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The effectiveness of workplace exercise interventions in the treatment of musculoskeletal disorders in office workers. A systematic review.

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ABSTRACT

Objectives: Determine the effectiveness of workplace exercise interventions in the treatment of musculoskeletal disorders.

Design: Systematic Review of Randomised Control Trials.

Data Sources: Bibliographical databases PubMed, CINAHL Plus, Cochrane, Scopus, ISI WoS and PeDRO were searched, including studies from 2010 to 2020.

Results: Seven studies met the inclusion criteria and were included in this review. Due to the heterogeneity of the different workplace exercise interventions, outcome measures and statistical analyses, a narrative synthesis was performed. The interventions were classified into three categories: multiple body regions, neck and shoulder and lower back. The seven studies concluded that workplace exercise interventions were effective as a treatment to reduce musculoskeletal disorders and pain compared to other types of interventions or control groups with no interventions. Therefore, a high risk of bias was found in six of the seven studies using the revised Cochrane Risk of Bias tool (RoB 2).

Conclusions: The most recent evidence related to workplace exercise interventions in treating musculoskeletal disorders in office workers was found to be effective. However, due to the high risk of bias of the included studies, no firm conclusions could be drawn, and more high-quality studies are needed.

Keywords Musculoskeletal disorders, Pain, Office Worker, Exercise, Workplace.

PROSPERO registration number CRD42020177462.

Article Summary

Strengths and limitations of this study

- The search strategy was developed in collaboration with an expert documentalist and included the following databases: PubMed, CINAHL Plus, Cochrane, Scopus, ISI WoS and PeDRO.
- A blinded peer review was conducted by the researcher to ensure rigorous and consistent sets of inclusion and exclusion criteria.
- This is an innovative review, as it focuses only on exercise interventions in employees' own workplaces, providing specific data on the most effective workplace exercise interventions (volume, intensity, time).
- The review is limited by the heterogeneity of study methodologies and outcome measures due to the diverse types of exercise interventions introduced to office workers.
- The risk of bias of the studies was high overall, making it difficult to draw firm conclusions.

INTRODUCTION

The exponential growth of a sedentary lifestyle in society is due to the great technological advances in recent years and the automatization of daily activities with just one click on our mobile phone devices, increasing the time spent sitting throughout the day.[1,2] Sedentarism is a significant health issue; there is a strong association between sitting time and all-cause mortality.[3] Prolonged homestays due to the pandemic caused by COVID-19 have also increased the time spent being sedentary, making it difficult to increase physical activity in the general population and thus increasing chronic diseases.[4]

It is important to remark that sedentary behaviour is not the opposite of moderate to vigorous physical activity.[5] Performing exercise 3 to 5 times a week, such as running or practising sports, does not guarantee an active lifestyle if the rest of the day is based on sedentary behaviour. Physical inactivity and sedentary behaviour are closely related and are both severe risk factors for health.[6,7] The average daily time spent in a seated position by the adult population is 346 minutes per day.[8] American and eastern Mediterranean countries have higher proportions of the population in physical inactivity, near half of their adult population (43%); the worldwide average is lower but still surpasses 30%.[9] Moreover, these numbers may be worse due to COVID-19, where home confinement and mobility restrictions are necessary to reduce the spread of the virus, increasing sedentary behaviour.[4]

Jobs that do not require physical activity, such as office workers, are traditionally considered a "low-risk" occupation in health outcomes. However, the overall accumulated sitting time at work may increase cardiovascular disease risk[10] and mental disorders.[11] Because the office workplace is an unfavourable environment in terms of high sedentary behaviour,[12] daily exercise is crucial to prevent pathologies caused by the lack of movement and poor posture while spending most of the workday in front of the computer.[13,14] Additionally, those who work overtime, without flexibility in schedules, perform demanding and decision-making tasks have a higher prevalence of musculoskeletal disorders in the neck, shoulder, and lower back region than if they had fixed schedules with rest breaks and jobs with no decision-making required by their bosses. This higher prevalence of suffering pain is due to working overtime with high quantitative demands and not performing breaks during work hours, increasing the total time spent in a seated position.[15,16]

