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Review article

Workplace interventions to prevent musculoskeletal disorders: a systematic review of randomized trials

Intervenções no trabalho para prevenção de distúrbios musculoesqueléticos: revisão sistemática de ensaios randomizados

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Abstract

Objective: to investigate the effects of workplace interventions aiming to prevent musculoskeletal disorders. **Methods:** systematic review that included randomized, individual or community trials, which investigated the effects of workplace interventions aiming to prevent musculoskeletal disorders, reported in articles published between 2015 and 2020 and indexed in the following databases: Lilacs, Medline/Pubmed, PEDro, and Web of Science. Studies were categorized according to the type of intervention and evaluated in terms of methodological quality. **Results:** of all 58 studies selected, 15 satisfactorily met the quality criteria, addressing different types of physical exercise and/or cognitive-behavioral approaches, applied alone or in combination. No study addressed organizational interventions. Despite the heterogeneity of interventions and outcomes, physical exercises performed in the workplace led to reduction in musculoskeletal pain, use of analgesics, and absence from work due to musculoskeletal disorders; however, combined with behavioral interventions, they did not show the expected results. The results with participatory ergonomics confirmed the critical role of workers in performing interventions in the workplace. **Conclusion:** despite the benefits observed, the studies reviewed did not produce consolidated evidence about the most effective interventions to prevent musculoskeletal disorders among workers.

Keywords: musculoskeletal disorders; cumulative trauma disorders; prevention of diseases; occupational health; systematic review.

Resumo

Objetivo: investigar os efeitos de intervenções no ambiente laboral para prevenção de distúrbios musculoesqueléticos. **Métodos:** revisão sistemática que incluiu ensaios randomizados, individuados ou comunitários, que investigaram efeitos de intervenções no trabalho para prevenir distúrbios musculoesqueléticos, relatados em artigos publicados entre 2015 e 2020 e indexados nas bases de dados: Lilacs, Medline/Pubmed, PEDro e Web of Science. Os estudos foram categorizados conforme a modalidade de intervenção e avaliados quanto à qualidade metodológica. **Resultados:** dos 58 estudos selecionados, 15 atenderam satisfatoriamente aos critérios de qualidade, abordando diferentes modalidades de exercícios físicos e/ou abordagem cognitivo-comportamental, aplicadas de forma única ou combinada; nenhum estudo abordou intervenções organizacionais. Apesar da heterogeneidade de intervenções e desfechos, exercícios físicos realizados nos locais de trabalho resultaram em diminuição da dor musculoesquelética, do uso de analgésicos e do afastamento do trabalho por distúrbios musculoesqueléticos, no entanto, combinados às intervenções comportamentais não mostraram os resultados esperados. Os resultados com a Ergonomia Participativa ratificaram o papel fundamental dos trabalhadores na realização de intervenções em seus ambientes de trabalho. **Conclusão:** apesar de benefícios observados, salienta-se que os estudos revisados não produziram evidências consolidadas acerca das intervenções mais eficazes para prevenir distúrbios musculoesqueléticos entre trabalhadores.

Palavras-chave: doenças musculoesqueléticas; transtornos traumáticos cumulativos; prevenção de doenças; saúde do trabalhador; revisão sistemática.

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Introduction

Work-related musculoskeletal disorders (MSD) represent a major cause of employee absenteeism, representing a global public health problem[1-4]. The use of the body in poor working conditions, as seen in sectors with a high level of automation or in activities that rely on intense manual work, with high physical burden on workers, has generated a high prevalence of MSDs. Therefore, workplace interventions to prevent these disorders are relevant to reduce the prevalence or intensity of musculoskeletal pain, avoiding physical and mental suffering[5,6] and incapacity for work, promoting workers' health.

In the last two decades, significant progress has been made in the methodological quality of studies, which have provided more solid evidence of the association between work and MSD based on observational and interventional studies.

However, the development of robust studies with reliable data and reproducible interventions with the possibility to extrapolate the results to other populations is still a challenge due to high costs involved and the market economy that neglects prevention and protection of workers' health, limiting the conditions that support the development of such studies.

Some prevention strategies may not be successful due to insufficient knowledge about workplaces, workers, and work situations, in their habituality and variability[6], without considering the individuality and complexity of the factors involved in musculoskeletal disorders. The proposal of preventive interventions must involve prior analysis of the workplace and work relationships, an understanding of the physical and psychosocial issues affecting workers, and the identification of specific measures to address the needs and challenges of each work context[6]. An evidence-based approach can be essential for the efficacy and effectiveness of interventions. Therefore, interventions must be previously assessed as timely and appropriate for each situation and work environment, considering that there is no single and effective strategy to prevent MSDs in all types of workplace[5].

Considering the multifactorial nature of MSDs and their impact on the workers' health, assessing the effect of workplace interventions for MSD prevention is a necessary topic in a research agenda, seeking evidence of interventions that can help reduce the incidence, prevalence, and severity of musculoskeletal disorders[5,6].

The objective of this review is to assess the effects of workplace interventions to prevent MSDs.

Methods

This is a systematic review (SR) with a protocol published in the PROSPERO systematic review protocol database, registered under CRD42020215076. This review is reported according to PRISMA 2020 recommendations[7].

Literature search

The formulation of a well-designed search strategy plays a crucial role in the quality of an SR. The first step to define appropriate descriptors involved establishing the concepts linked with the study question, which included a comprehensive analysis of interventions for the prevention of work-related MSD. The long process of discussion among the authors about the multifactorial outcome of MSD and the theory of protective factors for these disorders found some challenges for the identification of interventions to be included in this review, allowing the authors to define a degree of complexity to be adopted in the construction of syntax for the operational search stage conducted by the authors.

After an extensive period of search, discussion, and careful analysis of available options in terms of viability and relevance, two authors (PGASS and RCPF) formulated three groups containing the main concepts of the study: musculoskeletal disorders, work, and intervention/prevention. Later, the terms to create the search strategies and choose descriptors and keywords were selected from MeSH Terms and DeCS, by the authors (PGASS, RCPF e MSMS) (**Chart1**).

Chart 1 Search strategies

Pubmed/Medline	#1	"musculoskeletal diseases"[MeSH] OR "Back pain*" OR "low back pain*" OR Backpain*[TIAB] OR backache*[TIAB] OR "back ache*" OR Neckache* OR Cervicalgia* OR Cervicodynia* OR "Cervical Pain*" OR "Musculoskeletal Pain*"[TIAB] OR "Cumulative Trauma" OR "Repetition Strain Injur*" OR "Repetitive Motion Disorder*" OR "Overuse Syndrome*" OR "Carpal Tunnel" OR "Iliotibial Band Syndrome" OR "Ulnar Nerve Compression" OR "Cubital Tunnel Syndrome" OR "musculoskeletal disease*" OR "musculoskeletal disorder*" OR Tendinopath* OR Tendinos* OR Tendinit* OR Tendonit* OR Tendonopath* OR Epicondylit* OR ((Leg[TIAB] OR knee*[TIAB] OR foot[TIAB] OR feet[TIAB] OR neck[TIAB] OR arm[TIAB] OR arms[TIAB] OR finger*[TIAB] OR hand*[TIAB] OR shoulder*[TIAB] OR wrist*[TIAB]) AND (pain*[TIAB] OR injur*[TIAB] OR ache*[TIAB])) AND (occupation*[tiab] OR work*[tiab] OR Employ*[tiab] OR job[tiab] OR jobs[tiab] OR work[Mesh:NoExp] OR employment[Mesh:NoExp] OR workplace[Mesh:NoExp] OR occupations[Mesh:NoExp]) AND ("Occupational diseases"[MESH] OR "Occupational disease*")
	#2	(work[tiab] OR workplace[tiab] OR work-place[tiab] OR workload[tiab] OR Work[Mesh:NoExp] OR "employment"[Mesh:NoExp] OR Employ*[TIAB] OR Job[TIAB] OR jobs[TIAB] OR Occupation*[TIAB] OR Worksite*[TIAB] OR "working conditions" OR Workload[TIAB])
	#3	(interven*[tiab] OR strateg*[tiab] OR solution*[tiab] OR reorganis*[tiab] OR reorganiz*[tiab] OR re-organis*[tiab] OR re-organiz*[tiab] OR redesign[tiab] OR re-design[tiab] OR restructuring[tiab] OR re-structuring[tiab])
	#4	#1 AND #2 AND #3
		"randomized" OR "cross sectional" OR "cohort" OR "prophylactic study" OR "observational study" OR "case control"
Web of Science	#1	TS=("cumulative trauma disorder*" OR "musculoskeletal disorder*" OR "musculoskeletal disease*" OR "hand-arm vibration syndrome" OR tendinopath* OR tendinos* OR tendinit* OR tendonit* OR tendonopath* OR epicondylit* OR "repetition strain injur*" OR "repetitive motion disorder*" OR "overuse syndrome*" OR "carpal tunnel" OR "iliotibial band syndrome" OR "ulnar nerve compression" OR "cubital tunnel syndrome") OR TS= (musculoskeletal OR "low back" OR "back" OR "neck" OR "shoulder*" OR "upper extremit*" OR "chronic" OR "lower extremit*" OR "foot" OR "feet" OR "wrist*" OR "leg*" OR "knee*" OR "hand*" OR "trigger finger*" OR "arm*") AND TS=("pain" OR "ache" OR "injur*")
	#2	TS=(work* OR employ* OR job* OR labor OR labour OR occupation* OR workplace* OR "work location*" OR work-site* OR "work site*" OR worksite* OR "work place*" OR workplace* OR "job site*" OR "working environment" OR "working condition*" OR workload OR employment)
	#3	TS=("primary prevention" OR ergonomic* OR "change management" OR exercise OR "risk reduction behavior" OR "occupational health" OR strategy OR solution OR "risk prevention" OR intervention OR prevention OR organizational OR organisational OR redesign OR change*)
	#4	#1 AND #2 AND #3
		TS=("randomized" OR "cross sectional" OR "cohort" OR "prophylactic study" OR "observational study" OR "case control")

