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Alignment between Intervention Design and Multidimensional Risk in Educator WMSDs: A Systematic Review

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Abstract

Background: Work-related musculoskeletal disorders (WMSDs) are common among preschool and school educators and arise from interacting ergonomic, physical, and psychosocial workplace factors. Despite this multidimensional etiology, workplace interventions typically address only a limited range of these risk factors. **Purpose:** To systematically review workplace interventions targeting WMSDs among educators, classify intervention approaches, examine the breadth of reported outcomes, and identify gaps to inform future intervention development. **Methods:** PubMed/MEDLINE, Scopus, Web of Science, and ProQuest were searched from inception through December 2025. Eligible studies evaluated workplace-based ergonomic, physical/exercise, psychosocial, or multicomponent interventions among preschool and school educators. Owing to substantial heterogeneity in study design, intervention characteristics, and outcome measures, findings were synthesized narratively. **Results:** Thirty studies met the inclusion criteria. Interventions were classified as ergonomic (n = 6), physical/exercise-based (n = 7), psychosocial (n = 11), and multicomponent (n = 6). Single-domain interventions generally improved outcomes within their primary target domain, whereas multicomponent interventions demonstrated broader benefits across musculoskeletal, psychosocial, and work-related outcomes. However, all multicomponent interventions combined only two intervention domains. No study implemented a workplace-based intervention integrating ergonomic, physical, and psychosocial components within a single program. **Conclusions:** Current evidence is

dominated by single-domain and dual-domain interventions that do not fully address the multidimensional nature of WMSDs among educators. The absence of integrated tri-domain interventions highlights an important evidence gap. Based on the identified patterns, the Education-Oriented Tri-Domain Intervention Model (ETDIM) is proposed as a conceptual framework to guide the design and evaluation of future workplace interventions in educational settings.

Keywords

Work-Related Musculoskeletal Disorders, Educators, Occupational Health, Workplace Interventions, Ergonomics

1. Introduction

Work-related musculoskeletal disorders (WMSDs) are among the most prevalent occupational health conditions worldwide and remain a major cause of disability, reduced productivity, and economic burden [1]-[3]. From a human factors and ergonomics perspective, WMSDs arise from the interaction between physical, organizational, and psychosocial work demands rather than from a single exposure [1] [4]-[6]. Physical risk factors include repetitive movements, awkward or sustained postures, excessive mechanical loading, prolonged static work, and suboptimal workplace design [1] [7] [8], while psychosocial stressors such as high job demands, low job control, emotional strain, and limited workplace support may contribute to symptom development, persistence, and disability [5] [6]. Globally, musculoskeletal disorders account for a substantial proportion of disability and occupational productivity loss, with low-back pain representing a leading contributor to years lived with disability worldwide [9]-[12].

Educators represent a particularly vulnerable occupational group. Preschool educators are frequently exposed to child lifting and carrying, repetitive bending, prolonged kneeling or squatting, and work at child-height furniture [13]-[16]. School teachers may experience prolonged standing, repetitive writing and typing, sustained computer use, and other occupational ergonomic demands [17]-[20]. Consequently, reported 12-month prevalence rates of WMSDs among educators are high, with the lower back, neck, and shoulders among the most commonly affected regions [13] [17]-[20]. These disorders are associated with reduced work ability, absenteeism, and impaired job performance [21].

The development of WMSDs among educators is influenced by both biomechanical and psychosocial factors. Physical exposures include repetitive tasks, awkward or sustained postures, physically demanding caregiving activities, and suboptimal workplace ergonomics [7] [8] [13]-[16], whereas psychosocial stressors such as workload, emotional demands, burnout, and limited workplace support may amplify fatigue, perceived strain, and delayed recovery [5] [6] [22]-[24].

Longitudinal evidence further suggests that physical and psychosocial work factors may operate concurrently in shaping subsequent musculoskeletal risk [5] [6].

To address these risks, workplace interventions have generally focused on three domains. Ergonomic interventions target workplace design, task modification, equipment adaptation, and participatory problem-solving [7] [16] [25] [26]. Physical or exercise-based interventions aim to improve strength, mobility, physical capacity, and symptom management [27]-[30]. Psychosocial interventions include mindfulness, stress-management, organizational support, and cognitive-behavioral approaches [22] [24] [31] [32].

Despite growing research activity, the evidence remains fragmented. Most studies evaluate single-domain interventions and rarely examine whether broader, multidomain approaches produce wider benefits across musculoskeletal, psychosocial, and organizational outcomes. Furthermore, no education-specific framework currently integrates ergonomic, physical, and psychosocial intervention domains within a unified model.

Therefore, this systematic review aimed to: 1) synthesize evidence on the prevalence and risk factors of WMSDs among preschool and school educators; 2) map workplace-based ergonomic, physical, psychosocial, and integrated interventions; and 3) examine patterns of outcome breadth across intervention domains. Due to substantial heterogeneity in interventions and outcome measures, a narrative synthesis was conducted. Findings were subsequently used to develop the Education-Oriented Tri-Domain Intervention Model (ETDIM), a synthesis-based framework intended to guide future intervention design and occupational health strategies in educational settings.

2. Methods

2.1. Eligibility Criteria

Eligible studies included peer-reviewed original research articles published in English that examined workplace-based interventions for work-related musculoskeletal disorders (WMSDs) among preschool and school educators. Conference abstracts, dissertations or theses without peer-reviewed publication, laboratory simulation studies, and studies that did not report WMSD-related outcomes were excluded. Additional authoritative reports, books, and other reference sources were used exclusively to provide background context and were not included in the systematic review or evidence synthesis.

2.2. Search Strategy

A systematic literature search was conducted in PubMed/MEDLINE, Scopus, Web of Science, and ProQuest from database inception to 5 December 2025. Search terms combined concepts related to educators, WMSDs, and workplace interventions. Reference lists of included studies and relevant reviews were manually screened to identify additional eligible studies. The full search strategy for each database is available in Supplementary File 1.

2.3. Study Selection and Data Extraction

All identified records were imported into reference management software, and duplicate records were removed before screening. Titles and abstracts were screened independently by two reviewers according to the predefined eligibility criteria. Potentially eligible studies underwent full-text review. Disagreements at any stage of the screening process were resolved through discussion and, when necessary, consultation with a third reviewer.