Since productivity seems to be maintained by frequent standing and rest,[17] performing exercise interventions may help reduce the effect of sickness presenteeism on musculoskeletal complaints and the ability to work.[18]

With a small amount of time, approximately 22 minutes a day, it is possible to reduce sedentary behaviour.[19] Having a daily schedule for exercise interventions at work might help reduce the time sitting and increase the global physical activity of employees,[20] preventing cardiovascular and metabolic illnesses and reducing musculoskeletal dysfunction of the back.[21]

A systematic review[22] conducted on physical exercise in office workers states that the studies reviewed include a wide variety of interventions regarding the duration of the active breaks, the length of the physical program, or the type of exercise performed. Positive effects of active breaks with postural change were found for pain and discomfort of the lower back pain without affecting the office workers' productivity. Regarding the type of exercises, the most common interventions use stretching and strength training exercises.[23,24] Additionally, the practice of disciplines such as yoga[25] or qigong[26], was implemented in the workplace together with home-based sessions that could be considered a feasible option in the treatment of musculoskeletal disorders related to their job demands. Other studies[27,28] that examined workplace exercise interventions among symptomatic office workers with musculoskeletal disorders have demonstrated a decreased perception of pain.

Strength and aerobic exercises focusing on the reduction of the intensity, disability, and duration of neck and shoulder pain can be easily performed in work environments because they do not require equipment and can be performed with office worker's own bodyweight.[29]

Focusing on the treatment and prevention of musculoskeletal pain in office workers various systematic reviews have been published in recent years evaluating different types of exercise interventions,[29,30] or evaluating various kinds of breaks at work in symptomatic and asymptomatic participants.[22]

Additionally, sedentary behaviour and its consequences for office workers concern multinational corporations regarding the levels of presentism due to the health issues of their employees, which is an occupational issue resulting in economic costs due to a reduction in productivity levels[31].

However, to our knowledge, this is the first systematic review focusing exclusively on workplace exercise interventions in the treatment of musculoskeletal disorders in symptomatic office workers.

This review's practical implications aim to:

- Determine the effect of workplace exercise interventions in the treatment of musculoskeletal disorders.
- Describe the characteristics of workplace interventions to improve therapeutic exercise programs for office workers.
- Recommend future lines of research enhancing interventions for a more active lifestyle of sedentary workers.

2. METHODOLOGY

A systematic review of randomised controlled trials (RCTs) published in English and Spanish between 2010 and 2020 was conducted according to the PRISMA standards.[32] The study protocol provides more specific details.[33]

Patient and public involvement

There was no patient and public involvement in the whole process of conducting this systematic review.

Data sources and search strategy

The search was generated using PubMed MeSH terms and keywords related to office workers, musculoskeletal pain and exercise interventions. The PubMed search strategy through the MEDLINE nomenclature and thesaurus is available in Supplementary File 1. Subsequently, the search was adapted in the following databases: CINAHL Plus, Cochrane, Scopus, ISI WoS and PeDRO.

The strategy was reviewed in pairs and followed the criteria of the PRESS tool.[34] Two reviewers (RP and CT) performed a peer review of all the retrieved records by titles and abstracts and then by full text using the Covidence tool.[35]

Inclusion criteria and study selection

The selection criteria for conducting the review were as follows:

(1) RCT articles with at least one intervention through exercise interventions at work.

(2) Studies with an entire sample carried out on office workers who spent the majority of their working hours sitting.

(3) Evaluation of musculoskeletal disorders or pain in the intervention in all body regions or specific areas of the body.

(4) Exercise interventions in the workplace, excluding those with exercises prescribed at home or outside the office setting.

(5) Studies in which the intervention is by means of "Sit-Stand Workstations" or Guidelines of ergonomics and health education without a physical exercise program have been excluded.

Data extraction

Data extraction was performed by two reviewers (CT and CB), based on the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions.[36] Data extraction was carried out in a standardised way, following the characteristics of the studies' methodology taking into account participants, interventions, outcome measures and the results section. The consensus method was used to resolve differences between reviewers where it did not take a third reviewer (FR) to reach the full consensus.