(continues)

Chart 1 Continuation

Lilacs	#1	(tw:((“cumulative trauma disorder*” OR “Trastornos de Traumas Acumulados” OR “Transtornos Traumáticos Cumulativos”) OR (“Musculoskeletal Diseases” OR “Enfermedades Musculoesqueléticas” OR “Doenças Musculoesqueléticas”) OR (Tendinopathy OR Tendinopatía OR Tendinopatia) OR ((musculoskeletal OR musculoesquelético OR musculoesquelético) OR (“low back” OR “espalda baja” OR lombar) OR (neck OR cuello OR pescoço) OR (shoulder OR hombro OR ombro) OR (“upper extremit*” OR “extremidad superior” OR “extremidade superior”) OR (chronic OR crónico OR crônica) OR (“lower extremit*” OR “extremidad inferior” OR “extremidade inferior”) OR (foot OR pie OR pé) OR (wrist OR muñeca OR punho) OR (leg OR pierna OR perna) OR (knee OR rodilla OR joelho) OR (hand OR mano OR mão) OR (arm OR brazo OR braço) AND (pain OR dolor OR dor))))
	#2	(tw:((work OR trabajo OR Trabalho) OR (employment OR empleo OR emprego) OR (occupations OR ocupaciones OR ocupações) OR (workplace OR “lugar de trabajo” OR “local de trabalho”) OR (“working environment” OR “ambiente de trabajo” OR “ambiente de trabalho”) OR (“working conditions” OR “condiciones de trabajo” OR “condições de trabalho”) OR (workload OR “carga de trabajo” OR “carga de trabalho”)))
	#3	(tw:((“primary prevention” OR “prevención primaria” OR “prevenção primária”) OR (ergonomics OR ergonomía OR ergonomia) OR (exercise OR “ejercicio físico” OR “exercício físico”) OR (“change management” OR “gestión del cambio” OR “gestão de mudança”) OR (strategies OR estrategias OR estratégias) OR (“occupational health” OR “salud laboral” OR “saúde do trabalhador”)))
	#4	(tw:((“cumulative trauma disorder*” OR “Trastornos de Traumas Acumulados” OR “Transtornos Traumáticos Cumulativos”) OR (“Musculoskeletal Diseases” OR “Enfermedades Musculoesqueléticas” OR “Doenças Musculoesqueléticas”) OR (Tendinopathy OR Tendinopatía OR Tendinopatia) OR ((musculoskeletal OR musculoesquelético OR musculoesquelético) OR (“low back” OR “espalda baja” OR lombar) OR (neck OR cuello OR pescoço) OR (shoulder OR hombro OR ombro) OR (“upper extremit*” OR “extremidad superior” OR “extremidade superior”) OR (chronic OR crónico OR crônica) OR (“lower extremit*” OR “extremidad inferior” OR “extremidade inferior”) OR (foot OR pie OR pé) OR (wrist OR muñeca OR punho) OR (leg OR pierna OR perna) OR (knee OR rodilla OR joelho) OR (hand OR mano OR mão) OR (arm OR brazo OR braço) AND (pain OR dolor OR dor)))) AND (tw:((work OR trabajo OR Trabalho) OR (employment OR empleo OR emprego) OR (occupations OR ocupaciones OR ocupações) OR (workplace OR “lugar de trabajo” OR “local de trabalho”) OR (“working environment” OR “ambiente de trabajo” OR “ambiente de trabalho”) OR (“working conditions” OR “condiciones de trabajo” OR “condições de trabalho”) OR (workload OR “carga de trabajo” OR “carga de trabalho”))) AND (tw:((“primary prevention” OR “prevención primaria” OR “prevenção primária”) OR (ergonomics OR ergonomía OR ergonomia) OR (exercise OR “ejercicio físico” OR “exercício físico”) OR (“change management” OR “gestión del cambio” OR “gestão de mudança”) OR (strategies OR estrategias OR estratégias) OR (“occupational health” OR “salud laboral” OR “saúde do trabalhador”)))
PEDro	Therapy: health promotion Subdiscipline: ergonomics and occupational health Method: clinical trial Published Since: 2001 When Searching: Match all search terms (AND)	

Each group of terms was organized internally using the Boolean operator OR, aiming to cover several possible variations. After adjustments in each group, considering the variety of terms, the syntactic structure between the groups was defined using the Boolean operator AND. As the results were obtained, filters were applied to refine the search. Electronic searches were performed by one author (PGASS) on Medline/PubMed, Lilacs, Web of Science, and PEDro in the first half of November 2020. The entire search process conducted in these databases was carefully monitored, supervised, and reviewed by another author (RCPF).

A complementary search was conducted by two authors (PGASS and RCPF), independently, who analyzed the references of previously selected studies and identified which references had not been obtained through search strategies.

Eligibility of studies

Inclusion criteria

Inclusion criteria were randomized clinical trials (RCT) or community trials published between 2015 and 2020 (until October 31, 2020) in Portuguese, English, and Spanish, whose objectives addressed workplace interventions to prevent MSDs. Interventions could range from modifications to the physical environment, instruments, and tools used by workers; interventions focused on the individual, such as educational, behavioral, and physical practices like physical exercises; or organizational interventions, such as adjustments to the organization or pace of work, operational demands, and additional breaks.

Exclusion criteria

Exclusion criteria were workplace intervention studies, whose objectives were not related to the prevention of MSDs (such as productivity improvement, improvement of interpersonal relationships, impact on other health fields such as visual acuity, among others), and studies on clinical interventions from the perspective of health care (such as outpatient service in companies for clinical treatment of MSDs using drugs or physical therapy).

Selection of studies

The search results were exported to Mendeley Desktop and duplicates were eliminated. Then they were transferred and organized in a Microsoft Office Excel spreadsheet and duplicates not identified by Mendeley were eliminated.

First, the titles and abstracts were read in order to select the articles for full-text reading. Then full texts were read by the authors (PGASS and RCPF) and classified according to the type of intervention performed. Disagreements were discussed and resolved by consensus.

Data extraction

The following relevant information was extracted for evidence synthesis: country where the study was conducted, study year, journal and language of publication, characteristics of the study population, number of participants, objectives, control group and intervention group, intervention duration and follow-up, intervention characteristics, outcomes, effect and impact measures, and study limitations.

The interventions were categorized as follows: interventions on the work environment, interventions on the individual, interventions on organizational aspects, and multidimensional interventions (different approaches simultaneously), all of them aiming to prevent MSDs.

Assessment of study quality and structure of results

In order to evaluate the methodological quality of the studies, the Critical Appraisal Skills Program (CASP)[8] was used. This tool is considered a good measurement of transparency of study practice and standards[9]. The CASP checklists do not recommend a weighting system to infer methodological quality[8]. This way, the number of affirmative answers to the 13 questions was counted to establish the level of compliance with the CASP items (high, medium or low). For this evaluation, "CASP was satisfactorily met" with 10 to 13 affirmative answers (YES); "CASP was partially met" with 7 to 9 affirmative answers; and "CASP was poorly met" with 0 to 6 affirmative answers.