Data extraction was performed independently by two reviewers using a standardized extraction form. Extracted information included study characteristics (author, year, country, and study design), participant characteristics, educational setting, intervention components, intervention domain (ergonomic, physical, psychosocial, or integrated), duration, outcome measures, and reported findings related to musculoskeletal, psychosocial, and work-related outcomes.

The study selection process, including record identification, duplicate removal, title and abstract screening, full-text assessment, and final study inclusion, is summarized in the PRISMA flow diagram (**Figure 1**).

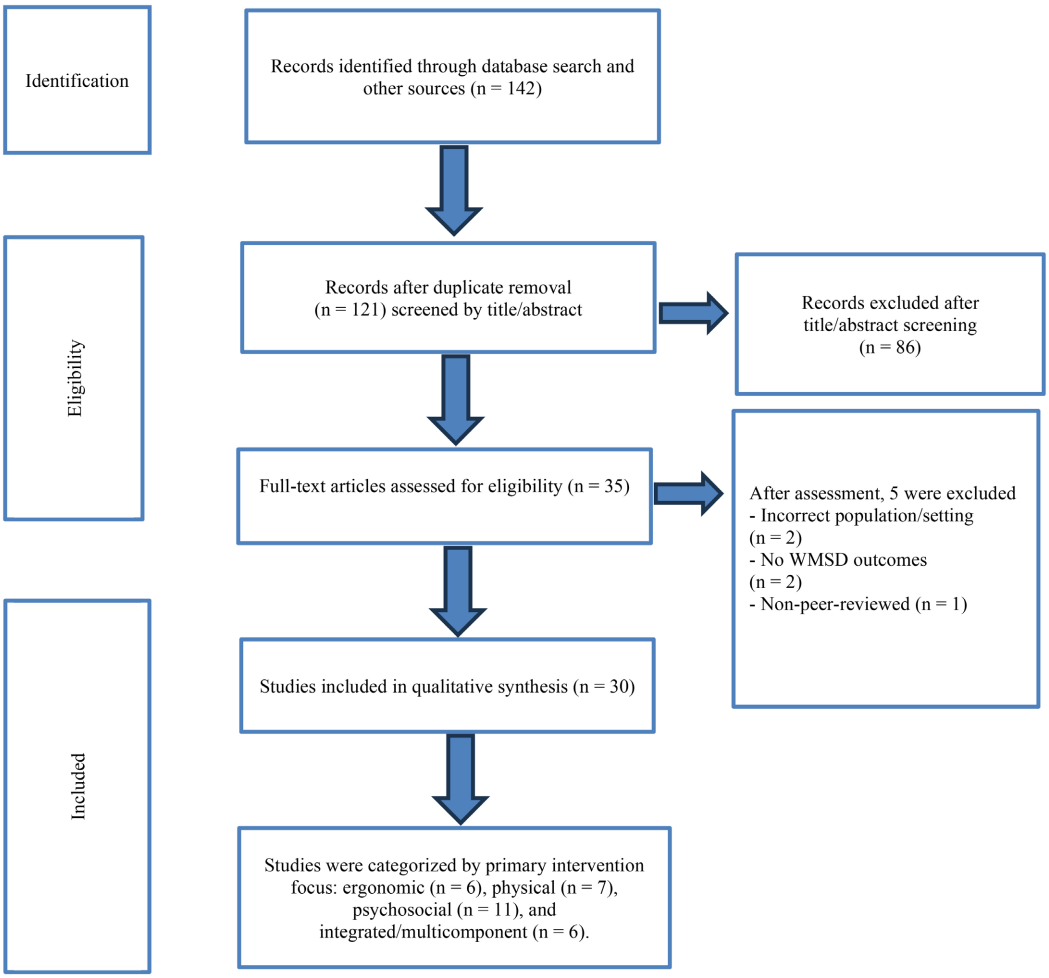

Figure 1. PRISMA flow diagram of study selection for studies addressing WMSDs among educators. Adapted from the *PRISMA 2020* Statement [33].

2.4. Data Synthesis

Due to substantial heterogeneity in study designs, intervention components, and outcome measures, quantitative meta-analysis was not feasible. Therefore, a structured narrative synthesis was conducted. Interventions were categorized into ergonomic, physical, psychosocial, or integrated domains, and outcomes were mapped across musculoskeletal, psychosocial, and organizational dimensions. Patterns of alignment and mismatch between intervention targets and reported outcomes were identified across studies and used to inform the development of the Education-Oriented Tri-Domain Intervention Model (ETDIM) (Figure 2).

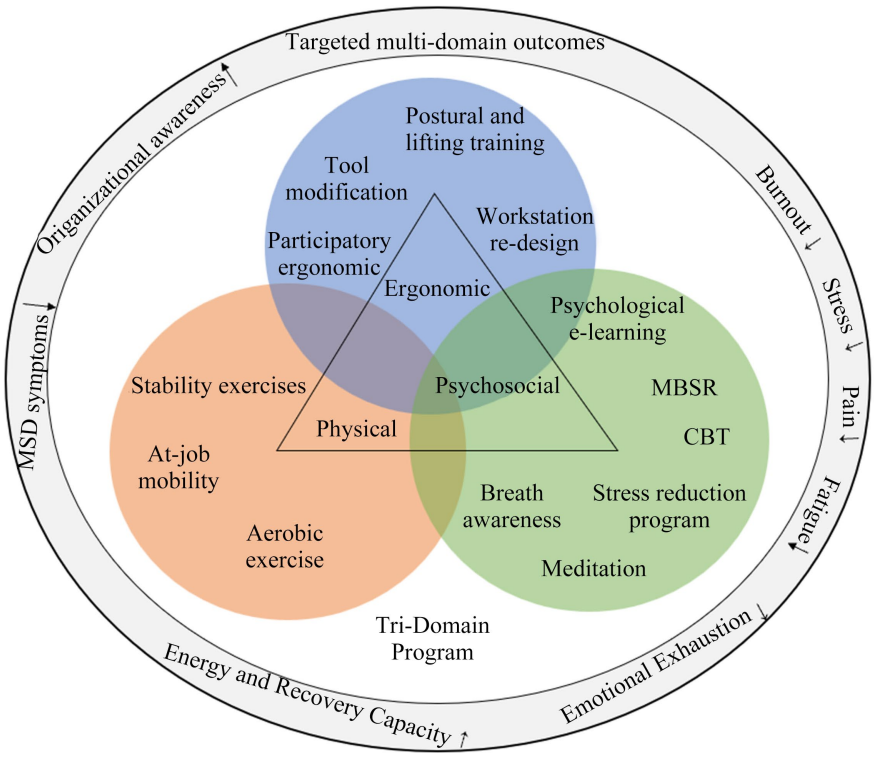

Figure 2. Conceptual framework of the multimethod assessment approach: Implications for intervention design and clinical evaluation.