Risk of bias assessment

The risk of bias of each article was independently assessed by two reviewers (FB, CT) using the Cochrane Risk of Bias 2 tool.[37] The sections where there was no coincidence were combined with a third reviewer (FR) to reach a consensus.

Data synthesis

It was not possible to conduct a meta-analysis due to the significant heterogeneity of the different workplace exercise interventions, outcome measures and the statistical analysis. A narrative synthesis was carried out.

RESULTS

3.1. Result of the search

The search results yielded 276 articles after removing duplicates. When screened by title and abstract, 232 were excluded, resulting in reading a total of 44 full-text studies. The search followed the aforementioned specified inclusion and exclusion criteria. In total, seven studies were included. More detailed information is presented in the adapted PRISMA flowchart (Figure 1).

Figure 1. Flow diagram of trial selection, adapted from PRISMA.

3.2. Characteristics of the studies

The seven studies that met the inclusion criteria ranged from 2010 to 2018: Andersen and Marangoni in 2010[38,39], del Pozo-Cruz in 2013[40], Nakphet and Andersen in 2014[41,42] Kaeding in 2017[43], and Shariat in 2018.[44] A total of 967 participants were included in the seven studies, from the smallest sample of 30 participants[41] to the largest with 549.[38] A summary of the different interventions, statistical analysis of the relevant outcomes and the results of the different studies are shown in Table 1.

Table 1. Summary of the results of the individual studies.

Authors	Participants	Intervention group versus control	Relevant outcome	Results	Measurement tools	Effect adverse
Andersen *et al* (2010)[38]	n=549 participants One-year of intervention	- Specific resistance training (SRT) (n=180). It consists in neck and shoulder strengthening exercises. - All-round physical exercise (APE) (n=187). It Suggests increase level of physical activity during leisure time and at work with physical activities for all-round strength and aerobic fitness. - Control group (REF) (n=182). It tries to improve health and working conditions; however no changes were implemented at the worksites.	There were main effects for Region (F=3.04, P<0.0005), group (F=2.93, P=0.05) and Status (F=905, P<0.0001). In relation to pain intensity decrease more in neck, low back, right elbow and right hand in SRT and APE groups (P<0.0001-0.05), also APE compared with REF had a preventative effect on development of pain symptoms in the right shoulder (P<0.05). In neck cases decreased in SRT (-0.73±0.36, P<0.05) and APE (-0.91±0.31, P<0.01).	Both specific resistance training and all-round physical exercise for office workers caused better effects than REF group in several regions of the upper body and number of pain regions in individuals with neck pain specifically.	Nordic Musculoskeletal Questionnaire, intensity of pain 0-9 last three months.	No
Andersen *et al* (2014)[42]	**n=47 (10 ♂, 37** ♀) Age=44 [12]; BMI =25 [4]	**-**Scapular Function Training (SFT) (n=24): 3x20 min training per week for 10 weeks during working-hours. It consists in a short warm-up, and exercises to activate the serratus anterior and lower trapezius muscles to a high extent with a low level of activation of the upper trapezius.	There was significant difference between groups in pain in the neck/shoulder region (p<0.01); also, on pressure pain threshold in the lower trapezius had an increase of 129 kPa (95% CI 31-227kPa) (p<0.01). In shoulder elevation and protraction strength SFT increased shoulder elevation strength 7.7Kg (95% CI 2.2; 13.3Kg) (p<0.01) more than control group.	SFT reduces pain intensity and increases shoulder elevation strength in adults with chronic non-specific pain in the neck/shoulder region.	Self-Rated Pain Intensity (0-9), Pressure Pain Threshold (PPT) with algometer, maximal muscle strength with dynamometer, adherence.	No