Due to the importance of the articles that satisfactorily met the CASP criteria, the authors decided to present and discuss only the results of these studies, which are presented through a representative figure of their methodological quality.

Results

The search found 1,068 documents after removing duplicates and files without valid metadata. After this stage, 124 studies were selected for full reading and screening, resulting in 97 articles retained for more detailed analysis. Of these, 58 were chosen for methodological quality assessment, resulting in 15 articles used to discuss this systematic review, as illustrated in **Figure 1**. Of these studies, nine were randomized community trials and six were randomized clinical trials.

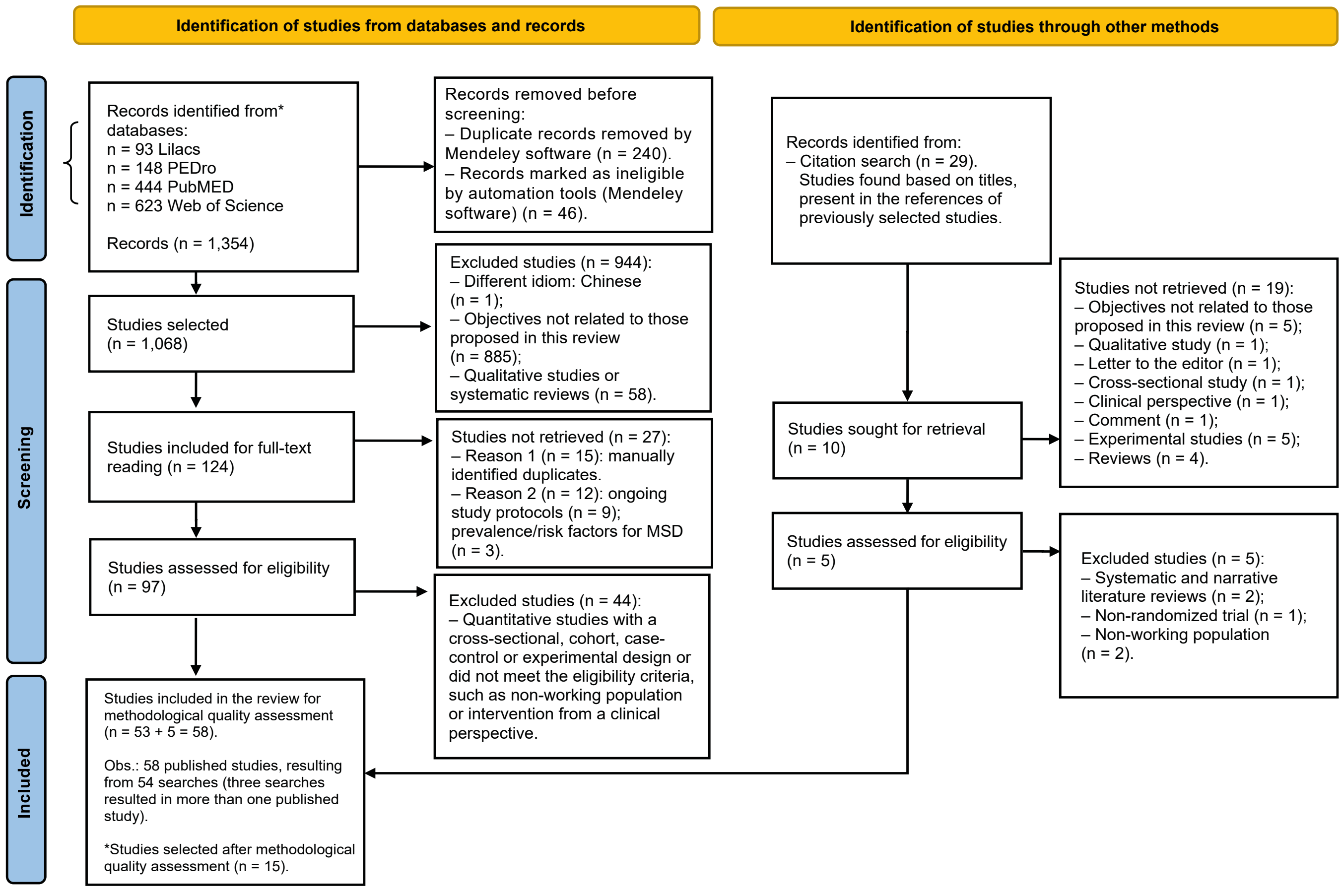

Figure 1 Flowchart of the systematic review on the effects of workplace interventions to prevent musculoskeletal disorders

Methodological quality of studies

Figure 2 shows the results of the methodological quality assessment of all 15 selected studies**.**

Y – Yes N – No CNT – Can Not Tell	Section A: Is the basic study design valid for a randomized clinical trial?			Section B: Was the study methodologically correct?					Section C: What are the results?		Section D: Will the results help locally?			Results	Evaluation
	1. Did the study address a clearly focused research question?	2. Was the assignment of participants to interventions randomized?	3. Were all participants who entered the study accounted for at its conclusion?	4. About study blinding: a) Were participants blind to the intervention they were given?	b) Were the investigators 'blind' to the intervention they were giving to participants?	c) Were the people assessing/analyzing outcomes 'blinded'?	5. Were the study groups similar at the start of the randomized clinical trial?	6. Apart from the experimental intervention, did each study group receive the same level of care (i.e., were they treated equally)?	7. Were the effects of the intervention reported comprehensively?	8. Was the precision of estimated intervention or treatment effect reported?	9. Do the benefits of the experimental intervention outweigh the harms and costs?	10. Can the results be applied to your local population/your context?	11. Would the experimental intervention provide greater value to the people in your care than any of the existing interventions?		10 - 13 = HIGH 7 - 9 = MEDIUM 0 - 6 = LOW
Ramussen et al. (2015)[10]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	11/13	HIGH
Jay et al. (2015)[11]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	CNT	Y	Y	10/13	HIGH
Stevens et al. (2019)[12]	Y	Y	N	N	CNT	Y	Y	Y	Y	Y	Y	Y	Y	10/13	HIGH
Becker et al. (2017)[13]	Y	Y	Y	N	Y	Y	Y	Y	Y	N	Y	Y	CNT	10/13	HIGH
Becker et al. (2020)[14]	Y	Y	Y	N	CNT	Y	Y	Y	Y	Y	Y	Y	CNT	10/13	HIGH
Pereira et al. (2019)[15]	Y	Y	Y	N	Y	CNT	Y	Y	Y	Y	Y	Y	Y	11/13	HIGH
Akyurek et al. (2020)[16]	Y	Y	Y	N	N	Y	Y	Y	Y	N	Y	Y	Y	10/13	HIGH
Jakobsen et al. (2015)[17]	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	11/13	HIGH
Jakobsen et al. (2017)[18]	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	10/13	HIGH
Jakobsen et al. (2018)[19]	Y	Y	Y	N	CNT	Y	Y	Y	Y	Y	Y	Y	CNT	10/13	HIGH
Korshøj et al. (2018)[20]	Y	Y	Y	N	CNT	CNT	Y	Y	Y	Y	Y	Y	Y	10/13	HIGH
Moreira et al. (2020)[21]	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	Y	10/13	HIGH
Doda et al. (2015)[22]	Y	Y	Y	N	Y	N	Y	Y	Y	Y	Y	Y	CNT	10/13	HIGH
Viester et al. (2015)[23]	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	CNT	Y	CNT	10/13	HIGH
Danquah et al. (2017)[24]	Y	Y	N	N	Y	Y	Y	Y	Y	Y	CNT	Y	Y	10/13	HIGH

Figure 2 Methodological evaluation of randomized clinical trials included in the systematic review on the effects of workplace interventions to prevent musculoskeletal disorders, using the Critical Appraisal Skills Programme[8] (CASP)

All 15 published studies that satisfactorily met the CASP are described in the table below. **Table 1** shows information about the type of trial (individual basis – RCT, or aggregate basis – community type, that is, with clusters), the types and characteristics of intervention programs, the follow-up time of the study, the population, and the results. **Table 2** shows the study objectives; the measurement instruments; the effect, impact, or association measures; and study limitations.

Heterogeneity was observed in the studies in terms of type of population, intervention programs, measurement instruments, statistical analyses, and outcomes, which did not allow a meta-analysis. Of all 15 studies analyzed, 10 investigated individual interventions—physical activities and behavioral approaches—and five articles investigated multidimensional interventions.