2.5. Coding of Outcome Breadth

Outcome breadth was coded according to the number of outcome domains in which improvement was reported following the intervention. Outcomes were grouped into three domains: 1) musculoskeletal outcomes, including pain, disability, posture, biomechanical exposure, physical workload, or functional capacity; 2) psychosocial outcomes, including stress, burnout, emotional exhaustion, mental well-being, coping, mindfulness, or psychological distress; and 3) work-related or organizational outcomes, including work ability, absenteeism, job satisfaction, work engagement, organizational climate, trust, coworker support, or implementation-related workplace changes.

A domain was coded as improved when the original study reported a statisti-

cally significant between-group or within-group improvement, or when the authors explicitly reported a meaningful positive intervention effect for that domain in studies where statistical testing was not available or not consistently reported. Studies were then classified as showing improvement in one outcome domain only or in two or more outcome domains. Coding was performed independently by two reviewers, and disagreements were resolved through discussion.

2.6. Methodological Quality Assessment

Methodological quality was assessed according to study design using the appropriate Joanna Briggs Institute (JBI) Critical Appraisal Tools. Randomized and cluster-randomized trials were evaluated using the JBI Checklist for Randomized Controlled Trials, quasi-experimental and pre-post intervention studies were evaluated using the JBI Checklist for Quasi-Experimental Studies, and systematic reviews were evaluated using the JBI Checklist for Systematic Reviews and Research Syntheses. Narrative reviews and non-primary contextual sources were not formally appraised and were used only to support background interpretation.

Quality appraisal findings were not used as exclusion criteria. Instead, they were used to inform the narrative synthesis by giving greater interpretive weight to higher-quality randomized, cluster-randomized, and quasi-experimental intervention studies when evaluating patterns of intervention effects and outcome breadth. Studies with lower methodological quality, incomplete reporting, or non-primary designs were interpreted cautiously and were not used as stand-alone evidence for ETDIM conclusions. The proposed ETDIM framework was therefore based primarily on consistent patterns observed across appraised intervention studies rather than on isolated findings from lower-quality or contextual sources. Detailed quality appraisal results are presented in Supplementary Table S1.

3. Results

3.1. Description of Studies and Intervention Domains

A total of 142 records were identified through systematic searches of PubMed/MEDLINE, Scopus, Web of Science, and ProQuest, together with manual searching of reference lists together with manual searching of reference lists, journal websites, and citation tracking. After duplicate removal, 121 records remained for title and abstract screening. Of these, 86 records were excluded based on title and abstract screening, leaving 35 full-text articles for eligibility assessment. Following full-text review, five studies were excluded because of an incorrect population or setting (n = 2), absence of WMSD-related outcomes (n = 2), or non-peer-reviewed publication (n = 1). Consequently, 30 studies met the inclusion criteria and were included in the qualitative synthesis. The study selection process is summarized in the PRISMA flow diagram (Figure 1).

3.2. Classification of Intervention Domains

The 30 included studies were categorized according to their primary intervention

focus into four domains: ergonomic, physical/exercise-based, psychosocial, and integrated (Tables 1-4). Six studies evaluated predominantly ergonomic interventions, seven examined physical or exercise-based programs, and eleven focused primarily on psychosocial interventions. Six studies were classified as integrated interventions, defined as programs combining components from at least two intervention domains.

Table 1. Ergonomic Interventions (TIDieR Format) programs among teachers and preschool educators.

Reference	Intervention	Components	Who Delivered	How (Mode of Delivery)	Where	Duration	Fidelity	Outcomes
[16]	Participatory ergonomics program	Postural analysis, task redesign, lifting optimization	Ergonomists and OHS specialists	Workshops, onsite coaching, individualized task modification	Childcare centres (Germany)	Several weeks	Onsite supervision and individualized implementation	↓ Trunk flexion; ↑ posture; ↓ biomechanical strain
[25]	Participatory ergonomics program	Workstation redesign, task modification, ergonomic risk mapping	Ergonomics specialists and worker groups	Participatory workshops and workplace implementation	Childcare institutions	20 weeks	Participatory implementation with workplace follow-up	↑ Ergonomic conditions; ↓ perceived exertion and MSD risk; cost-effective
[26]	Participatory ergonomics training	Safe lifting, child handling, posture optimization	Participatory ergonomics trainers and OHS team	Classroom training with supervised practice	Childcare centres (Denmark)	3 months	Supervised practical training	↓ Physical exertion; ↓ neck, shoulder and low-back pain
[30]	Ergonomic assessment and training	Ergonomic assessment, lifting techniques, posture correction	Physiotherapists	Worksite assessment and group training	Schools (Austria)	3 months	Instructor-supervised sessions	↑ Ergonomic awareness; ↓MSD symptoms (trend)
[34]	Ergonomic education program	Posture education, risk identification, workstation organization	Occupational health educators	Lectures, demonstrations, printed materials	Schools (China)	Single structured program	Standardized educational programme	↑ Ergonomic behaviours; ↓ MSD complaints
[35]	Ergonomic redesign programme	Workplace redesign, lifting strategies, load management, behavioural coaching	OHS specialists and workplace coaches	Workshops, onsite task modification and coaching	Workplaces (Denmark)	Stepped-wedge implementation	Structured implementation with workplace coaching	↓Physical workload and pain behaviours; no change in sickness absence

Note. OHS = occupational health and safety; MSD = musculoskeletal disorder. Fidelity reflects adherence or implementation procedures reported in the original studies (e.g., supervision, standardized protocols, workplace follow-up). Outcomes are summarized qualitatively.

Table 2. Psychosocial interventions (TIDieR Format) among teachers and preschool educators.