Authors	Participants	Intervention group versus control	Relevant outcome	Results	Measurement tools	Effect adverse
		-Control (n=23): not offered any physical training.				
Marangoni *et al* (2010)[39]	**n=68 (8 ♂, 60**♀) Age= 43 **(21-62 years)**	- CASP Subjects (n=22) Performed a 10-15 seconds stretch from a Computer Assisted Stretching Program every 6 minutes while working on the computer. - FLIP Subjects (n=23) Performed a 10-15 seconds stretch from a Facsimile Lesson with Instructional Pictures Program every 6 minutes while working on the computer. - Control Subjects (n=23) non-treatment.	There were significant improvements in reduction of pain in the intervention groups (CASP Subjects VAS= -73%; PSA=-70% and FLIP Subjects VAS= -64%; PSA=-62%) compared to the control group that lightly increased VAS= 1%; PSA=1%).	Positive effect on the reduction in pain in the Interventions groups compared to the control group. No significant differences in the type of media used to prompt stretching exercises.	VAS scale. Pain Spot Assessment (PSA) created by the author.	No
Kaeding *et al* (2017)[43]	**n=41 (13 ♂, 28** ♀) Age =45.5 [9.1], BMI =26.6 [5.2]	- Whole-body vibration training (WBV) (n=21): It consists training applying sinusoidal vibrations with 2.5 (30-45 min/wk) sessions per week for 3 months. - Control group (n=20): they received any training.	There were significant differences regarding RMQ and ODI between groups (*p*=0.027), *t* test (*p*=0.002, ANCOVA *P*<0.001), also SF36 physical scale (*t* test *P*=0.013, ANCOVA *P*=0.026) and finally Freiburger activity questionnaire showed significant difference using a Wilcoxon test (*P*=0.022). Also, sick-leave showed difference (*P*=0.008).	WBV training seems to be an effective, safe, and suitable intervention for seated working employees with CLBP.	Roland and Morris disability questionnaire (RMQ), Oswestry Disability Index (ODI), Work Ability Index Questionnaire (WAI), SF-36, Freiburger activity questionnaire, isokinetic performance, sick-leave, posturography.	No
Authors	**Participants**	**Intervention group versus control**	**Relevant outcome**	**Results**	**Measurement tools**	**Effect adverse**

Del Pozo-Cruz *et al* (2013)[45]	**n=90 (24 ♂, 66 ♀**) Age CG =45.5 [7.02] and IG =46.83 [9.13] with diagnosis of sub-acute LBP	-Intervention group (n=46). It consists online session daily within postural reminders, stretching, exercises to improve postural stability, muscle strength, flexibility, mobility, and finally moderate stretching lasting nine months. -Control group (n=44): they had access to usual preventive medicine care only.	In the intervention group participants were more likely to exhibit improvements in functional disability (Oswestry Disability Index questionnaire clinical change, 85%, P = 0.001), risk of chronicity (SBST clinical change, 75%, P < 0.001), and most of the EQ-5D-3L components (visual analogue scale (VAS) 73%, P < 0.001; EQ-5D-3L utility score clinical change, 78%, P <0.001; mobility, 77%, P < 0.001; self-care, 79%,P = 0.003; pain/discomfort, 88%, P < 0.001 and anxiety/depression, 84%, P < 0.001).	A web-based occupational intervention in university administrative office is effective in improving quality of life and reducing the severity of low back pain.	Visual Analogue Scale from the Euroquol-5D (EQ-5D), ODI, STarT Back Screening Tool (SBST).	No
Shariat *et al* (2018)[44]	**n=142 (47 ♂, 95 ♀**) Age Ex. G =29.41 [1.16]; Erg. G =28.31 [0.92]; Com. G = 29.64[0.9] and CG=28.74 [0.82]	-Exercise group (n=43). It consists in stretching and flexibility exercises of muscles of the back, shoulders and neck joints. Once a day three times a week lasting 6 months. -Ergonomic modification (n=37). It contained the modification of working place -Combined group (n=34). It consists de combined of exercise and ergonomic intervention. -Control group (CG) (n=28).	After 6 months, there were significant differences in pain scores for neck [MD-10.55(-14.36 to -6.74)] right and left shoulder [MD-12.17(-16.87 to -7.47)]; [MD-11.1(-15.1 to -7.09)] and lower back [MD-7.8(-11.08 to -4.53)] between exercise and CG. Also, between combined group and CG in pain for neck, right and left shoulder and lower back [MD-9.99(-13.63 to -6.36)]; [MD-11.12(-15.59 to -6.65)]; [MD-10.67(-14.49 to -6.85)]; [MD-6.87(-10 to -3.74)].	The exercise modification was more effective in comparison with ergonomic modification after 4 months.	Cornell Musculoskeletal Disorders Questionnaire (CMDQ).	No
Authors	**Participants**	**Intervention group versus control**	**Relevant outcome**	**Results**	**Measurement tools**	**Effect adverse**
Nakphet *et al* (2014)[41]	**n=30 ♀ (18-40 years**) SG= 31.4 [5.9];	- Stretching group (n=10) It consist in stretch of neck and	There was significant time effect on myoelectric activity (MF) between three sessions of a 20-min computer typing	Positive effect on the muscle discomfort on the	Surface myoelectric activity (SEMG)	No