The target populations of the studies included professionals from different sectors, and most were healthcare workers. Most studies (n = 11) were conducted in Europe, with a concentration in Nordic and Scandinavian countries (n = 8). Different instruments were used to measure musculoskeletal symptoms and applied alone or combined with other instruments, with a predominance (n = 8) of the Nordic Musculoskeletal Questionnaire (NMQ).

Table 1 Characteristics of the studies included in the systematic review on the effects of workplace interventions to prevent musculoskeletal disorders (Part I)

Authors, year, country	Study type	Type of intervention	Characteristics of intervention	Follow-up	Population	Result/ outcome
Multidimensional interventions						
Rasmussen et al., 2015[10], Denmark	Cluster	1) Physical exercises 2) Cognitive-behavioral therapy	Participatory ergonomics (prevent effort and pain) 1) Physical training (introduce different types of physical exercises to present different types of physical activities: 1) body awareness and body postures; 2) strength and coordination training; 3) general physical activity. 2) Cognitive-behavioral training (CBT): workshops focused on changing maladaptive pain behaviors and cognitive processes.	3 months	**Nursing and kitchen assistants, and cleaning staff, as well as caretakers (workers employed in elderly care in nursing homes or home care)** This study assessed four groups, each doing an activity at different times. **594 participants** **21 clusters divided into four groups** **Study population assessed = 586** – Group 1: 5 clusters/12 teams, n = 126 participants; – Group 2: 5 clusters/14 teams, n = 146 participants; – Group 3: 5 clusters/13 teams, n = 158 participants; – Group 4: 6 clusters/15 teams, n = 164 participants	The analyses produced significantly reduced the number of days of low back pain, pain intensity, and discomfort after the intervention when compared to the control group. A multidimensional workplace intervention consisting of physical training and CBT effectively reduced the number of days of low back pain, pain intensity, and discomfort among workers in workplaces with elderly people.
Jay et al., 2015[11], Denmark	Individual RCT	1) Physical exercises 2) Cognitive-behavioral training – Mindfulness	The experimental intervention treatment (PCMT group) consisted of four main elements: 1) Individualized motor control training. 2) Individualized resistance and specific training for the area affected by pain.	10 weeks	**Workers of a large pharmaceutical company** Control group (n = 56): an email was sent to people encouraging them to participate in existing initiatives, such as weekly training with elastic bands and active breaks.	– Pain reduction in the PCMT and control groups: 52% and 15%, respectively; – Significant associations for change in pain with the number of physical-cognitive training sessions per week and number of mindfulness sessions.

(continues)

Table 1 Continuation

Authors, year, country	Study type	Type of intervention	Characteristics of intervention	Follow-up	Population	Result/ outcome
			3) Cognitive training and behavior change education, emphasizing specific individual concerns about pain and movement. 4) Mindfulness.		Intervention group – PCMT (n = 56): Group-based mindfulness training; 20-minute physical training with flexible schedules; guided mindfulness	– Significant reduction in musculoskeletal pain when compared to the control group after the intervention. – The authors hoped to reduce pain through the influence of stress, because if stress decreases, pain decreases too, and vice versa; however, while mindfulness can help reduce pain, dose-response analysis showed an opposite effect. – Participation in mindfulness sessions increased the perception of pain at each session attended.
Stevens et al., 2019[12], Denmark	Cluster	1) Physical exercises 2) Cognitive-behavioral training	Participatory ergonomics training: two 3-hour workshops and two 1-hour assessment sessions focused on reducing physical effort at work, changing work tasks perceived as physically demanding. 1) Physical exercise program: 12 weekly 1-hour sessions (various types of physical activity). 2) Cognitive-behavioral training program: 2 three-hour workshops focused on the use of cognitive processes to change maladaptive pain behaviors.	3 months	**Elderly care workers** N = 420 Control group: did not perform any activity. Intervention group: performed proposed activities.	Effects of the intervention to reduce fear avoidance by increasing the use of assistive devices, but not on perception of muscle strength or physical effort. The intervention reduced beliefs about avoiding fear and increased the use of assistive devices at work, but it did not lead to changes in low back pain patterns (number of days with low back pain, pain intensity, and days with some discomfort).

(continues)

Table 1 Continuation

Authors, year, country	Study type	Type of intervention	Characteristics of intervention	Follow-up	Population	Result/ outcome
Becker et al., 2017[13]. Germany	Individual RCT	1) Physical therapy 2) Coaching	**1) Physical therapy** The standard treatment for musculoskeletal complaints is guided monitored movement therapy. In addition, an appreciation for posture and proprioceptive movements must be developed to reduce fear of movement. Preventive physical therapy was performed at five physical therapy practice sites. **2) Coaching** Coaching focuses on a private consultation with qualified personnel and management of individual development issues at work.	10 weeks	**Nurses from five hospitals located in the Paderborn region, in Germany** Control group (34): received only the exercises from the physical therapy program. Intervention group (34): received physical therapy exercises and psychosocial coaching intervention.	Significant improvement was observed in both groups over time. Tendency of more pain due to the maximum degree of movement in the intervention group. The result of the time × group interaction showed that combined intervention of physical therapy and coaching, when compared to physical therapy alone, helps improve current mobility. Combined intervention of physical therapy and coaching, when compared to physical therapy alone, reduced the level of pain in daily movements at the first follow-up.
Becker et al., 2020[14], Germany	Individual RCT	1) Physical therapy 2) Coaching	Both groups **received physical therapy exercises** over a 10-week period (focused on individual functional status and job-specific physical demands; 10 × 45 min.). In addition, **the intervention group received work-related psychosocial coaching** during this period. This psychosocial coaching intervention consisted of 1 × 120 minutes of introduction to the theoretical model of selection, optimization, and compensation.	10 weeks	**Nurses** Control group (n = 31): received physical therapy only. Intervention group (n = 32): received physical therapy and coaching sessions.	A significant effect of the intervention was observed on maximal spinal motion restriction for imputed data sets only, which means a higher decrease in disability in the IG than in the CG at the third follow-up. No other significant effect of the intervention was observed.

(continues)

Table 1 Continuation

Authors, year, country	Study type	Type of intervention	Characteristics of intervention	Follow-up	Population	Result/ outcome
Individual interventions						
Pereira et al., 2019[15], Australia	Cluster	1) Ergonomic guidance 2) Physical exercises	Group 1) EET -> Workplace ergonomics and specific physical training for the neck: exercise at work in groups for 20 minutes, three times a week. Group 2) EHT -> Workplace ergonomics and health promotion information: received a weekly series of health promotion seminars, each lasting one hour for 12 weeks.	12 weeks	**Office workers** There was no control group, the study had two groups with different activities for compariso. EET -> Workplace ergonomics and specific physical training for the neck: exercise at work in groups for 20 minutes, three times a week. EHT -> Workplace ergonomics and health promotion information: received a weekly series of health promotion seminars, each lasting one hour for 12 weeks. 12 weeks.	At the end of the program, EET participants with neck pain had lower absenteeism over 12 months when compared to participants in the EHP group.
Akyurek et al., 2020[16], Türkiye	Individual RCT	1) Physical exercises 2) Ergonomic guidance	Workplace Health Promotion Programs (WHPP): 1) Physical exercises: – Progressive muscle relaxation (PMR). – Postural exercises (specific strengthening and stretching). – Breathing exercises. 2) Ergonomic guidance (postural guidance, chair position, among others).	5 weeks	**Nurses** Control group (n = 15): rested in a room with reading materials, but without other activities. Individuals were instructed not to change their activities or forms of relaxation for one year. Intervention group (n = 15): performed the entire proposed activity twice a week.	The authors reported in the results that, after the WHPP, the intervention group had a significant improvement in pain, fatigue, stress, coping skills, and quality of professional life immediately after the end of the program, when compared to baseline data. The results (improvements) were maintained after one year.

