comfort (Rasmussen et al., 2020; Rivilis et al., 2008a). Furthermore, engaging workers in the process also generates a sense of ownership and raises the likelihood of sustainable behavior change and thus both better health status and productivity (Sukapto et al., 2019).

Although participatory ergonomics show promise, the evidence concerning its efficacy in the construction sector remains inconclusive. Certain studies indicate substantial decrease in MSDs related symptoms and enhancement in worker productivity, whereas others observe no significant alterations in health outcomes or job performance (Van Der Molen et al., 2005; Visser et al., 2018). The difference among the findings can be ascribed to variations in study designs, intervention types, and measurement methodologies, resulting in a deficiency in our comprehension of the most effective strategies for the implementation of participatory ergonomics in construction workplace. There have been a few reviews on participatory ergonomics in general workplace settings. For instance, a systematic review investigating the efficacy of participatory ergonomics interventions on health outcomes analyze general occupations without concern specifically on the construction industry, exploring the correlation between PE and health outcomes (Rivilis et al., 2008b). Another review, PE approaches to design and intervention in workspace, examined the broad application of PE frameworks within organizations, emphasizing the challenges encountered during implementation (Rodrigues & Rocha, 2023). Furthermore, bibliometric studies have examined leadership styles in PE programs, concentrating on the impact of leadership on PE implementation however, this research does not address the specific nuances of PE in construction (Schall & Michel, 2020). These reviews underscore the lack of literature reviews focused on the construction sector. This gap demonstrates a lack of understanding of how PE can be tailored for the unique construction industry challenges.

This systematic review aims to fill these gaps by synthesizing all the existing research that has been undertaken on participatory ergonomic interventions in the construction industry. The two primary research questions to be answered by this review will be: What is the effect of PE interventions on MSDs health of Construction Workers? How do these interventions affect workers' health and productivity?

2. Method

2.1 Design and Search Strategy

In order to achieve the aim of our research we carried the systematic literature review following the PRISMA 2020 guidelines (Page et al., 2021). In May 2025, a literature review was conducted to identify studies about participatory ergonomics and its effects on construction workers. The search was conducted across multiple databases, including PubMed, Google Scholar, Scopus, and ScienceDirect. These databases were selected for their high relevance to occupational health and ergonomics, as well as their credibility in indexing peer-reviewed scientific literature. Additionally, they are among the most widely used and accessible databases for researchers in Indonesia, ensuring practicality and representativeness for this review

The search strategy used a Boolean method for all the databases. The first search, which was done on Scopus, used the following query : TITLE-ABS-KEY(("participatory ergonomics" OR "worker participation in ergonomics" OR "employee involvement in ergonomics") AND ("construction workers" OR "construction industry" OR "construction laborers" OR "building trades" OR "manual labor") AND ("musculoskeletal disorder" OR "injury prevention" OR "health outcomes" OR "fatigue" OR "workplace injury" OR "physical workload")). The second search on ScienceDirect utilized the following query: ("participatory ergonomics" OR "worker participation in ergonomics" OR "employee involvement in ergonomics") AND ("construction workers" OR "construction industry" OR "construction"). The third search was conducted in PubMed using the search terms: ("participatory ergonomics" OR worker AND participation AND ergonomics OR employee AND involvement AND ergonomics) AND ("construction workers" OR "construction industry" OR "construction laborers" OR "building trades" OR "manual labor") . A final search was performed on Google Scholar utilizing the query: allintitle: participative ergonomics construction. Google Scholar was used as a supplementary source in this review. To minimize the inclusion of non-peer-reviewed or lower-quality publications, a restrictive query (using “allintitle”) was applied. This was necessary because Google Scholar indexes a wide variety of document types with variable levels of quality control, unlike curated databases such as PubMed, Scopus, and ScienceDirect

The search was limited to articles published in English and restricted to peer-reviewed journal articles to guarantee the quality and reliability of the included studies. Non-journal sources, including book chapters, conference papers, and unpublished manuscripts, were omitted.

2.2 Study Selection

All articles obtained from the chosen databases were exported into a reference management program (Zotero), where duplicates were removed. A systematic multi-phase screening procedure was established to verify that the articles conformed to the requisite inclusion and exclusion criteria as per PRISMA flowchart (Page et al., 2021). Initial screening of titles and abstracts was performed independently by two authors. Subsequently, selected articles underwent eligibility screening based on full-text review. Any discrepancies between the two authors were resolved by a third author

2.3 Inclusion and exclusion criteria

An eligibility criteria for this review were developed using the PICO (Population, Intervention, Comparison, Outcome) framework. The aim of the review was to evaluate the effectiveness of participatory ergonomic interventions in improving health outcomes for construction workers. The inclusion and exclusion criteria are outlined in

Table 1 Inclusion and Exclusion Criteria. No limits were placed on the publication year, allowing studies from any time period to be considered, provided they met the other criteria