	DCG=29.6 [5.9]; RG=27.6 [3.0]	shoulder muscles in their 3-min breaks. -Dynamic contractions (n=10) It consist to perform strength exercises of the neck and shoulders during each 3-min break. - Reference group (n=10) The participants were instructed to take their hands off the computer and relax sitting back on their chairs during the breaks.	task of Upper Trapezius F(1.59,42.81)= 5.35,*p*=0.013. However, no significant differences between groups there was.	three groups after the rest-break interventions. Rest breaks with a variation in activities did not decrease the level of muscle electrical activity in the neck and shoulder muscles during computer work.	Borg's CR-10 scale (0-10 scale for muscle discomfort) Productivity= Total number of correct words/Overall time of typing.

Abbreviations: CMDQ: Cornell Musculoskeletal Disorders Questionnaire; CVAS: Visual analogue scale; CLBP: chronic low back pain; EQ-5D: Euroquol-5D; MF: Myoelectric activity; ODI: Oswestry Disability Index; PSA: Pain Spot Assessment; PPT: Pressure Pain Threshold; RMQ: Roland and Morris disability questionnaire; SF-36: Short Form 36; SBST: STarT Back Screening Tool; SEMG: Surface myoelectric activity; WAI: Work Ability Index Questionnaire; wk: week.

Exercise interventions varied in each study, from 10- to 15-second stretch exercises every six minutes while working[39] to up to one-hour strengthening exercises for 2–3 sets of 10–15 repetitions, combined with 5-second static neck exercises once a week.[38] A three-minute breaks intervention in Nakphet[41] with a dynamic contraction group and a stretching group focused on the neck/shoulder region; Andersen and Shariat[42,44] with a three-days-a-week intervention, Andersen with 10- to 15-minutes stretching routine[44] and Shariat[42] with a 20-minutes strength routine with scapular training function. Kaeding's study[43] with whole-body interventions performed 2.5 sessions a week with 15 minutes of vibration training and del Pozo-Cruz[40] with a five-day-a-week exercise intervention of seven minutes of physical exercise combining postural stability strengthening, flexibility, mobility, and stretching.

Regarding the length of the interventions, prevail studies with medium- and long-term interventions, except for Nakphet,[41] were performed with a one-day intervention to observe the acute effects of two workplace exercise interventions compared with a passive pause and Marangoni[39] with a three-week intervention. The rest of the studies lasted from a 10-week intervention in the case of Andersen[42], three months in the Kaeding[43] intervention, Shariat[44] with a six-month intervention, and the longest, with a nine-month intervention in the del Pozo-Cruz study[40] and a one-year intervention in Andersen's[38].

There is great variety in the comparison groups that sort from control groups without intervention, the ergonomic guidelines in Marangoni, Andersen, Kaeding and Shariat,[39,42–44] ergonomic guidelines or health prevention in Andersen and del Pozo-Cruz,[38,40] and a passive pause intervention group taking hands off of the computer for a three-minutes rest period in Kaeding's study.[41]

3.3. Risk of bias

All of the studies, except for Andersen's,[38] had a "high risk" in the "measurement of the outcome" section because the participants and/or instructors were not blinded. The main difference in Andersen's[38] was that participants were blinded due to the cluster randomisation and the internet-based questionnaires.