(continues)

Table 1 Continuation

Authors, year, country	Study type	Type of intervention	Characteristics of intervention	Follow-up	Population	Result/ outcome
Jakobsen et al., 2015[17], Denmark	Cluster	Physical exercises	Any physical exercise at work or at home. – Both groups were encouraged to do the exercise for 5 to 10 minutes every week for 10 weeks. Both groups: – Ergonomic training and education on patient transfer and use of assistive devices.	10 weeks	**Healthcare professionals from three Danish hospitals.** Control group (physical exercise at home – HOME) – Participants received a bag with exercise equipment. – Folders explaining the exercises. Intervention group (physical exercise in the workplace – WORK) – Supervised high-intensity strength training with Thera-Band elastic bands and kettlebells during working hours at the hospital. – 10 exercises. – 5 coaching sessions of 30 to 45 minutes to motivate participants to practice exercise. – One of the objectives of coaching was to encourage participation in the intervention – whether physical exercise or coaching sessions (stimulate other colleagues).	– Pain intensity decreased in the WORK group. – Muscle strength (lumbar spine) increased in the WORK group. – Higher reduction in the use of analgesics in the WORK group. – The study showed a significant decrease in the intensity of musculoskeletal pain, an increase in muscle strength, and a reduction in the use of analgesics among healthcare workers in response to exercise for 10 weeks in the workplace when compared to exercise performed at home.
Jakobsen, et al., 2017[18], Denmark	Cluster	Physical exercises	Any physical exercise at work or at home, both groups were encouraged to exercise for 5 to 10 minutes per week. Both groups: – Ergonomic training and guidance on patient transfer and use of assistive devices.	10 weeks	**Healthcare professionals from three Danish hospitals.** Control group (n = 89, 9 clusters) (physical exercise at home – HOME). Intervention group (n = 111, 9 clusters) (physical exercise in the workplace – WORK).	The authors identified that a higher adherence to training also led to better results.

(continues)

Table 1 Continuation

Authors, year, country	Study type	Type of intervention	Characteristics of intervention	Follow-up	Population	Result/ outcome
						However, the study showed that even when the analysis was adjusted for training adherence (among other parameters), performing physical exercise, and receiving motivational coaching in the **workplace** more effectively reduced musculoskeletal pain intensity in low back, neck, and shoulders when compared to performing exercise at home.
Jakobsen et al., 2018[19], Denmark	Cluster	Physical exercises	Intervention: physical exercise at work or at home (5 to 10 minutes). ***Groups:** # WORK – Supervised strength training. – 2 to 20 workers per session. – 4 to 6 exercises (from pre-established exercises). – The group that exercised at work (WORK) also participated in 5 motivational training sessions of 30 to 45 minutes in a group of 5 to 12 participants. # HOME – Participants were instructed to exercise for 10 minutes, five times a week, and perform 4 exercises (out of 10 proposed exercises). – The group at home (HOME) performed the activities during leisure time.	10 weeks	**Healthcare professionals from three hospitals** Control group (9 clusters, n = 89): was part of the HOME group and performed the exercises at home. Intervention group (9 clusters, n = 111): was part of the WORK group and participated in the proposed activities.	According to the study authors, although adherence was higher in the group that performed the intervention in the workplace, in the analyses, adjustments were made for training adherence and the WORK group presented better results. *The coaching sessions, with motivation to participate in the program, may have impacted the results.

(continues)

Table 1 Continuation

Authors, year, country	Study type	Type of intervention	Characteristics of intervention	Follow-up	Population	Result/ outcome
Korshøj et al., 2018[20], Denmark	Cluster	Physical exercises	First phase of the intervention: Control group (reference): 2 classes/lectures of 2 hours/class. Intervention group: 2 × 30 min. --> 32 sessions (16 hours). Second phase of the intervention: Control group (reference): 3 classes/lectures of 2 hours/class. Intervention group: exercise group: 2 × 30 min. --> 52 sessions (26 hours). In the second phase, exercise supervision of the intervention group gradually decreased, as follows: – period from baseline up to 4 weeks: 6 supervised sessions, – period from 4 to 8 weeks: 5 supervised sessions, – period from 8 to 12 weeks: 4 supervised sessions, – period from 12 to 16 weeks: 2 supervised sessions, – period from 16 to 20 weeks: 1 supervised session. Participation was recorded only when the instructor was present.	12 weeks	**Cleaning companies in the suburban area of Copenhagen, Denmark, recruited by contact.** Control group (reference) (20 clusters, n = 59): lectures with guidance about healthy lifestyle. Intervention group (20 clusters, n = 57): physical activity (at or near the location, during working hours).	– 4 months: no significant changes, except in the hip; – 12 months: significant changes in shoulders, arms, wrists, and trends in knees, feet, and ankles; – the study showed significant results in upper limbs; however, it showed worsening in lower limbs.
Moreira et al., 2020[21], Brazil	Individual RCT	Physical exercises	Intervention: therapeutic exercise program twice a week for 12 weeks, each session of 30 minutes.	12 weeks	**Active nursing assistants at a general hospital in Brazil.** Control group (n = 44): did not receive any intervention, only after the end of the analyses. Intervention group (n = 46): received proposed intervention.	Results of low back pain: positive, pain relief (measurements before and after the intervention), although it is not possible to predict long-term effects.

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Table 1 Continuation

Authors, year, country	Study type	Type of intervention	Characteristics of intervention	Follow-up	Population	Result/ outcome
Doda et al., 2015[22], Australia	Cluster	Behavioral approach (SOC – Stages of Change model)	Interventions addressed various types of recommendations to control MSD, including redesign of tools, workstations, work processes, purchase of new equipment, job rotation, workplace inspection programs, manual handling training, and exercises. – In total, 25 interventions (13 standardized and 12 customized) were monitored in 21 companies from eight industrial sectors. The interventions were implemented by the manager for workers. The ergonomist monitored the interventions every three months, through a telephone call to the manager. The main focus of the study question was not the effect of the intervention at the individual level.	12 weeks	**29 work groups from 23 medium-sized companies (20 to 200 employees) and large companies (more than 200 employees)** Group of personalized interventions based on the SOC model (15 groups from 14 companies, n = 109) and group of standardized interventions (14 groups from 12 companies, n = 133).	Interventions adapted according to the SOC model showed relative benefit, particularly for low back pain and discomfort.
Viester et al., 2015[23], The Netherlands	Individual RCT	Behavioral approach	– Lifestyle coaching program – Personalized lifestyle information, lifestyle coaching sessions, exercise instructions, and the VIP (vitality in practice) under construction with Toolbox. – Participants received a 'personal energy plan' form to write goals and action plans.	12 weeks	**Workers of a large construction company.** Control group (n = 152): received usual care, without any other intervention. Intervention group (n = 162): performed proposed intervention.	The prevalence of musculoskeletal symptoms decreased; however, the reduction was not statistically significant.

(continues)

Table 1 Continuation

Authors, year, country	Study type	Type of intervention	Characteristics of intervention	Follow-up	Population	Result/outcome
Danquah et al., 2017[24], Denmark/Greenland	Cluster	Behavioral approach	The Take a Stand! intervention included five elements: (1) appointment of local ambassadors, management and support; (2) environmental changes; (3) a lecture; (4) a workshop aiming to ensure local adaptation of the individual at office and workplace level; and (5) emails and text messages. The intervention focused on four strategies to reduce sitting time: use of a desk with support for sitting, taking breaks for extended periods, standing up, adoption of walking meetings, and setting common office-level goals.	3 months	**Office workers** Control group (9 offices, n = 144): instructed to maintain their usual activities. Intervention group (10 offices, n = 173): followed the proposed intervention program.	When comparing the intervention and control groups after 1 and 3 months, taking into account baseline levels, a small reduction was observed in total pain score. After 3 months, the prevalence of neck-shoulder pain was slightly reduced in the intervention group when compared to the control group, but for back and extremity pain, no change was found (exploratory analyses). For total pain score, a small reduction was observed in the intervention group when compared to the control group at 1- and 3-month follow-up.

CG: control group; IG: intervention group.

Table 2 Characteristics of the studies included in the systematic review on the effects of workplace interventions to prevent musculoskeletal disorders (Part II)

Authors, year, country	Study type	Study objective	Measurement instruments	Effect/impact/association measures OR, RR, mean difference	Study limitations
			Multidimensional interventions		
Rasmussen et al., 2015[10], Denmark	Cluster	Test the effectiveness of a 3-month multidimensional intervention consisting of participatory ergonomics, physical exercises, and cognitive behavioral therapy for low back pain in the workplace with nursing assistants.	Numerical scale (0-10) Oswestry Disability Questionnaire Roland Morris Questionnaire	Linear regression models estimated the intervention effect. Beta coefficients and 95% confidence interval (CI) were calculated. After the intervention, reduction was observed in parameters, as follows: – 0.8 day reduction in low back pain; – 0.4 point pain intensity and reduction of discomfort, with	– Difference in dropout between the 4 groups, with higher dropout in groups that started the intervention at a later time. It may cause a small selection bias toward a healthier population being analyzed.