Table 1 Inclusion and Exclusion Criteria

Criteria	Inclusion Criteria	Exclusion Criteria
Population (P)	Construction workers or employees in related sectors (e.g., civil engineering, building trades, manual labor) who have been involved in ergonomic interventions.	Non-construction workers, workers in non-physical or less physically demanding occupations (e.g., office workers).
Intervention (I)	Participatory ergonomic interventions, including training programs, workstation changes, collaborative design of ergonomic strategies, and employee involvement in safety training.	Non-ergonomic interventions (e.g., safety training unrelated to ergonomic practices).
Comparison (C)	Workers exposed to participatory ergonomic interventions compared to those in control groups, or within-group pre- and post-intervention comparisons in quasi-experimental studies.	Studies with no comparison group or non-participatory interventions.
Outcomes (O)	Health outcomes (e.g., reduction in musculoskeletal disorders, injury prevention, absenteeism), and intermediate outcomes (e.g., knowledge, attitude, and behavioral changes related to ergonomic practices).	Studies reporting only non-health-related outcomes (e.g., economic performance without consideration of health).
Study Design	Randomized controlled trials (RCTs), controlled before-and-after studies (CBA), quasi-experimental studies, pre-post studies	Non-experimental studies, observational studies.
Language	English	Studies published in languages other than English.
Setting	Workplaces in construction or related industries (e.g., civil engineering, building trades) within any country.	Studies conducted in non-physical or non-construction environments.

Source: Primary Data, 2025

2.4 Critical Appraisal

Randomized controlled trial were assessed for quality using the Joanna Briggs Institute (JBI) Checklist (Barker et al., 2023) which evaluates studies against 13 criteria. Pre-post studies were assessed using the National Institute of Health Quality Assessment Tool (National Institute of Health, 2021) for Before-After (Pre-Post) Studies, which evaluates studies against 12 criteria and provides an overall rating of good, fair, or poor quality. Disagreements were resolved through discussion, and if necessary, a third reviewer was consulted. Articles deemed poor were classified as having lower methodological quality and were consequently excluded.

2.5 Data Extraction and Synthesis

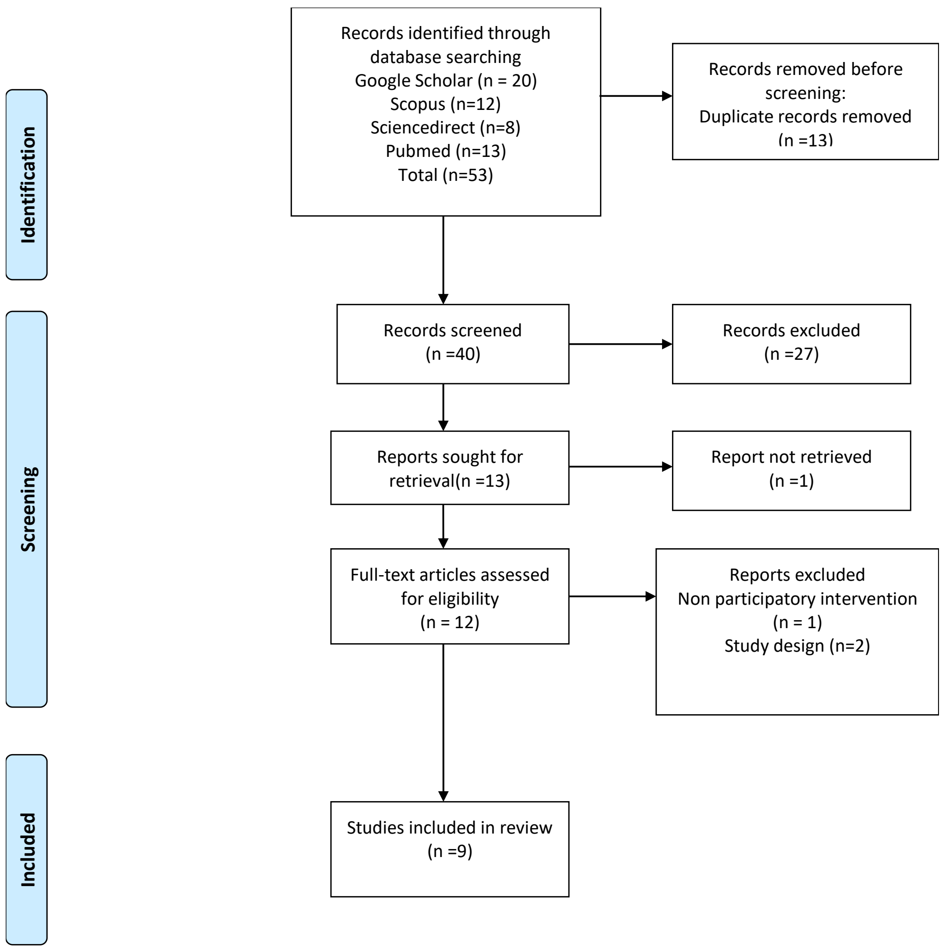
Data was extracted by two authors using a standardized extraction form. Key data points were systematically extracted, including study characteristics such as the author, year of publication, country, and study design. Population characteristics, including sample size, worker demographics (such as age and sex), and the nature of the workplace (e.g., construction or related industries) were also recorded. Intervention details, such as the type of ergonomic intervention (e.g., training programs, workstation changes), along with the duration and frequency of the intervention, were collected. Outcome measures, including health outcomes (such as the reduction in musculoskeletal disorders, injury prevention, and absenteeism), productivity outcomes, and follow-up periods, were also extracted. Data were synthesized using a narrative approach.