In Marangoni, Nakphet and Shariat[39,41,44] we found "some concerns" in the section "selection of the reported results" due to the lack of a "prespecified analysis plan". Although all the studies were randomised, in the study of Nakphet,[41] the type of randomization was not specified and was considered "high risk" in the "randomization process". Another section to highlight is that in charge of evaluating "missing the outcome data", where, despite finding five articles with low adherence, Andersen and Shariat documented the cause of the dropout.[42,44] In Andersen[38] there is no information about why the participants dropped out of the study, and Marangoni[39] did not specify the number of participants or the reason for the drop out having a "high risk" of bias in this section. A summary of the risk of bias is shown in Figure 2 and Figure 3.

Figure 2. Risk of bias graph: review authors' judgements about risk of bias items presented as percentages across the included RCTs

Figure 3: Risk of bias summary: review authors' judgements about each risk of bias item for each included study. In green (Low risk), yellow (Some concerns) and red (High risk).

3.4. Effects of workplace exercise interventions in reducing musculoskeletal disorders and pain

In Andersen, Marangoni and Shariat,[38,39,44] the reduction of musculoskeletal pain in office workers was assessed in multiple body parts. Nakphet and Andersen[41,42] focused on the neck and shoulder area, while del Pozo-Cruz and Kaeding[40,43] assessed workplace interventions concerning disability caused by lower back pain.

3.4.1. Effects of workplace exercise interventions in reducing musculoskeletal disorders in multiple body regions

As mentioned above, Andersen, Marangoni and Shariat[38,39,44] evaluated workplace exercise interventions' effectiveness in reducing musculoskeletal pain

in more than one specific region. In Andersen's[38] Nordic Questionnaire was used to measure musculoskeletal symptoms, and the VAS scale was used to measure the participants' pain perception. The intensity of pain had a significant reduction in the neck, lower back, right elbow and right hand, in the two interventions, with exercise and physical activity compared to the reference group ($P< 0.0001–0.05$) main effects for region ($F=3.04$, $P<0.0005$), group ($F=2.93$, $P=0.05$) and status ($F=905$, $P<0.0001$). In the feet region, the group where participants were encouraged to perform physical activity on their own, had a greater decrease in pain perception than the workplace exercise intervention ($P< 0.001$) and the reference group ($P< 0.05$).

Marangoni's[39] exercise interventions found a positive effect on the reduction in pain in both intervention groups compared to the control group. The VAS scale (CASP Subjects = -73%; FLIP Subjects = -64%) and a pain spot assessment created by the author (CASP Subjects = -70%; FLIP Subjects = -62%) were used to measure the computer workers' pain reduction. There were no significant differences in pain reduction when using stretching exercises prompted via a software program ($p < 0.001$) or hard copy paper ($p < 0.001$) when compared to the control group, which had a slight increase in pain of 1%.

The Shariat study[44] found significant differences in pain reduction after 6 months of intervention using the Cornell Musculoskeletal Disorders Questionnaire in the groups with exercise sessions, compared to the control group without intervention in the neck [MD-10.55(-14.36 to -6.74)], right shoulder [MD-12.17(-16.87 to -7.47)], left shoulder [MD-11.1(-15.1 to -7.09)] and lower back [MD-7.8(-11.08 to -4.53)]. Additionally, significant differences were found with the combined group with exercises and ergonomic guidelines compared to the control group in the same regions, neck (-13.63 to -6.36)], right shoulder [MD-11.12 (-15.59 to -6.65)], left shoulder [MD-10.67 (-14.49 to -6.85)] and lower back [MD-6.87 (-10 to -3.74)]. Measures were taken every 2 months, and the most significant improvement in pain reduction was experienced from months 4 to 6 in the exercise group ($p < 0.05$).