Reference	Intervention	Components	Who Delivered	How (Delivery Mode)	Where	Duration	Fidelity	Outcomes
[36]	Mindfulness-based intervention	Mindfulness practice, stress reduction, attention regulation	Trained mindfulness instructors	Face-to-face group sessions with in-class practice	Schools (Portugal)	8 weeks	Standardized MBI protocol	↓ Teacher stress; ↑ classroom climate and student outcomes
[37]	Cognitive-behavioural group therapy	CBT techniques for burnout and emotional regulation	Clinical psychologists	Weekly face-to-face group sessions	Schools (USA)	8 sessions	Standardized CBT protocol	↓ Burnout and emotional exhaustion
[38]	CBT versus yoga programme	CBT skills or yoga-based stress management	Psychologists and certified yoga instructors	Group CBT sessions or supervised yoga classes	Sweden	10 weeks	Standardized intervention protocols	↓ Stress in both groups; CBT showed greater long-term coping benefits
[39]	Mindfulness-Based Stress Reduction (MBSR)	Mindfulness training, meditation, home practice	Certified MBSR instructors	Weekly group sessions with guided home practice	Elementary schools (Netherlands)	8 weeks	Attendance and home practice monitored	↓ Stress and burnout; ↑ emotion regulation
[40]	CBT and mindfulness interventions	CBT, mindfulness, and emotion-focused skills	Mixed providers (systematic review)	Group programmes and workshops	Multiple settings	Variable	Not applicable (meta-analysis)	Strong evidence for ↓ burnout, anxiety and emotional distress
[41]	Health Belief Model educational programme	Neck-pain prevention, behavioural education, health promotion	Health educators	Lectures, behavioural training and printed materials	Schools (Iran)	Multiple sessions	Standardized educational programme	↑ Preventive behaviours; ↓ neck pain
[42]	Mindfulness-based CBT (MB-CBT)	Mindfulness, CBT skills, stress management	Psychologists	Online sessions and group workshops	Schools (Nepal)	6 weeks	Attendance monitored	↓ Burnout, stress and depressive symptoms
[43]	Mind Sound Resonance Technique (MSRT)	Guided yogic relaxation and meditation	Yoga therapists	Guided relaxation sessions	Schools (India)	1 month	Standardized MSRT protocol	↑ Psychological well-being, sleep quality and cognitive function

Continued

[44]	Video-based mindfulness programme	Guided mindfulness meditation	Video-based mindfulness instructors	Self-guided online video sessions	Schools (Japan)	Daily sessions for 2 - 4 weeks	Digital adherence monitored	↓ Depression, anxiety and perceived stress
[45]	Mindfulness-based emotional self-regulation programme	Mindfulness and emotional regulation training	MBSR facilitators	Face-to-face group sessions	Public schools (Brazil)	Multi-week	Attendance monitored	↓ Psychological distress; improved inflammatory biomarkers
[46]	Participatory work-stress prevention programme	Organizational stress prevention, team meetings, action planning	Organizational psychologists and school teams	Workshops, team meetings and action planning	Primary schools	Multi-stage programme	Structured implementation with team participation	↓ Psychosocial risks; ↑ coping and stress management

Note. CBT = cognitive-behavioural therapy; MBSR = Mindfulness-Based Stress Reduction; MB-CBT = mindfulness-based cognitive behavioural therapy; MSRT = Mind Sound Resonance Technique; MBI = mindfulness-based intervention. Fidelity reflects adherence or implementation procedures reported in the original studies (e.g., attendance monitoring, standardized protocols, or digital adherence). Outcomes are summarized qualitatively and are not intended for direct comparison of effect sizes.

Table 3. Physical/exercise-based interventions (TIDieR Format) among teachers and preschool educators.

Reference	Intervention	Components	Who Delivered	How (Delivery Mode)	Where	Duration	Fidelity	Outcomes
[47]	Posture correction programme	Posture correction, strengthening exercises, ergonomic education	Physiotherapists	Face-to-face group sessions with supervised practice	Childcare centres	~10 weeks (1 - 2 sessions/week)	Not reported	↓ Low-back pain; ↑ posture awareness
[48]	Group-based leisure-time physical activity programme	Aerobic exercise, strength training, playful activities, back-pain prevention exercises	Exercise instructors and research team	Face-to-face group sessions with work colleagues	Secondary schools (Spain)	32 sessions, twice weekly, one academic year	Attendance monitored throughout the intervention	↑ Work satisfaction, vigour, absorption and relatedness; ↓ burnout; no musculoskeletal outcomes measured
[49]	Back School versus Yogasana programme	Physical exercise, functional training, Yogasana	Yoga instructors and physiotherapists	Face-to-face training sessions	School setting	6 weeks	Not reported	↓ Pain; ↑ functional capacity (greater improvement with Yogasana)
[50]	Yoga-based exercise programme	Breathing exercises, warm-up, Hatha yoga, stretching, meditation and relaxation	Certified yoga instructors	Supervised face-to-face group sessions	Public high school (Italy)	8 weeks; 60 min twice weekly	Mean attendance 91.4%; no injuries reported	↓ Stress and musculoskeletal symptoms; ↑ flexibility and well-being

Continued

[27]	At-job micro-exercise programme	Workplace micro-exercises and daily self-practice	Experienced physiotherapists	Face-to-face instruction with daily home/ workplace practice	Pre-primary schools	4 weeks	Daily exercise logs	↓ Pain and disability (ODI); superior to ergonomic brochure
[51]	Workplace exercise programme	Workplace exercises and ergonomic training	Physiotherapists	Face-to-face group exercise sessions	Nursery schools	4 months	Not reported	↓ Neck and low-back complaints; ↓ sickness absence
[52]	Workplace yoga programme	Joint loosening, stretching, yoga postures, breathing exercises, relaxation and mindfulness meditation	Certified yoga instructor	Supervised face-to-face group sessions	Secondary schools	6 weeks; 60 min/session, 4 sessions/week	Attendance monitored; standardized instructor-led protocol	↓ Musculoskeletal pain and disability; ↓ anxiety, depression, stress and fatigue; ↑ sleep quality and quality of life

Note. MSD = musculoskeletal disorders; ODI = Oswestry Disability Index. Fidelity reflects adherence or implementation procedures reported in the original studies (e.g., attendance monitoring, exercise logs, or standardized intervention protocols). Outcomes are summarized qualitatively and are not intended for direct comparison of effect sizes.

Table 4. Multicomponent interventions among teachers and preschool educators (TIDieR Format).