3. Result and Discussion

3.1 Study Inclusion

Initially, 53 documents were identified from database searches across four platforms: Google Scholar (n=20), Scopus (n=12), ScienceDirect (n=8), and PubMed (n=13). Following the elimination of 13 duplicate records, a total of 40 records were evaluated by two reviewers based on their titles and abstracts. In the second stage, full-text papers of research deemed relevant or potentially relevant were pursued for retrieval. On the 13, 1 article was not obtained. A total of 12 full-text articles were reviewed and evaluated for eligibility according to the inclusion criteria. Articles that did not satisfy the eligibility criteria were excluded from the review. Exclusions were implemented due to non-participatory interventions (1 article) or unsuitable study designs (2 articles). The selection process resulted in a final sample of 9 studies. Source: Primary Data, 2025

Figure 1 presents a flowchart that delineates the selection process



Source: Primary Data, 2025

Figure 1 Screening process of systematic review using PRISMA flowchart

3.2 Methodological quality

Figures 2 and 3 show the results of the quality evaluation of the studies using the Quality Assessment Tool as per study design. For the Pre-Post Studies, the quality of the studies was generally rated as Good or Fair. The studies by Zhang & Lin (2024) and Dale et al. (2012) were evaluated as Good quality by rater (Dale et al., 2012; Zhang & Lin, 2024). These studies met the prespecified criteria, including a clear research question, appropriate participant selection, and consistent intervention delivery. The outcome measures were clearly defined, which contributed to the quality of rating.

However, the studies by Dale et al. (2016) and Hess et al. (2004) were rated as fair. Some methodological weaknesses were identified (Dale et al., 2016; Hess et al., 2004). Specifically, Dale et al. (2016) did not provide sufficient information on statistical analysis of the pre-to-post changes, and Hess et al. (2004) faced issues with blinding and follow-up procedures (Dale et al., 2016; Hess et al., 2004).

For the Randomized Controlled Trial (RCTs), there was uniformity of response across the studies to the checklist items. A common limitation among the studies was the lack of blinding. Allocation concealment and baseline imbalance were also issues. Two studies were randomized (Brandt et al., 2018; Van Der Molen et al., 2005), and one showed unclear allocation concealment, a key component for addressing selection bias (Visser et al., 2018).

Assessment item	(Zhang & Lin, 2024)	(Dale et al., 2012)	(Dale et al., 2016)	(Jensen & Friche, 2007)	(Jaegers et al., 2014)	(Hess et al., 2004)
Item 1	✓	✓	✓	✓	✓	✓
Item 2	✓	✓	✓	✓	✓	✓
Item 3	✓	✓	✓	✓	✓	✓
Item 4	✓	✓	✓	✓	✓	✓
Item 5	✓	✗	✗	✓	✗	✗
Item 6	✓	✓	✓	✓	✓	✓
Item 7	✓	✓	✓	✓	✓	✓
Item 8	✗	✗	✗	✗	✗	✗
Item 9	✓	✓	✓	✓	✓	✓
Item 10	✓	✓	✓	✓	✓	✓
Item 11	✓	✗	✓	✗	✗	✓
Item 12	✓	✓	✓	✓	✗	✗

Source: Secondary Data, 2025

Figure 2. Summary of quality appraisal on pre-post design (I1: Study Question Clearly Stated (Clarity Bias); I2: Eligibility/Selection Criteria Defined (Selection Bias); I3: Representativeness of Participants (External Validity); I4: Participation of All Eligible Subjects (Selection Bias); I5: Adequacy of sample size (Statistical Power Bias); I6: Detailed Description and Consistent Execution of Intervention (Implementation Bias); I7: Outcome Measures Defined, Valid, and Consistent (Measurement Bias); I8: Outcome Assessors Blinded to Exposures (Detection Bias); I9: Addressed Loss to Follow-Up (≤20%) (Attrition Bias); I10: Statistical Methods for Pre-Post Outcome Change (Analysis Bias); I11: Multiple

Outcome Measures Pre/Post Intervention (Design Bias); I12: Group-Level Intervention with Individual-Level Analysis (Design Bias).

Assessment item	(Brandt et al., 2018)	(Visser et al., 2018)	(van der Molen et al., 2005)
Item 1	✓	✓	✓
Item 2	✓	~	✓
Item 3	✗	✓	✓
Item 4	✗	✗	✗
Item 5	✗	✗	✗
Item 6	✓	✓	✓
Item 7	✓	✗	✓
Item 8	✓	✓	✓
Item 9	✓	✓	✓
Item 10	✗	✗	✓
Item 11	✓	✓	✓
Item 12	✓	✓	✓
Item 13	✓	✓	✓

Source: Secondary Data, 2025

Figure 3 Summary of quality appraisal for RCT studies (I1: True Randomization for Assignment to Treatment Groups (Selection Bias); I2: Allocation Concealment (Selection Bias); I3: Treatment Groups Similar at Baseline (Baseline Bias); I4: Participants Blind to Treatment Assignment (Performance Bias); I5: Those Delivering the Treatment Blind to Assignment (Performance Bias); I6: Identical Treatment for Groups Other Than Intervention (Performance Bias); I7: Outcome Assessors Blind to Treatment Assignment (Detection Bias); I8: Outcomes Measured Consistently Across Treatment Groups (Measurement Bias); I9: Reliable Measurement of Outcomes (Measurement Bias); I10: Complete Follow-Up and Analysis of Differences (Attrition Bias); I11: Participants Analyzed in Their Randomized Groups (Analysis Bias); I12: Trial Design Appropriate and Deviations Accounted For (Design Bias).