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Table 2 Continuation

Authors, year, country	Study type	Study objective	Measurement instruments	Effect/impact/association measures OR, RR, mean difference	Study limitations
				-0.5 day reduction in discomfort in the intervention group.	– Due to the specific population analyzed in this study, the results cannot be generalized to other occupational groups. – Low participation rate (50%). – It was not possible to evaluate the effects of every component of the intervention separately.
Jay et al., 2015[11], Denmark	Individual RCT	Investigate the effect of a workplace intervention – with individually adapted physical and cognitive elements – on pain intensity and stress level among laboratory technicians with chronic musculoskeletal pain.	Nordic Musculoskeletal Questionnaire (NMQ) Visual Analogue Scale (VAS)	Beta coefficients from the models showed the punctual measure of change, with accuracy estimated with 95% CI. The models evaluated the pain reduction effect. Significant effects of the intervention on "fear avoidance" and use of safety devices: $\beta < 1.0$ (CI < 1.0) after the intervention.	– Inability to blind participants. – Self-reported results may be influenced.
Stevens et al., 2019[12], Denmark	Cluster	Investigate whether a workplace intervention would cause significant change in proposed mediators, which would, in turn, cause a significant change in low back pain outcomes.	Örebro Musculoskeletal Pain Questionnaire (OMPQ)	No effect of interventions on low back pain outcomes.	– Tools used to measure potential mediators may not have been ideal. – Use of a self-reported measurement of muscle strength. – Variables may be related. These interrelations have to be tested in future studies which would include multiple measurements of each variable.

(continues)

Table 2 Continuation

Authors, year, country	Study type	Study objective	Measurement instruments	Effect/impact/association measures OR, RR, mean difference	Study limitations
Becker et al., 2017[13], Germany	Individual RCT	Determine whether an additional psychosocial coaching intervention focused on dealing with psychosocial work stressors is superior to physical therapy techniques alone as a standard intervention to reduce musculoskeletal complaints..	Nordic Musculoskeletal Questionnaire (NMQ); Visual Analogue Scale (VAS); West Haven-Yale Multidimensional Pain Inventory (WHYMPI).	Mean difference between groups was the effect measure: NMQ (restriction of daily activities, last three months, 0-9 scale) – IG: t1 = 1.09 (1.86) / t7 = 0.55 (1.37) / t8 = 0.59 (1.62) – CG: t1 = 1.22 (1.7) / t7 = 0.48 (1.00) / t8 = 0.40 (1.00) time effect F: t1-t7 = 14,393 ($p < 0.05$) / t1-t8 = 8,935 ($p < 0.05$) t1 = time 1 t7 = time 7 t8 = time 8	– The initially desired number of participants was not reached (95 instead of 110 participants). – ANOVA was used, but the authors reported that it did not fully meet the criteria for an intention-to-treat analysis. – Result based on self-reported data (possible Hawthorne effect – minimized effect due to physical examinations performed by physical therapists, who were not aware of study conditions). – The effects of the intervention can be attributed to the combined intervention only (coaching plus physical therapy), and not to coaching alone. – Extrapolation of results to other occupational groups was not clarified.
Becker et al., 2020[14], Germany	Individual RCT	Determine the long-term effects on non-specific musculoskeletal complaints of an intervention that combined physical therapy and coaching compared to physical therapy alone. The coaching intervention focused on enabling better strategies to deal with work stressors.	West Haven-Yale Multidimensional Pain Inventory (WHYMPI); Nordic Musculoskeletal Questionnaire (NMQ).	Mean difference between groups was the effect measure. The results showed reduced effect, with good accuracy measured at the 95% CI. NMQ (restriction of daily activities, last three months, 0-9 scale): 0.22 (-0.44; 0.87).	– A statistically significant long-term effect of the combined intervention was observed only on one of the four primary outcome indicators. – High number of dropouts, risk of biased results, and limited power to detect the effects of the intervention.

(continues)

Table 2 Continuation

Authors, year, country	Study type	Study objective	Measurement instruments	Effect/impact/association measures OR, RR, mean difference	Study limitations
			Individual interventions		
Pereira et al., 2019[15], Australia	Cluster	Compare the immediate and long-term impact of workplace ergonomics and neck-specific exercises versus ergonomics and information of health promotion regarding health-related productivity in a general population of office workers and workers with neck pain.	World Health Organization Health and Work Questionnaire	Multiple linear regression was conducted in hierarchical or multilevel models. Beta coefficients allowed authors to compare the groups submitted to two interventions and estimate changes that occurred at 12 months compared to the baseline for each group in terms of loss of productivity, absenteeism, and presenteeism.	– The 12-month follow-up rate was 49.5%, lower than expected. – The human capital approach was used to quantify the monetary amount of lost productivity, which may be an overestimate compared to the attrition cost approach. – The presenteeism measurement used in the study, which is not health-specific and is an overview of reduced work performance. – Use of a self-reported measurement.
Akyurek et al., 2020[16], Türkiye	Individual RCT	Investigate the effects of Workplace Health Promotion Programs (WHPP) on pain, fatigue, stress, professional quality of life (Pro-QOL), and coping skills for nurses working in healthcare settings.	Visual Analogue Scale (VAS)	Comparison of intervention and control groups to assess pain, fatigue, stress, coping skills, and professional quality of life scores at the beginning and at the end of treatment, and at 1-year follow-up. The results showed no difference in effect after follow-up (Z test and p value).	– Small sample. – Potential physiological and/or psychological mechanisms that may be responsible for reducing pain, fatigue, and stress and improving quality of life should be analyzed in future studies.
Jakobsen et al., 2015[17], Denmark	Cluster	Investigate the effect of physical exercise in the workplace versus at home (WORK versus HOME) on musculoskeletal back and neck/shoulder pain among healthcare professionals.	Visual Analogue Scale (VAS); Nordic Musculoskeletal Questionnaire (NMQ).	Mean difference between groups at follow-up was the effect measure. The results showed reduced effect, with good accuracy measured at the 95% CI.	– Inability to blind participants and those responsible for the intervention. – Perceived pain can be influenced by outcome expectations (Hawthorne bias).

(continues)

Table 2 Continuation

Authors, year, country	Study type	Study objective	Measurement instruments	Effect/impact/association measures OR, RR, mean difference	Study limitations
					– The authors did not stratify the randomization for pain/non-pain cases; therefore, the results should be interpreted with caution. – Follow-up questionnaire not validated; therefore, it should be interpreted with caution.
Jakobsen et al., 2017[18], Denmark	Cluster	Investigate whether adherence to training, type of physical exercise intervention (at work or at home), pain state, frequency of patient handling, body mass index (BMI), age, and leisure activities affect the relief of musculoskeletal pain.	Visual Analogue Scale (VAS); Nordic Musculoskeletal Questionnaire (NMQ).	Mean difference between groups at follow-up was the effect measure. The results showed reduced effect, with good accuracy measured at the 95% CI.	– Short-term follow-up. – Training intensity (individual muscle load) and training volume (number of sets and repetitions in every 10-minute session) were not quantified in this study, did not allow the authors to identify whether it was the potential difference in training volume, the training intensity or technical performance of the exercises that contributed to a better result after 10 weeks of workplace exercises when compared to home exercises. – Assessment of training adherence was measured retrospectively at follow-up.
Jakobsen et al., 2018[19], Denmark	Cluster	Assess the effect of physical exercise in the workplace versus at home on pressure pain threshold and musculoskeletal pain intensity in various regions of the body among healthcare workers.	Nordic Musculoskeletal Questionnaire (NMQ). Visual Analogue Scale (VAS);	Changes in pain intensity and pressure pain threshold from baseline to 10-week follow-up. Values are differences in means (95% confidence interval).	– No significant increase was observed in absolute pain threshold after exercise in the workplace, which somehow confuses the relationship between pain perception and sensitivity.