Reference	Intervention	Components	Who Delivered	How (Delivery Mode)	Where	Duration	Fidelity	Outcomes
[53]	Multicomponent ergonomics and exercise programme	Ergonomic adjustments, safe lifting education, strengthening, stretching, work-organization changes	Physiotherapists and ergonomics specialists	Group workshops, onsite training and individual guidance	Day-care centres ("Emuna")	Several weeks	Onsite supervision and adherence monitoring	↓ Back pain; ↑ ergonomic awareness and functional capacity
[23]	Multilevel workplace intervention	Individual psychological counselling, psychosocial group sessions, participatory ergonomic redesign (EG1), postural exercises, manual handling education and vocal hygiene training (EG2)	Psychotherapists, psychologists, architect, physiotherapist and speech therapist	Face-to-face individual and group sessions	University and preschool settings	3 counselling sessions; 3 psychosocial sessions; 3 ergonomics/ physiotherapy sessions; 2 speech therapy sessions	Standardized multidisciplinary protocol delivered by trained professionals	↓ Stress, burnout, psychological exhaustion and indolence; ↑ work enthusiasm, trust and coworker support; no improvement in work ability

Continued

[54]	Goldilocks work redesign programme	Child-handling redesign, activity rotation, moderate physical activity, participatory ergonomics	Trained workplace facilitators and researchers	Cluster-randomized implementation, workshops and onsite work redesign	Childcare institutions (Denmark)	Several months	Structured implementation protocol with cluster oversight	↑ Physical activity balance and worker well-being; ↓ musculoskeletal strain
[55]	Integrated workplace programme	Ergonomic improvements, organizational changes, leadership training and physical activity modules	Implementation specialists and trained supervisors	Stepped-wedge implementation using workshops, digital tools and onsite coaching	Childcare institutions (Copenhagen)	Multi-month rollout	Implementation checklists and embedded fidelity monitoring	↑ Adoption of workplace practices and ergonomics; ↓ physical workload
[32]	Mindfulness-based intervention	Mindfulness practice, yoga, group discussion, lectures, guided home practice and reflective exercises	Mindfulness instructor	Face-to-face group sessions with guided home practice	Public school districts (Canada and USA)	8 weeks; 11 sessions (36 contact hours)	Attendance and home-practice journals monitored; standardized curriculum	↑ Mindfulness, self-compassion and attention; ↓ occupational stress, burnout, anxiety and depression
[56]	Occupational therapy and psychosocial programme	Relaxation training, cognitive reframing, coping strategies and activity-based occupational therapy	Occupational therapists and psychosocial therapists	Group and individual therapy sessions	Schools and occupational therapy clinics	Several weeks	Session attendance and therapist logs	↓ Low-back pain; ↑ coping and functional participation

Note. LBP = low back pain; OT = occupational therapy. Fidelity reflects adherence or implementation procedures reported in the original studies (e.g., attendance monitoring, standardized protocols, supervision, therapist logs, or implementation checklists). Outcomes are summarized qualitatively and are not intended for direct comparison of effect sizes.

Ergonomic interventions primarily targeted task redesign, posture optimization, participatory ergonomics, and workplace modifications, and were generally associated with improvements in biomechanical exposures and musculoskeletal symptoms. Physical interventions focused on workplace-based exercise, strengthening, and movement programs and most commonly reported reductions in pain and disability. Psychosocial interventions, including mindfulness-based programs, cognitive-behavioral approaches, and stress-management strategies, consistently demonstrated benefits in stress reduction, burnout, and psychological well-being.

Importantly, none of the included intervention studies integrated ergonomic, physical, and psychosocial components within a single, unified intervention program. Although several studies were labeled as "integrated," closer examination revealed that these programs combined only two domains, most commonly ergonomic and physical components, or physical and organizational elements. Psychosocial interventions, when present, were delivered as standalone programs or clinical treatments rather than being embedded alongside ergonomic and physical modifications within the educational work environment.

Thus, no intervention studies were identified that deliberately combined ergonomic, physical, and psychosocial strategies within a coherent, theory-informed framework designed to address the multidimensional nature of work-related musculoskeletal disorders among educators. This absence represents a critical gap in the intervention literature.

Overall, the distribution of studies reveals a clear imbalance, with a predominance of single-domain and dual-domain approaches, and a notable absence of tri-domain intervention studies that target physical, ergonomic, and psychosocial risk factors simultaneously.

3.3. Outcome Breadth across Intervention Domains

As summarized in Table 5, single-domain interventions were predominantly associated with improvements limited to their respective target domain. Ergonomic, physical, and psychosocial interventions most commonly demonstrated benefits within a single outcome category and only occasionally extended across multiple outcome domains.

Table 5. Breadth of outcome improvements across intervention domains (pattern-synthesis summary).

Domain	N (studies)	Improved one domain only	Improved ≥ 2 domains
Ergonomic	6	2	4
Physical/exercise-based	7	5	2
Psychosocial	11	8	3
Multicomponent (dual-domain only*)	6	0	6

Note. All multicomponent interventions combined components from two domains only. No study integrated ergonomic, physical, and psychosocial components within a single intervention program.

In contrast, multicomponent interventions were consistently associated with improvements across at least two outcome domains. However, all multicomponent interventions combined components from two domains only.

Importantly, no study implemented a true tri-domain intervention integrating ergonomic, physical, and psychosocial components within a single program. Consequently, no evidence was identified regarding the effectiveness of fully inte-

grated tri-domain interventions for preventing or managing WMSDs among educators.

Overall, the literature is characterized by a predominance of single-domain and dual-domain approaches, highlighting an important gap in the development and evaluation of comprehensive interventions targeting the multidimensional nature of WMSDs among educators.

4. Discussion

This systematic review synthesized workplace-based interventions addressing work-related musculoskeletal disorders (WMSDs) among preschool and school educators across ergonomic, physical/exercise-based, psychosocial, and multicomponent domains. The findings indicate that the current intervention literature remains dominated by single-domain and dual-domain approaches. Although multicomponent interventions generally demonstrated broader outcome profiles than single-domain programs, none of the included studies integrated ergonomic, physical, and psychosocial components within a single workplace-based intervention. This represents an important gap in the occupational health literature and highlights the limited translation of the multidimensional etiology of WMSDs into comprehensive intervention design.

Why do single- and dual-domain interventions dominate?

The predominance of single-domain interventions likely reflects practical and organizational constraints rather than a lack of recognition of WMSD complexity. Educational workplaces are characterized by limited resources, demanding schedules, and limited opportunities for the delivery of multidisciplinary interventions. Consequently, psychosocial interventions are typically delivered as standalone mindfulness- or stress-management programs [57] [58]; ergonomic interventions often focus on task redesign or posture education; physical interventions emphasize exercise and movement programs, and ergonomic interventions often focus on task redesign or posture education [54] [55] [59] [60].