3.3 Overview of Studies

A total of nine studies were included in this review, each assessing the impact of participatory ergonomic interventions on health outcomes and productivity for construction workers. The studies employed a range of designs, including pre-post designs, and randomized controlled trials (RCTs). The sample sizes varied considerably, ranging from smaller ones such as the 16 workers in Dale et al. (2012) to larger studies with 292 workers, as seen in Jensen & Friche (2007). The interventions themselves covered various ergonomic approaches, from the use of new tools and workstation modifications to broader participatory strategies involving training programs and workplace redesigns. A summary of findings is presented in Table 2.

Table 2 Characteristics and finding participatory ergonomic intervention at construction

Author, Year	Country	Study Design	Population characteristic	Intervention Details	Outcome measure	Finding
(Brandt et al., 2018)	Denmark	Cluster RCT	80 male workers (age 19-67)	3 phases of workshops	Health: Fatigue, Workload; Productivity: Influence on work	No significant change in physical workload; significant reduction in fatigue (p = 0.001) and increase in work influence (p = 0.04). Statistically significant results at follow-up.
(Zhang & Lin, 2024)	USA (Pacific Northwest)	Pre-Post	106 workers surveyed; 42 for follow-up	Duration : 4.5 years ; intervention : ergonomic awareness, skill training, workplace redesign	Short-term: Worker knowledge; Medium-term: Teamwork, job rotation	Significant improvement in ergonomic knowledge and worker confidence; zero injuries from cart handling post intervention; substantial cost savings
(Hess et al., 2004)	USA	Quasi-experimental pretest-posttest design	4 laborers evaluated with Lumbar Motion Monitor (LMM), 10 in focus groups	Duration: 6-8 weeks during concrete placement phases Type: Introduction of skid plates (60 cm diameter metal disks) placed under concrete hose couplings	Health: Low-back kinematics, LBD risk; Productivity: Worker effort	Significant reduction in LBD risk (67% to 46%), decreased lateral and twisting velocity ($p<0.001$), improved worker satisfaction and ease of use.

Author, Year	Country	Study Design	Population characteristic	Intervention Details	Outcome measure	Finding
(Dale et al., 2012)	USA	Pre-Post	Sample Size: 16 workers (floor layers)	Duration: 3 months Phase I: Ergonomic training; Phase II: Problem-solving facilitation	Health: Discomfort (back/wrist pain); Productivity: Task modification	Significant reduction in discomfort, with 92 ergonomic solutions identified and 86% knowledge retention. Workers preferred interactive training.
(Visser et al., 2018)	Netherlands	Cluster Randomized Trial	277 workers from 12 construction companies	F2F and e-Guidance strategies with ergonomics consultant, 6-month duration	Health: Knowledge, attitude, culture; Behavioral Change	Low engagement (1%) and compliance with interventions. F2F strategy showed more knowledge improvement; e-guidance improved culture. Suggest combining both strategies.
(van der Molen et al., 2005)	Netherlands	Cluster RCT	118 bricklayers (65 intervention, 53 control)	Duration: 6 months • Frequency: Ongoing intervention over 6 months Consultant-guided participatory ergonomics strategy	Health: Ergonomic measure use; Behavioral: Self-efficacy	No significant difference in ergonomic measure use; improvement in self-efficacy (p = 0.021). Low compliance with intervention steps.
(Dale et al., 2016)	USA	Pre-Post	Sample Size: 95 workers Age: Mean 40 years (range 19 to 60) Occupation: Floor layers, sheet metal workers, carpenters	Duration: 3 months Intervention : Multiple ergonomic training sessions, task analysis,	Health: MSD symptoms, pain, discomfort; Behavioral change	No significant change in MSD symptoms or discomfort; significant short-term improvements in

Author, Year	Country	Study Design	Population characteristic	Intervention Details	Outcome measure	Finding
				tool provision		ergonomic skills and willingness to try new tools ($p<0.05$).
(Jensen & Friche, 2007)	Denmark	Pre-Post	Sample Size: 292 floor layers Age: Mean 37 years (range 17 to 61)	Duration: 3 months Training: 2-day courses	Health: Knee pain; Productivity: Work quality	Significant reduction in knee pain for users of new methods ($p < 0.0001$); no significant impact on work quality or productivity.
(Jaegers et al., 2014)	USA	Pre-Post	Sample Size: 25 floor layers Industry: Construction (floor layers)	Duration: 3 to 4 months Intervention: Ergonomics training, researcher-led, worker-led meetings, and one-on-one interactions	Health: MSD symptoms; Behavioral: Adoption of ergonomic tools	Increased awareness and adoption of ergonomic methods; 83% of workers changed work methods to reduce physical strain.