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Table 2 Continuation

Authors, year, country	Study type	Study objective	Measurement instruments	Effect/impact/association measures OR, RR, mean difference	Study limitations
				Neck: -0.3 (-0.8–0.1) / p-value = 0.133 Shoulder: -0.5 (-0.9–0) / p-value = 0.034 Upper back: -0.5 (-0.9–0.1) / p-value = 0.009 Low back: -0.7 (-1.1–0.3) / p-value = 0.001 Elbow: -0.1 (-0.3–0.2) / p-value = 0.711 Wrist/hand: -0.4 (-0.7–0) / p-value = 0.057 Hip: -0.4 (-0.8–0.1) / p-value = 0.020 Knee: -0.1 (-0.4–0.3) / p-value = 0.676 Foot: -0.6 (-0.9–0.2) / p-value = 0.002	One explanation for the absence of increase in pain threshold may be related to the variation of sessions, since the baseline test was performed at the end of summer, and the follow-up in December (in winter when the weather is cold).
Korshøj et al., 2018[20], Denmark	Cluster	Assess changes in the musculoskeletal system in the context of an aerobic exercise.	Nordic Musculoskeletal Questionnaire (NMQ).	**Measurements of musculoskeletal pain intensity after four months.** **Neck** Mean difference = -0.40 Standard error = 0.47 95% CI = -1.33 to 0.53 p = 0.40 **Low back** Mean difference = 0.11 Standard error = 0.42 95% CI = -0.73 to 0.94 p = 0.80 **Hip** Mean difference = -0.61 Standard error = 0.26 IC 95% = 0.11 to 1.12 p = 0.02	– One study limitation refers to convenience sampling of only three companies in Copenhagen, Denmark, limiting the representativeness of the results for cleaning staff in general. – Possible selection bias for a population in unhealthier situations. – Loss to follow-up: 29% at 4-month follow-up and 35% at 12-month follow-up.
Moreira et al., 2020[21], Brazil	Individual RCT	Assess the effectiveness of a therapeutic exercise program on muscle strength and low back symptoms among nursing assistants.	Nordic Musculoskeletal Questionnaire (NMQ).	**Post-intervention low back symptoms:** The clinical examination identified a positive effect in the reference group, in 67.5% of the population, and in 93% of the intervention group, with p-value = 0.002 and OR (95% CI) = 6.25 (1.6; 24.1).	– Short follow-up period. The authors suggest an adequate follow-up period in order to identify long-term effects of the therapeutic exercise program.

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Table 2 Continuation

Authors, year, country	Study type	Study objective	Measurement instruments	Effect/impact/association measures OR, RR, mean difference	Study limitations
Doda et al., 2015[22], Australia	Cluster	Report the differences between standard interventions (ergonomic) and a psychological approach (stage of change – SOC) for the prevention of work-related musculoskeletal pain and discomfort (MSPD).	A number of questionnaires about: – demographic information; – MSD symptoms.	General effect of the intervention: RR less than 1.0, characterizing protection against MSD in any region and an increase in the protective capacity against the development of low back pain.	– Participant attrition rate from baseline to follow-up studies (40.1%).
Viester et al., 2015[23], The Netherlands	Individual RCT	Evaluate whether the intervention program for blue-collar construction workers reduced musculoskeletal symptoms.	Dutch musculoskeletal questionnaire (DMQ)	Effect of the intervention with protection measured by RR < 1.0. The results showed punctual measurements (RR) for 6 and 12 months, with low accuracy of confidence intervals (1.0 < CI > 1.0).	– Power calculation was performed at the measured primary outcome of the study, i.e., body weight. – Results of measurements based on self-report. – The possibility of contamination was not completely ruled out.
Danquah et al., 2017[24], Denmark/ Greenland	Cluster RCT	Assess the effects on musculoskeletal pain of a 3-month intervention to reduce sitting time.	MSD questionnaire developed by the authors.	Effect of the intervention with protection measured by RR < 1.0. The results showed punctual measurements (RR) for 6 and 12 months, with low accuracy of confidence intervals (1.0 < CI > 1.0).	– The pain measurement was not very precise, as it was measured in only three categories (no discomfort, small discomfort, strong discomfort). – Short intervention period may not have been enough.

Description of interventions performed in all 15 studies with satisfactory CASP

1) In three studies, multidimensional interventions involved physical training and a cognitive-behavioral approach that used mindfulness, adopting the methodological perspective of participatory ergonomics[10-12]. These studies showed a reduction in the number of days with pain and the intensity of low back pain[10-12], as well as pain in other body regions (neck, upper back, shoulders, elbows, and hands)[11].

2) In two studies, multidimensional interventions involved physical training associated with a cognitive-behavioral approach (coaching)[13,14]. After three months of intervention, pain reduction was more pronounced in the intervention group than in the control group[13]. In contrast, after 22 months, members of the intervention group had a wider range of movements, but not necessarily less pain when compared to the control group[14].

3) In two studies, individual interventions were performed using physical training (relaxation, stretching, resistance and postural training) in an approach of participatory ergonomics, according to the authors[15,16]. Concomitantly with physical exercises, participants had practical sessions on comfortable sitting positions at work, as well as adjustments to their workstations, according to individual needs. A reduction was observed in general pain intensity[16] and absenteeism due to neck pain[15].

4) In five studies, individual interventions were performed, with different types of physical exercises to prevent MSD[17-21], which resulted in reduction in pain intensity and use of analgesics when compared to the reference group. In the study by Korshøj et al.[20], no change was observed in pain intensity in evaluated regions after four months of intervention; however, after 12 months, a decrease was observed in self-reported musculoskeletal symptoms in the neck, shoulders, arms, wrists, knees, and feet/ankles.

5) In three studies, individual interventions were performed with cognitive-behavioral training to prevent MSD using the Stage of Change (SOC) approach or coaching sessions, in addition to encouraging healthy practices with changes in lifestyle[22-24]. No statistically significant difference was observed in the prevention of MSD in the back and lower limbs[22,23], nor in the reduction of neck/shoulder pain[24], when comparing the intervention and control groups.

Discussion

The studies analyzed in this review show positive results in terms of reduction in the intensity and frequency of musculoskeletal symptoms; however, they do not show strong evidence of effective methods to prevent work-related MSDs, which expose some issues and weaknesses in these studies, such as insufficient sample, loss to follow-up, and low variability of occupational categories analyzed. In this sense, results from interventions performed with a very specific occupational group can be extrapolated to other groups with limitation.

Previous systematic reviews already showed such insufficient evidence regarding the effectiveness of interventions to prevent work-related MSDs. Since the 1990s, reviews pointed to improvements of MSD in low back as a result of workplace interventions and interventions addressing individual factors, such as physical exercise or use of assistive devices including lower back brace. However, there was a lack of randomized intervention trials, with evidence showing that isolated interventions would be less effective when compared to multiple or multidimensional interventions[5]. Subsequent contributions were presented in a review of randomized studies[25], which investigated interventions in the physical and organizational environment to prevent low back and neck pain. Some limitations were identified in the body of evidence, given the reduced number of randomized trials available and heterogeneity of populations assessed in each trial, such as office workers in some studies and kitchen workers in others. That created obstacles to comparisons, heterogeneity of intervention types, definition of control groups, and outcomes. The set of studies[25] showed insufficient strength of evidence of intervention effectiveness and the need to expand randomized studies.

Participatory ergonomics (PE), cited in some studies in this review as a relevant strategy for the development of the intervention, has been defined as an approach that foresees the active involvement of workers in the development and implementation of changes in the workplace aiming to improve health, safety, and productivity[26]. This approach, however, can present itself in different ways, taking into account the role and management of organizations, as well as the configurations of each company or work situation in the exercise of worker participation, more or less expanded or effective.

Due to the nature of the program, developed with a PE approach, the solutions were more effective because they resulted in participants taking ownership of changes and innovations, as in the case of the study by Akyurek et al.[16]

with a population of nurses. In the study by Stevens et al.[12] using a PE approach, the intervention increased the use of assistive devices in the workplace, which reduced perceived physical effort, i.e., the participation of workers positively contributed to the results. However, the authors[12] highlight the importance of conducting more studies with a PE approach in other populations, since health effects are not always obtained and some previous studies showed limitations of this type of program for musculoskeletal symptoms[26,27].

Regarding the cognitive-behavioral approach, a program was implemented for the prevention of MSD using mindfulness, a meditation technique for the development of full attention[11], based on the experience of pain and Vipassana, a Buddhist philosophy[28,29.] According to Buddhist monks, mindfulness meditation can modify the perception of pain[28]. Although a positive effect was observed for musculoskeletal disorders, when the elements of the intervention (exercise and cognitive-behavioral approach) were analyzed separately, a contrast effect was observed in the study by Jay et al.[11]. The dose-response analysis with physical-cognitive training showed a reduction in pain as each physical training session was performed, while mindfulness sessions increased pain with each session.

A possible explanation for the results obtained by Jay et al.[11] is that the mindfulness sessions may have favored full attention of workers to their bodies during work activity and nociceptive information during the workday. Therefore, the technique may have allowed an increase in the perception of existing pain.

Therefore, this study[11] did not obtain the expected results, as it did not relieve stress, as predicted by the authors, the technique influenced the expected effect of the intervention on pain because, when combined with physical training, it increased pain perception. The authors expected that, by reducing stress through mindfulness, pain relief could happen, which in turn would lead to a reduction in stress; however, it was not observed. The methods of effect measurement by quantifying pain are probably not well suited to the type of intervention performed.