In addition, intervention research in this field remains largely discipline-specific. Occupational health and human factors researchers, physical interventions by physiotherapists or exercise scientists [27] [51] [61], and psychosocial interventions by psychologists commonly lead ergonomic interventions. This disciplinary separation may contribute to intervention designs that address isolated risk pathways rather than the interacting physical, ergonomic, and psychosocial factors known to contribute to WMSDs. The greater methodological complexity associated with evaluating integrated interventions may further explain the scarcity of comprehensive workplace programs [40].

Toward an Integrated Intervention Framework

The findings reveal a clear mismatch between the multidimensional causes of WMSDs and the predominantly single-domain strategies used to address them. While biomechanical exposures, physical capacity, and psychosocial demands are known to interact within educational work environments, current interventions generally target only a subset of these factors. As a result, opportunities to address

multiple risk pathways simultaneously may be missed.

Importantly, no identified study deliberately combined ergonomic, physical, and psychosocial components within a unified intervention framework specifically designed for educators. Existing interventions either focused on a single domain or combined only two domains. This gap provided the rationale for developing the Education-Oriented Tri-Domain Intervention Model (ETDIM) [1] [5] [6].

The Education-Oriented Tri-Domain Intervention Model (ETDIM)

ETDIM is proposed as a synthesis-based conceptual framework designed to align intervention strategies with the multidimensional nature of WMSDs among educators. Rather than serving as a prescriptive treatment protocol, the model provides an organizing structure that integrates three complementary domains: ergonomic modification, workplace-based physical activity, and psychosocial support.

The model was derived inductively from the patterns identified in this review. Single-domain interventions were generally associated with narrower outcome profiles, whereas dual-domain approaches demonstrated broader effects but still failed to address the full range of factors associated with educator health and work participation. ETDIM therefore offers a framework for designing future interventions that address multiple interacting exposure pathways within the same workplace environment.

Beyond its conceptual contribution, ETDIM has practical implications for intervention planning and evaluation. The framework encourages researchers and practitioners to assess musculoskeletal, psychosocial, and work-related outcomes concurrently and to consider intervention implementation as a coordinated system-level process rather than a collection of isolated activities. In doing so, ETDIM may support the development of more sustainable and context-sensitive occupational health strategies for educational settings.

Clinical and Organizational Implications

From a clinical perspective, the findings support a multidimensional approach to WMSD prevention and management that extends beyond pain reduction alone. Assessment of functional capacity, work participation, psychosocial well-being, and recovery trajectories may provide a more comprehensive understanding of intervention effectiveness.

From an organizational perspective, sustainable improvements are unlikely to be achieved through individual-level interventions alone. Leadership support, workload management, participatory implementation processes, and organizational commitment are likely to play important roles in determining intervention success. ETDIM therefore highlights the need to align clinical and workplace-level strategies when addressing educator musculoskeletal health [60] [61].

5. Limitations

Several limitations should be considered when interpreting the findings of this review. Substantial heterogeneity in study designs, intervention components, out-

come measures, and follow-up periods precluded quantitative meta-analysis and limited di-rect comparisons across intervention domains. Classification of interventions was based on the programme content reported in the included studies and may therefore have been affected by incomplete or insufficiently detailed reporting. In addition, most studies assessed short- to medium-term outcomes, limiting conclusions regarding the long-term sustainability of intervention effects. Restricting inclusion to Eng-lish-language, peer-reviewed publications may also have resulted in the omission of relevant evidence.

Although the intervention-classification framework was predefined and applied con-sistently, several interventions contained overlapping components, requiring a degree of judgement when assigning them to specific domains. Despite these limitations, consistent patterns were observed across the included studies, particularly the pre-dominance of single-domain and dual-domain interventions. Moreover, based on the predefined classification framework and the intervention components reported by the included studies, no workplace intervention was identified that deliberately integrated ergonomic, physical, and psychosocial components within a single programme.

Future research should prioritize the development and evaluation of workplace interventions that deliberately integrate ergonomic, physical, and psychosocial components within a single intervention framework. Future studies should concurrently evaluate musculoskeletal, psychosocial, functional, and work-related outcomes while incorporating longer follow-up periods to determine sustainability. Cluster-randomized and implementation-focused study designs may be particularly valuable for evaluating both effectiveness and real-world feasibility in educational settings. Such research will be essential for evaluating the proposed ETDIM framework and determining whether integrated tri-domain interventions provide broader and more sustainable benefits than the single-domain and dual-domain approaches that currently dominate the literature.

6. Conclusion

Workplace interventions targeting WMSDs among educators remain predominantly single-domain or dual-domain despite the multidimensional nature of occupational musculoskeletal risk. The proposed Education-Oriented Tri-Domain Intervention Model (ETDIM) provides a conceptual framework for developing and evaluating integrated workplace interventions that simultaneously address ergonomic, physical, and psychosocial determinants of educator health.

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Conflicts of Interest

The authors declare no conflicts of interest.

Data Availability

No new datasets were generated or analysed during this study. All data supporting the findings of this systematic review are available within the article and its Supplementary Materials.

Ethics

Ethical approval was not required because this study is a systematic review of previously published studies.

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Supplementary File 1. Full Search Strategy

This supplementary file presents the full search strategy used to identify studies examining work-related musculoskeletal disorders (WMSDs), ergonomic risk factors, and workplace-based interventions among preschool and school educators.

Databases searched: PubMed/MEDLINE, Scopus, Web of Science, and ProQuest.

Search date: 5 December 2025.

Search period: From database inception to 5 December 2025.

Language restriction: English.

Publication type restriction: Peer-reviewed journal articles.