Source: Secondary Data, 2025

3.4 Health Outcomes

The most common health outcomes assessed were musculoskeletal disorders (MSDs) and fatigue. In the study by Brandt et al. (2018), the intervention led to a significant reduction in general fatigue ($p = 0.001$), though no significant change in physical workload was observed ($p = 0.75$) (Brandt et al., 2018). Similarly, Dale et al. (2012) found that workers who used ergonomic tools, such as extended handles for spray cans and electric carpet pullers, reported a significant reduction in discomfort from back and wrist pain (Dale et al., 2012). Workers expressed high satisfaction with these interventions, indicating that not only did these ergonomic modifications help alleviate pain, but they also contributed positively to overall worker comfort.

In research conducted by Jensen & Friche (2007), workers who implemented newly introduced ergonomic technique experience a substantial decrease in knee pain ($p < 0.0001$), while tool utilization surge significantly, from 13% to 86% (Jensen & Friche, 2007). This result demonstrates that ergonomic interventions may have a positive effect not only on physical health but also on ergonomic methods used. Van der Molen et al. (2005) found that the intervention had increased self-efficacy and skills in the application ergonomic measures but found no significant difference in the number of people who apply these measures between the two groups (van der Molen et al., 2005).

3.5 Productivity Outcomes

Productivity effects from ergonomic change interventions were assessed using several lenses including injury, productivity and employee perceptions of workload. Zhang and Lin (2024) found that no injuries due to cart handling occurred after implementation while there were improvements in teamwork and in performing housekeeping and better task planning (Zhang & Lin, 2024). Hess et al. (2004) found a lower degree of biomechanical issues with workers demonstrating less turning and lateral velocities ($p<0.001$). These findings support the position that workers experienced less physical stress which leads to increased comfort and illustrates the principle that ergonomics can be introduced in a manner which does not disrupt the process (Hess et al., 2004).

Compliance with productivity based intervention improves the outcome, however the adherence to the intervention was very low and that reduced its effectiveness overall(Visser et al., 2018). However, face-to-face guidance led to improvements not only in knowledge but also in workplace culture around the adoption of ergonomics practices, which are longer lasting shifts in attitudes toward organizational ergonomics than mere compliance.

3.6 Worker Engagement and Satisfaction

In all the studies, worker engagement and satisfaction were crucial in assessing how well ergonomics procedures were implemented. As reported by Dale et al. (2016), workers were expressed satisfaction with both the ergonomic equipment they received, and the training offered to them. The participants noticed 92 solutions during the program (Dale et al., 2016). After the training, 86% of workers reported remembering the information and expressed intent to continue using the tools provided to them. Even with these positive outcomes, however, due their lack of pain relief or symptom improvement on follow-up, enduring effects on musculoskeletal symptoms remain uncertain.

On the other hand, Visser et al. (2018) noted particularly low e-guidance participant satisfaction as a result of minimal contact and lack of subsequent interaction (Visser et al., 2018). Workers who had been guided in person demonstrated higher satisfaction levels and greater participation in the interventions reinforcing the need for personal contact and follow up support to maximize effectiveness of ergonomic interventions.

The objective of this systematic review is to examine, by means of participatory ergonomics interventions, the effect on health outcomes, particularly MSDs and productivity and well-being in the construction industry. The results suggest that participatory ergonomics can decrease health-related symptoms and enhance work performance, albeit not consistently across all studies. These results provide valuable knowledge for occupational ergonomics and are specially interesting for the construction sector as consuming physical work may be expected to cause physical strain and injury to the work force.

This study proved the effectiveness of participatory ergonomic interventions in health effects (i.e. MSDs and fatigue) of construction workers. For example, studies by Brandt et al. (2018) and Jensen & Friche (2007) were found to be remarkably lowered after ergonomic implementations (Brandt et al., 2018; Jensen & Friche, 2007). This is in line with previous research which showed that ergonomic interventions can decrease worker discomfort and MSD symptoms (Rasmussen et al., 2020; Rivilis et al., 2008c). However, the review finds that this isn't always true of all interventions. Some research found limited benefits, or effects not consistently found to apply. For example, Visser et al. (2018) found that the intervention wasn't as effective because people weren't practicing good ergonomic behavior as much as they could or should have been. They highlighted that engagement is a critical ingredient that mediates the success of participatory models (Visser et al., 2018). This highlights the importance of engagement and adapted models for participatory mechanisms if effectiveness is to be sustained.

A few studies seemed to indicate that ergonomic interventions might have some favorable effects on workers' health which is consistent with the general premises that those plans work. This variability can be accounted for by differences between study designs, interventions studied and the level of worker participation. The effectiveness of ergonomic interventions may largely be determined by workers' involvement. Studies by Zhang & Lin (2024) and Dale et al. (2016) find that more active and satisfied participation in the intervention are linked to better health outcomes, whereas lower participation, found in various studies (e.g., Van Der Molen et al., 2005), reduces the impact of the intervention. This is in line with ergonomics intervention studies that show that employees' perceived usefulness, ease of use and peer influence are key factors that influence adoption of solutions (Dale et al., 2017; Weiler et al., 2012). These findings support to the suggestion that the effects of participatory ergonomics on health outcomes depend largely on the design of the intervention, the agreement and endorsement of the intervention by workers and the environment.