Another way to perform the cognitive-behavioral approach was through the Stage of Change (SOC) model used in some studies[22,23]. The objective was to improve or prevent musculoskeletal symptoms based on workers' perception of their activities and willingness for behavioral changes while performing their work tasks[22,23,30,31].

According to this approach, individuals who are more willing to make behavioral changes believe the benefits are more important than the disadvantages related to the change. The discussion about techniques that favor changes in health-related behavior is complex, with different theories seeking to explain the different factors involved in this process[22,23,30]. Understanding individual needs and providing conditions so that workers can overcome barriers at work – or overcome the insufficiency of resources available in real work situations – seems to be more appropriate.

In one of the studies[22], workers with shorter length of time at the job were less likely to report musculoskeletal symptoms, which may be justified by an insufficient exposure to risk factors in the workplace, with lower occurrence of morbidity, and insecurity regarding the new job and fear of reporting the morbidity. These authors also identified that, regardless of workers' willingness to change behavior patterns, a factor that can contribute to an ineffective intervention is the lack of priority assigned by the company: the resources provided to health prevention programs may not be enough to support physical or organizational changes at work or ensure the required comprehensiveness of interventions[22] according to the worker's needs.

In this perspective, we consider the definition of interventions that is not based on the worker's point of view, i.e., the challenges experienced in daily work, may compromise the results obtained and expected by researchers.

Physical exercises in the workplace, whether or not combined with behavioral strategies, reduced musculoskeletal symptoms[10-21], in agreement with findings from a review conducted by Gobbo et al.[32], which included studies that evaluated the effects of different types of physical exercise, associated or not with cognitive-behavioral therapies, specifically for low back pain in office workers.

Another aspect identified in our review[18,19] refers to varying results when physical exercises are performed in the workplace or at home, and with professional supervision. At work, exercise has a more favorable impact on pain relief when compared to exercise performed at home. Being in the work environment and taking the required breaks to perform exercises seems to be more effective, just as weekly physical training favors pain reduction, which means that higher frequencies in a week lead to better result. Therefore, interrupting work for a session of physical activity or physical exercise involves postural variability, in addition to the break itself, favoring the musculoskeletal system – a situation that is not seen with workers who perform physical exercise at home, i.e., outside the usual workday.

Physical exercises also promoted reduced use of analgesics for low back pain when compared to the control group, with no change observed for neck pain[17], but the authors did not make explain clearly the reason for this difference, probably because the exercises were not the best for the cervical region in the studied population. On the other hand, an improvement was observed in the strength of trunk flexor muscles, increasing balance between flexor and extensor muscles, with a consequent reduction in musculoskeletal symptoms in the lumbar spine[21]. It may happen because the stronger and more stable trunk muscles act as a protective belt for the low back region, allowing more mobility with less mechanical overload and, consequently, reduced pain[33].

Although physical exercise has positive effects on musculoskeletal symptoms among workers, the heterogeneity of strategies adopted in the studies found in the literature contributed to insufficient evidence of which type of physical exercise can effectively improve overall physical capacity and musculoskeletal symptoms[21]. Therefore, the results of studies should be evaluated with caution. A review conducted by Brewer et al.[34] in 2006 did not find sufficient evidence to determine whether physical training would have a protective effect on musculoskeletal disorders because of an insufficient number of studies available.

Regular physical exercise is relevant for overall body conditioning, as it provides more energy for various activities, reducing the likelihood of disorders[35]. However, the effect of physical conditioning on work-related MSDs should be more accurately assessed. In an observational study by Mascarenhas and Fernandes[35], the interaction of physical fitness and heavy physical work was analyzed among maintenance and operation workers from plastic companies. Workers with poor self-perceived physical fitness had around three times more disorders (MSDs in the neck, shoulder, or upper back) when compared to workers with good self-perceived physical fitness. However, this association was observed in workers with low physical demand or lighter physical work. Among workers exposed to exhaustive physical work, the occurrence of MSD in the neck, shoulder or upper back was very high, regardless of the level of self-perceived physical fitness[35]. When exposed to exhaustive physical work, that supposed protection from good physical fitness against MSD is almost null[35].

Also, static positions for extended periods can lead to fatigue, pain, or injury, even in workers with good postural balance. Therefore, even with regular practice of different types of physical exercise, other aspects, such as physical and organizational demands, should be taken into account.

Organizational aspects are critical aspects when analyzing work conditions and preventing MSD. In a review conducted by Stock et al.[6] in a 2018 assessing organizational interventions, the authors reported low quality of evidence of these interventions to prevent MSD, except for the implementation of additional breaks in different contexts. This review[6] of intervention studies identified that breaks are a good strategy for the prevention of musculoskeletal symptoms, confirming previous evidence from observational studies on the role of breaks for the prevention of MSDs[5]. The studies analyzed in this review presenting good quality according to CASP do not include studies with organizational interventions. Then, a gap was identified in the studied period, as no randomized intervention study addressing this aspect in MSD prevention strategies was found in the literature.

In interventional studies, another aspect mentioned by the authors[11,20,36] refers to program adherence, which is required to ensure valid results. Adherence to intervention programs in the workplace depends on the conditions to favor worker participation and the strategies used by researchers[37]. In this sense, studies suggest[11,20,36] that, regardless of the approach, strategies should be adopted to encourage and maintain group participation.

Poor adherence can compromise and limit the results of interventions which, under favorable conditions, could be effective[38]. It can occur due to factors not controllable by researchers, such as organizational issues, for example, collective vacations and changes in work demands, as discussed by Lanhers et al.[39]. This situation shows that intervention programs in the workplace must be associated with strategies that include a planning phase, predicting and ensuring the conditions for continuous participation[6].

As expected, studies with longer follow-up periods of over six months presented more cases of loss to follow-up. It explains why many studies use statistical analysis based on intention-to-treat analysis, which recommends the inclusion of all participants in the analysis, regardless of actual participation or dropout[38]. This type of analysis is more frequently used by researchers because it ensures the maintenance of random groups and evaluates the intervention with the limitations found in real conditions – in this case, in the workplace[40]. Driessen et al. al.[25] observed that shorter periods, between six weeks and six months, were not sufficient to measure the effect of the intervention and, therefore, the results should be evaluated with caution. On the other hand, longer periods allow better measurements of long-term effects and along the follow-up. This situation represents a challenge in the evaluation of workplace interventions, since longer periods may imply more cases of loss to follow-up. Brewer et al.[34] suggested that studies should last 4 to 12 months for satisfactory results regarding the prevention of musculoskeletal symptoms or disorders.

Most studies in our review were conducted in European countries, particularly in Nordic and Scandinavian countries, as reported in a review conducted by van Eerd et al.[41], which may indicate differences in investment and incentive to research between countries. It limits the generalization of findings to other populations and countries with very different socioeconomic and cultural characteristics. Also, low social, health, and safety protection at work in peripheral or semi-peripheral countries can result in obstacles for the adoption of effective prevention programs in companies and development of studies to properly analyze such programs.

Economic issues that involve unsafe work practices can also be a limiting factor for the adoption of interventions to prevent work-related risks and disorders. In scenarios where the perspective of productivity prevents the provision of decent and healthy working conditions, business managers are against initiatives or programs that implement structural changes, which could have favorable results for health and safety. Therefore, ensuring proper working conditions involves different political, economic, and social contexts.

The strengths of this review include the use of PRISMA recommendations in this systematic review; the inclusion of randomized, clinical, and community trials; no restriction in terms of type of intervention, analyzing those interventions available in the databases in the period selected for the analysis; and the use of a tool to assess study quality.

Conclusion

According to our review, the interventions to prevent MSD among workers resulted in improvements in different aspects; however, data are not sufficient for strong evidence of more effective methods. Some approaches generated positive impacts, such as reduced pain intensity or frequency and reduced use of analgesics and absenteeism due to musculoskeletal symptoms – in particular, pain.

Given the complexity of work environments, multidimensional interventions can be a promising strategy since these programs can address different needs. However, the studies in our review that met the CASP quality criteria and combined physical exercise with behavioral interventions, did not show the expected results. On the contrary, the best responses for MSD prevention were obtained with physical exercises performed in the workplace, with the supervision of a health professional and, in particular, adopting a Participatory Ergonomics approach. These findings using Participatory Ergonomics confirm the critical role of workers as subjects of intervention processes at work and to protect their health.

This review of randomized trials identified as a gap from 2015 to 2020 among the studies that satisfactorily met the CASP criteria, which referred to the absence of interventions focused on work organization, such as time demands, control over work, intensification of pace, absence of breaks – all characteristics that have been consistently associated with MSD in workers in observational studies.

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