Core search concepts:

1) Educators and educational workers

2) Work-related musculoskeletal disorders and musculoskeletal pain

3) Ergonomics, occupational health, workplace risk factors, and interventions

PubMed/MEDLINE

((“teacher*”[Title/Abstract] OR “school teacher*”[Title/Abstract] OR “preschool teacher*”[Title/Abstract] OR “kindergarten teacher*”[Title/Abstract] OR “educator*”[Title/Abstract] OR “teaching assistant*”[Title/Abstract] OR “childcare worker*”[Title/Abstract] OR “child care worker*”[Title/Abstract] OR “nursery teacher*”[Title/Abstract] OR “early childhood educator*”[Title/Abstract] OR “early childhood teacher*”[Title/Abstract] OR “school staff”[Title/Abstract]))

AND

((“musculoskeletal disorder*”[Title/Abstract] OR “work-related musculoskeletal disorder*”[Title/Abstract] OR “work related musculoskeletal disorder*”[Title/Abstract] OR WMSD[Title/Abstract] OR WMSDs[Title/Abstract] OR MSD[Title/Abstract] OR MSDs[Title/Abstract] OR “musculoskeletal symptom*”[Title/Abstract] OR “musculoskeletal pain”[Title/Abstract] OR “musculoskeletal complaint*”[Title/Abstract] OR “low back pain”[Title/Abstract] OR “back pain”[Title/Abstract] OR “neck pain”[Title/Abstract] OR “shoulder pain”[Title/Abstract] OR “upper limb pain”[Title/Abstract] OR “lower limb pain”[Title/Abstract]))

AND

((“ergonomic*”[Title/Abstract] OR “occupational health”[Title/Abstract] OR “occupational safety”[Title/Abstract] OR “workplace”[Title/Abstract] OR “work environment”[Title/Abstract] OR “risk factor*”[Title/Abstract] OR “physical demand*”[Title/Abstract] OR “psychosocial factor*”[Title/Abstract] OR “workload”[Title/Abstract] OR “job demand*”[Title/Abstract] OR “intervention*”[Title/Abstract] OR “prevention”[Title/Abstract] OR “workplace intervention*”[Title/Abstract] OR “participatory ergonomics”[Title/Abstract] OR “exercise”[Title/Abstract] OR “physical activity”[Title/Abstract] OR “physiotherapy”[Title/Abstract] OR “stretching”[Title/Abstract] OR “strengthening”[Title/Abstract] OR “mindfulness”[Title/Abstract] OR “stress management”[Title/Abstract] OR

"cognitive behavioral"[Title/Abstract]))

Filters applied: English.

Scopus

TITLE-ABS-KEY (teacher* OR "school teacher*" OR "preschool teacher*" OR "kindergarten teacher*" OR educator* OR "teaching assistant*" OR "childcare worker*" OR "child care worker*" OR "nursery teacher*" OR "early childhood educator*" OR "early childhood teacher*" OR "school staff")

AND

TITLE-ABS-KEY

("musculoskeletal disorder*" OR "work-related musculoskeletal disorder*" OR "work related musculoskeletal disorder*" OR WMSD OR WMSDs OR MSD OR MSDs OR "musculoskeletal symptom*" OR "musculoskeletal pain" OR "musculoskeletal complaint*" OR "low back pain" OR "back pain" OR "neck pain" OR "shoulder pain" OR "upper limb pain" OR "lower limb pain")

AND

TITLE-ABS-KEY

(ergonomic* OR "occupational health" OR "occupational safety" OR workplace OR "work environment" OR "risk factor*" OR "physical demand*" OR "psychosocial factor*" OR workload OR "job demand*" OR intervention* OR prevention OR "workplace intervention*" OR "participatory ergonomics" OR exercise OR "physical activity" OR physiotherapy OR stretching OR strengthening OR mindfulness OR "stress management" OR "cognitive behavioral")

AND (LIMIT-TO (LANGUAGE, "English"))

Web of Science

TS = (teacher* OR "school teacher*" OR "preschool teacher*" OR "kindergarten teacher*" OR educator* OR "teaching assistant*" OR "childcare worker*" OR "child care worker*" OR "nursery teacher*" OR "early childhood educator*" OR "early childhood teacher*" OR "school staff")

AND

TS = ("musculoskeletal disorder*" OR "work-related musculoskeletal disorder*" OR "work related musculoskeletal disorder*" OR WMSD OR WMSDs OR MSD OR MSDs OR "musculoskeletal symptom*" OR "musculoskeletal pain" OR "musculoskeletal complaint*" OR "low back pain" OR "back pain" OR "neck pain" OR "shoulder pain" OR "upper limb pain" OR "lower limb pain")

AND

TS = (ergonomic* OR "occupational health" OR "occupational safety" OR workplace OR "work environment" OR "risk factor*" OR "physical demand*" OR "psychosocial factor*" OR workload OR "job demand*" OR intervention* OR prevention OR "workplace intervention*" OR "participatory ergonomics" OR exercise OR "physical activity" OR physiotherapy OR stretching OR strengthening OR mindfulness OR "stress management" OR "cognitive behavioral")

Refined by: Language = English.

ProQuest

AB, TI(teacher* OR "school teacher*" OR "preschool teacher*" OR "kindergarten teacher*" OR educator* OR "teaching assistant*" OR "childcare worker*" OR "child care worker*" OR "nursery teacher*" OR "early childhood educator*" OR "early childhood teacher*" OR "school staff")

AND

AB,TI("musculoskeletal disorder*" OR "work-related musculoskeletal disorder*" OR "work related musculoskeletal disorder*" OR WMSD OR WMSDs OR MSD OR MSDs OR "musculoskeletal symptom*" OR "musculoskeletal pain" OR "musculoskeletal complaint*" OR "low back pain" OR "back pain" OR "neck pain" OR "shoulder pain" OR "upper limb pain" OR "lower limb pain")

AND

AB,TI(ergonomic* OR "occupational health" OR "occupational safety" OR workplace OR "work environment" OR "risk factor*" OR "physical demand*" OR "psychosocial factor*" OR workload OR "job demand*" OR intervention* OR prevention OR "workplace intervention*" OR "participatory ergonomics" OR exercise OR "physical activity" OR physiotherapy OR stretching OR strengthening OR mindfulness OR "stress management" OR "cognitive behavioral")

Limits applied: English; peer-reviewed journals.

Additional Search Procedures

Reference lists of all included articles and relevant review papers were manually screened to identify additional eligible studies. Journal websites and citation tracking were also checked when potentially relevant studies were identified but not retrieved through database searching. Duplicate records were removed before title and abstract screening. Titles and abstracts were screened first, followed by full-text assessment according to the predefined eligibility criteria.

Table S1. Methodological quality assessment of included studies using joanna briggs institute (jbi) critical appraisal tools.