This review goes beyond simply reporting on health outcomes; it also gathers evidence concerning workplace productivity. Findings indicate that traditional metrics such as average output per worker or straightforward time-on-task recordings rarely take center stage in research on ergonomic interventions. Instead, productivity tends to be inferred through proxies linked to psychological states, perceived effort, and the extent to which tasks are adapted. For instance, study demonstrated that granting employees greater autonomy and allowing them to shape their immediate environment serve as reliable indicators of productivity (Brandt et al., 2018). When workers feel empowered in this way, their engagement and performance tend to rise, driving overall productivity upward. Equally important is the measurement of worker effort, typically captured through assessments of reduced physical strain or lowered rates of MSDs (Hess et al., 2004). The decrease in MSDs risk may permit workers to work with greater endurance, presumably increasing productivity. This suggests that reducing physical effort is good to improve productivity. Task redesign and ergonomics solutions were also used as a measures for productivity in a few of the studies (Dale et al., 2012; Jaegers et al., 2014). Not only do such interventions alleviate physical discomfort, but they also serve as an indication of increased productivity. When workers change the way, they do things to fit ergonomic tools or practices, the idea is that these changes will make work more efficient and less physically demanding, which can boost overall productivity. Finally, injury prevention, though not a traditional productivity measure, affects productivity by reducing downtime caused by injuries (Zhang & Lin, 2024). With fewer injuries there are less interruptions in the workflow and productivity are increased. Most studies don't directly measure productivity, but reducing injuries is a key factor in keeping workers productive over time. These results align with other research finding that psychological and behavioral work features, including autonomy, worker exertion, and ergonomic use, serve as effective productivity proxies when traditional output measures are difficult to assess, though not specifically in construction settings (Akogun et al., 2021; Johannsen & Zak, 2020). However, while improvements in health, such as reduced pain and fatigue, are frequently measured, the specific relationship with traditional productivity measures, including work units produced per hour or time spent on tasks, remains to be fully understood. Future research should examine more specific indicators of productivity and performance measures. In addition, it is important to examine if improvements in long term health eventually translate to increases in productivity, since this would provide a more complete picture of the influence of ergonomic and behavioral interventions on productivity output.

It is also found that the existing literature has some gaps to be filled. Many studies have investigated the short-term effects of ergonomic interventions have been conducted, but there are few long-term follow up studies. The studies included in this review consistently document positive short-term health and productivity effects, although the long-term sustainability of such benefits remains doubtful. Van Der Molen et al. (2005) also noted the lack of long-term follow-up in some research, and indicated that additional studies are needed, to study effects of long lasting participatory ergonomics on employee health and well-being (van der Molen et al., 2005). This knowledge gap is significant as previous studies have indicated that without ongoing support and surveillance the effects of ergonomic interventions may not be sustained. To ensure long-term effectiveness, it is essential that ergonomic initiatives receive enduring support from senior management (Dixon et al., 2009). Leadership involvement is crucial in securing resources, authorizing change teams, and making ergonomics a priority within the organization. Research indicates that comprehensive interventions, ones that combine worker training, effective supervision, changes to the physical workspace, and periodic follow-up evaluations tend to produce lasting gains in employee health after ergonomics programs are introduced (Szeto et al., 2013). Furthermore, when ergonomic principles are woven into everyday workplace procedures and formal policies, organizations help guarantee that these improvements endure, transforming ergonomics from a one-time fix into a routine aspect of the labor environment (Susihono & Adiatmika, 2021)

The review also finds that studies measure outcomes in a wide variety of ways, complicating attempts to pool the results. Some studies, like Brandt et al. (2018), have predominantly targeted the health effects such as MSD symptoms. Others, like Zhang & Lin (2024), studied productivity indicators ambiguously. One problem is that the outcomes are not uniform. This makes the results less comparable, and less useful for other studies. Future studies should standardize the methods used to record health and productivity end points to enable comparison and pooling of results.

This review has an implication on how participatory ergonomics can enhance both worker well-being and operational efficiency in the construction sector. By involving workers in the design and adjustment of their workspace, companies have managed to lower rates of musculoskeletal disorders while simultaneously boosting output. However, for such initiatives to sustain, senior managers must not only champion them vocally but also weave ergonomic principles into core health and safety policies. Organizations also need to provide support by having targeted training sessions, hands-on supervision, and timely modifications to tools or work areas. Looking forward, future studies need to adopt consistent measures of health and productivity so that outcomes from different projects can be accurately benchmarked against one another. Standardized metrics will strengthen the evidence base and make it clearer which strategies yield the best returns across diverse construction environments. By embedding ergonomic practices into daily routines, organizations can sustain health improvements and foster a more productive work environment

This systematic review has limitations. The review focused solely on published English language articles, potentially introducing publication bias and excluding relevant data. Literature search was conducted in the four major electronic databases: Scopus, PubMed, ScienceDirect, and Google Scholar but no other databases were searched, such as Web of Science, CINAHL. Future studies should consider a broader range of databases to ensure more comprehensive coverage of literature.

4. Conclusion

The evidence of this systematic review indicates that participatory ergonomic interventions may significantly contribute to improving the health of construction workers, particularly for MSDs, and in decreasing worker's tiredness. But in the studies, the degree of treatment effect varies, depending on considerations like how the intervention was designed and how much workers were involved or even how much they followed along. There are short-term benefits, but it's still unclear if these changes will last. This demonstrates how important it is to conduct further long-term research. To improve the effectiveness of participatory ergonomics, as part of future research focus should be on standardized outcome measures, tailored interventions and the evaluation of the long-term effects on health and productivity thus contributing to the continuous improvement of working conditions and health in construction work.

References

Akogun, O., Dillon, A., Friedman, J., Prasann, A., & Serneels, P. (2021). Productivity and health: Physical activity as a measure of effort. *The World Bank Economic Review*, *35*(3), 652–680. https://doi.org/10.1093/wber/lhaa011

Barker, T. H., Stone, J. C., Sears, K., Klugar, M., Tufanaru, C., Leonardi-Bee, J., Aromataris, E., & Munn, Z. (2023). The revised JBI critical appraisal tool for the assessment of risk of bias for randomized controlled trials. *JBI Evidence Synthesis*. https://doi.org/10.11124/JBIES-22-00430

Brandt, M., Madeleine, P., Samani, A., Ajslev, J. Z., Jakobsen, M. D., Sundstrup, E., & Andersen, L. L. (2018). Effects of a participatory ergonomics intervention with wearable technical measurements of physical workload in the construction industry: Cluster randomized controlled trial. *Journal of Medical Internet Research*, *20*(12), e10272. https://doi.org/10.2196/10272

Burgess-Limerick, R. (2018). Participatory ergonomics: Evidence and implementation lessons. *Applied Ergonomics*, *68*, 289–293. https://doi.org/10.1016/j.apergo.2017.12.009

Dale, A. M., Jaegers, L., Buchholz, B., Welch, L., & Evanoff, B. A. (2012). Using process evaluation to determine effectiveness of participatory ergonomics training interventions in construction. *WORK: A Journal of Prevention, Assessment & Rehabilitation*, *41*(S1), 3824–3826. https://doi.org/10.3233/WOR-2012-0684-3824

Dale, A. M., Jaegers, L., Welch, L., Barnidge, E., Weaver, N., & Evanoff, B. A. (2017). Facilitators and barriers to the adoption of ergonomic solutions in construction. *American Journal of Industrial Medicine*, *60*(3), 295–305. https://doi.org/10.1002/ajim.22693

Dale, A. M., Jaegers, L., Welch, L., Gardner, B. T., Buchholz, B., Weaver, N., & Evanoff, B. A. (2016). Evaluation of a participatory ergonomics intervention in small commercial construction firms. *American Journal of Industrial Medicine*, *59*(6), 465–475. https://doi.org/10.1002/ajim.22586

Dixon, S. M., Theberge, N., & Cole, D. C. (2009). Sustaining management commitment to workplace health programs: The case of participatory ergonomics. *Relations Industrielles*, *64*(1), 50–74. https://doi.org/10.7202/029538ar

Hess, J. A., Hecker, S., Weinstein, M., & Lunger, M. (2004). A participatory ergonomics intervention to reduce risk factors for low-back disorders in concrete laborers. *Applied Ergonomics*, *35*(5), 427–441. https://doi.org/10.1016/j.apergo.2004.04.003

Ibrahim, A., Nnaji, C., Namian, M., Koh, A., & Techera, U. (2023). Investigating the impact of physical fatigue on construction workers' situational awareness. *Safety Science*, *163*, 106103. https://doi.org/10.1016/j.ssci.2023.106103

Jaegers, L., Dale, A. M., Weaver, N., Buchholz, B., Welch, L., & Evanoff, B. (2014). Development of a program logic model and evaluation plan for a participatory ergonomics intervention in construction. *American Journal of Industrial Medicine*, *57*(3), 351–361. https://doi.org/10.1002/ajim.22249

Jensen, L. K., & Friche, C. (2007). Effects of training to implement new tools and working methods to reduce knee load in floor layers. *Applied Ergonomics*, *38*(5), 655–665. https://doi.org/10.1016/j.apergo.2006.03.008

Johannsen, R., & Zak, P. J. (2020). Autonomy raises productivity: An experiment measuring neurophysiology. *frontiers in psychology*, *11*, 963. https://doi.org/10.3389/fpsyg.2020.00963

Mishra, S., Avinash, G., Kundu, M. G., Verma, J., Sheth, A., & Dutta, A. (2024). Work-related musculoskeletal disorders among various occupational workers in India: A systematic review and meta-analysis. *Journal of Occupational Health*, *67*(1), uiae077. https://doi.org/10.1093/joccuh/uiae077

National Institute of Health. (2021). *Study quality assessment tools*. https://www. nhlbi.nih.gov/health-topics/study-quality-assessment-tools