Ref	Study design	JBI tool	Rating
23	Cluster quasi-experimental controlled study	JBI Critical Appraisal Checklist for Quasi-Experimental Studies	Moderate
27	Quasi-experimental comparative intervention study	JBI Critical Appraisal Checklist for Quasi-Experimental Studies	Moderate
32	Randomized controlled trial (waitlist-controlled)	JBI Critical Appraisal Checklist for Randomized Controlled Trials	High
16	Pre-post intervention study	JBI Critical Appraisal Checklist for Quasi-Experimental Studies	Moderate-High
25	Cluster randomized controlled trial (economic evaluation alongside trial)	JBI Critical Appraisal Checklist for Randomized Controlled Trials	High
26	Wait-list cluster randomized controlled trial	JBI Critical Appraisal Checklist for Randomized Controlled Trials	High

Continued

30	Cluster randomized pilot trial	JBI Critical Appraisal Checklist for Randomized Controlled Trials	Moderate-High
34	Educational intervention study	JBI Critical Appraisal Checklist for Quasi-Experimental Studies	Moderate
35	Stepped-wedge cluster randomized controlled trial	JBI Critical Appraisal Checklist for Randomized Controlled Trials	High
36	Quasi-experimental mindfulness intervention	JBI Critical Appraisal Checklist for Quasi-Experimental Studies	Moderate-High
37	Randomized controlled trial	JBI Critical Appraisal Checklist for Randomized Controlled Trials	High
38	Randomized controlled trial	JBI Critical Appraisal Checklist for Randomized Controlled Trials	High
39	Randomized controlled trial	JBI Critical Appraisal Checklist for Randomized Controlled Trials	High
40	Systematic review and meta-analysis	JBI Critical Appraisal Checklist for Systematic Reviews and Research Syntheses	High
41	Educational intervention study	JBI Critical Appraisal Checklist for Quasi-Experimental Studies	Moderate
42	Quasi-experimental intervention study	JBI Critical Appraisal Checklist for Quasi-Experimental Studies	Moderate-High
43	Randomized controlled trial	JBI Critical Appraisal Checklist for Randomized Controlled Trials	Moderate-High
44	Randomized controlled trial	JBI Critical Appraisal Checklist for Randomized Controlled Trials	High
45	Quasi-experimental mindfulness intervention	JBI Critical Appraisal Checklist for Quasi-Experimental Studies	Moderate-High
46	Quasi-experimental study	JBI Critical Appraisal Checklist for Quasi-Experimental Studies	Moderate-High
47	Quasi-experimental posture correction intervention	JBI Critical Appraisal Checklist for Quasi-Experimental Studies	Moderate
48	Cluster randomized controlled trial	JBI Critical Appraisal Checklist for Randomized Controlled Trials	Moderate
49	Randomized controlled trial	JBI Critical Appraisal Checklist for Randomized Controlled Trials	Moderate
50	Quasi-experimental exercise intervention	JBI Critical Appraisal Checklist for Quasi-Experimental Studies	Moderate
51	Quasi-experimental workplace exercise intervention	JBI Critical Appraisal Checklist for Quasi-Experimental Studies	Moderate-High
52	Parallel-group randomized controlled trial	JBI Critical Appraisal Checklist for Randomized Controlled Trials	High

Continued

53	Program evaluation (quasi-experimental)	JBI Critical Appraisal Checklist for Quasi-Experimental Studies	Moderate
54	Cluster randomized controlled trial	JBI Critical Appraisal Checklist for Randomized Controlled Trials	High
55	Stepped-wedge cluster randomized hybrid effectiveness-implementation trial	JBI Critical Appraisal Checklist for Randomized Controlled Trials	High
56	Quasi-experimental intervention study	JBI Critical Appraisal Checklist for Quasi-Experimental Studies	Moderate

Supplementary File S2

PRISMA 2020 Checklist

Title: *Do Integrated Interventions Achieve Broader Outcomes? A Systematic Review of Work-Related Musculoskeletal Disorder Interventions in Educators and the ETDIM Framework.*

Section & Topic	Item	Checklist item	Location in manuscript
TITLE	1	Identify the report as a systematic review.	Title
ABSTRACT	2	See PRISMA 2020 for Abstracts checklist.	Abstract
INTRODUCTION	3	Describe the rationale for the review.	Introduction
	4	Provide an explicit statement of the objectives/questions.	Introduction (last paragraph)
METHODS	5	Specify inclusion and exclusion criteria.	Section 2.1 Eligibility criteria
	6	Specify all information sources.	Section 2.2 Search strategy
	7	Present the full electronic search strategy.	Supplementary File 1
	8	Specify the selection process.	Section 2.3 Study selection and data extraction
	9	Specify the data collection process.	Section 2.3 Study selection and data extraction
	10a	List and define all outcomes sought.	Section 2.5 Coding of outcome breadth
	10b	List and define other variables collected.	Section 2.3 Data extraction

Continued

	11	Specify methods used to assess risk of bias.	Section 2.6 Methodological Quality Assessment
	12	Specify effect measures.	Not applicable (narrative synthesis)
	13a	Describe synthesis methods.	Section 2.4 Data synthesis
	13b	Methods used to prepare data.	Section 2.4 Data synthesis
	13c	Methods used to tabulate or visualize results.	**Tables 1-4**; **Figure 1**; **Figure 2**
	13d	Methods used to synthesize results.	Section 2.4 Narrative synthesis
	13e	Methods used to explore heterogeneity.	Narrative synthesis
	13f	Sensitivity analyses.	Not performed
	14	Reporting bias assessment.	Not performed
	15	Certainty assessment (GRADE).	Not performed
RESULTS	16a	Describe search and selection process.	Section 3.1; **Figure 1**
	16b	Cite studies excluded after full-text review.	Section 3.1
	17	Cite characteristics of included studies.	**Tables 1-4**
	18	Present risk-of-bias assessments.	Supplementary **Table S1**
	19	Present results of individual studies.	**Tables 1-4**
	20a	Summarize characteristics and risk of bias contributing to syntheses.	Results
	20b	Present statistical syntheses.	Not applicable
	20c	Present investigations of heterogeneity.	Narrative synthesis
	20d	Present sensitivity analyses.	Not performed
	21	Reporting biases.	Not assessed
	22	Certainty of evidence.	Not assessed
DISCUSSION	23a	General interpretation of findings.	Discussion
	23b	Limitations of included evidence.	Limitation
	23c	Limitations of review process.	Limitation
	23d	Implications for practice and research.	Discussion; Future Research

Continued

OTHER INFORMATION	24a	Registration information.	**Not registered**
	24b	Protocol access.	**No protocol published**
	24c	Amendments to protocol.	**Not applicable**
	25	Sources of support.	Funding
	26	Competing interests.	Conflict of Interest
	27	Availability of data/materials.	Data Availability