Page, M. J., McKenzie, J. E., Bossuyt, P. M., Boutron, I., Hoffmann, T. C., Mulrow, C. D., Shamseer, L., Tetzlaff, J. M., Akl, E. A., Brennan, S. E., Chou, R., Glanville, J., Grimshaw, J. M., Hróbjartsson, A., Lalu, M. M., Li, T., Loder, E. W., Mayo-Wilson, E., McDonald, S., … Moher, D. (2021). The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. *Journal of Clinical Epidemiology*, *134*, 178–189. https://doi.org/10.1016/j.jclinepi.2021.03.001

Rasmussen, C. D. N., Sørensen, O. H., Van Der Beek, A. J., & Holtermann, A. (2020). The effect of training for a participatory ergonomic intervention on physical exertion and musculoskeletal pain among childcare workers (the TOY project) – a wait-list cluster-randomized controlled trial. *Scandinavian Journal of Work, Environment & Health*, *46*(4), 429–436. https://doi.org/10.5271/sjweh.3884

Reddy, GopireddyM. M., Nisha, B., Prabhushankar, T., & Vishwambhar, V. (2016). Musculoskeletal morbidity among construction workers: A cross-sectional community-based study. *Indian Journal of Occupational and Environmental Medicine*, *20*(3), 144. https://doi.org/10.4103/0019-5278.203134

Rivilis, I., Van Eerd, D., Cullen, K., Cole, D. C., Irvin, E., Tyson, J., & Mahood, Q. (2008a). Effectiveness of participatory ergonomic interventions on health outcomes: A systematic review. *Applied Ergonomics*, *39*(3), 342–358. https://doi.org/10.1016/j.apergo.2007.08.006

Rivilis, I., Van Eerd, D., Cullen, K., Cole, D. C., Irvin, E., Tyson, J., & Mahood, Q. (2008b). Effectiveness of participatory ergonomic interventions on health outcomes: A systematic review. *Applied Ergonomics*, *39*(3), 342–358. https://doi.org/10.1016/j.apergo.2007.08.006

Rivilis, I., Van Eerd, D., Cullen, K., Cole, D. C., Irvin, E., Tyson, J., & Mahood, Q. (2008c). Effectiveness of participatory ergonomic interventions on health outcomes: A systematic review. *Applied Ergonomics*, *39*(3), 342–358. https://doi.org/10.1016/j.apergo.2007.08.006

Rodrigues, V., & Rocha, R. (2023). Participatory ergonomics approaches to design and intervention in workspaces: A literature review. *Theoretical Issues in Ergonomics Science*, *24*(4), 413–428. https://doi.org/10.1080/1463922X.2022.2095457

Schall, M. C., & Michel, J. S. (2020). Leadership styles in participatory ergonomics programs: A bibliometric analysis. *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, *64*(1), 900–904. https://doi.org/10.1177/1071181320641215

Sukapto, P., Octavia, J. R., Pundarikasutra, P. A. D., Ariningsih, P. K., & Susanto, S. (2019). Improving occupational safety and health in footwear home industry through implementation of ILO-PATRIS, NOSACQ-50 and participatory ergonomics: A case study. *International Journal of Technology*, *10*(5), 908. https://doi.org/10.14716/ijtech.v10i5.3033

Susihono, W., & Adiatmika, I. P. G. (2021). The effects of ergonomic intervention on the musculoskeletal complaints and fatigue experienced by workers in the traditional metal casting industry. *Heliyon*, *7*(2), e06171. https://doi.org/10.1016/j.heliyon.2021.e06171

Szeto, G. P. Y., Wong, T. K. T., Law, R. K. Y., Lee, E. W. C., Lau, T., So, B. C. L., & Law, S. W. (2013). The impact of a multifaceted ergonomic intervention program on promoting occupational health in community nurses. *Applied Ergonomics*, *44*(3), 414–422. https://doi.org/10.1016/j.apergo.2012.10.004

van der Molen, H. F., Sluiter, J. K., Hulshof, C. T., Vink, P., van Duivenbooden, C., Holman, R., & Frings-Dresen, M. H. (2005). Implementation of participatory ergonomics intervention in construction companies. *Scandinavian Journal of Work, Environment & Health*, 191–204.

Van Der Molen, H. F., Sluiter, J. K., Hulshof, C. T., Vink, P., Van Duivenbooden, C., Holman, R., & Hw Frings-Dresen, M. H. (2005). Implementation of participatory ergonomics intervention in construction companies. *Scandinavian Journal of Work, Environment & Health*, *31*(3), 191–204. https://doi.org/10.5271/sjweh.869

Visser, S., Van Der Molen, H. F., Sluiter, J. K., & Frings-Dresen, M. H. W. (2018). The process evaluation of two alternative participatory ergonomics intervention strategies for construction companies. *Ergonomics*, *61*(9), 1156–1172. https://doi.org/10.1080/00140139.2018.1454514

Weiler, M. R., Lavender, S. A., Crawford, J. M., Reichelt, P. A., Conrad, K. M., & Browne, M. W. (2012). Identification of factors that affect the adoption of an ergonomic intervention among emergency medical service workers. *Ergonomics*, *55*(11), 1362–1372. https://doi.org/10.1080/00140139.2012.714474

Zhang, Z., & Lin, K.-Y. (2024). Applying implementation science to evaluate participatory ergonomics program for continuous improvement: A case study in the construction industry. *Applied Ergonomics*, *115*, 104181.