3.4.2. Effects of workplace exercise interventions in reducing musculoskeletal disorders and pain in the neck and shoulder region

Nakphet and Andersen[41,42] carried out interventions where neck and shoulder pain were assessed. In Andersen's study,[42] there was a significant reduction in pain in the neck and shoulder region 2.0 (95% CI 0.4–3.6) ($p < 0.01$) and an increase in the lower trapezius pressure pain threshold 129 kPa (95% CI 31–227 kPa) ($p < 0.01$) in the active pause group compared to the control group that did not perform any intervention in the neck/shoulder region. No significant differences in the pressure pain threshold in the other body regions were measured.

Otherwise, in Nakphet,[41] for the assessment of pain, the Borg Scale for pain perception was used, and there was a reduction in neck discomfort in the three groups after each pause without significant differences between the active pauses and the passive pauses intervention group: neck: $F(6.16, 83.16) = 1.41$, $p = .221$; right shoulder: $F(4.97, 67.11) = 1.30$, $p = .273$; left shoulder: $F(6.56, 88.54) = 1.15$, $p = .342$; right elbow: $F(6.78, 91.76) = 0.91$, $p = .500$; left elbow: $F(5.29, 71.36) = 0.73$, $p = .613$; right wrist and hand: $F(5.45, 73.55) = 1.14$, $p = .347$; and left wrist and hand: $F(4.86, 65.59) = 1.39$, $p = .242$.

3.4.3. Effects of workplace exercise interventions in reducing musculoskeletal disorders and pain in disability caused by low back pain

The del Pozo-Cruz and Kaeding studies involved reducing disability and the intensity of lower back pain[40,43]. In Kaeding,[43] where the intervention was made through the use of a whole-body vibration machine, improvements were reported in reducing lower back disability compared to the control group in which there was no intervention. There was a mean difference between the two groups in the Roland Morris Questionnaire of 1.8 RMQ points (95% CI: [0.2, 3.4]) (P = .027), with an improvement in the training group of 1.5 (±2.6) RMQ points, while the control group worsened by an average of 0.3 (±2.6) RMQ points. Additionally, measures for the Oswestry Disability Index and changes at the end of the intervention were significantly higher in the training group, with a 4.5 (±6.6) improvement in relation to a −1.2± (3.2) worsening for the control group (P = .002).

There was also a reduction in disability caused by lower back pain in the del Pozo-Cruz study[40] among participants who performed a physical exercise intervention measured by the Oswestry Disability Index questionnaire, with a clinical change of 5.420 (1.707 to 17.216) 85%, P = 0.001) compared to the control group. Additionally, there was a reduction in the risk of chronicity (SBST clinical change, 75%, P < 0.001) and the EQ-5D-3 L pain- and disability-related components (visual analogue scale (VAS) 73%, P < 0.001; mobility, 77%, P < 0.001; self-care, 79%, P = 0.003; pain/discomfort, 88%, P < 0.001). However, the participants in the intervention group did not perceive an improvement in the performance of their daily tasks (P = 0.103). Additionally, in the nonphysical exercise group, an increase in disability and low back pain episodes was reported at the end of the intervention.

4. DISCUSSION

Based on the results of seven randomised controlled trials, exercise has significant benefits in treating musculoskeletal disorders of the lower back, neck and general regions of the body. There was a wide variety of exercise routines performed in the different interventions, with supervised or unsupervised programs, different outcome measures, and the number of participants with musculoskeletal disorders who participated in each study. Diversity has also been found in comparative groups with other exercise interventions and ergonomic advice or control groups without intervention.

There is a lack of consistency in the outcomes, not allowing us to draw firm conclusions regarding the effectiveness of workplace exercise interventions in treating musculoskeletal disorders.

The trials' overall risk of bias was considered high, except for Andersen's,[38] which was the only study that blinded the instructor and the participants. The rest of the RCTs did not provide blinding of their participants or the exercise program's instructors, both being the most important aspects for quality assessment that can affect the internal validity of the results, despite being very complicated to implement in exercise interventions.[46] Regarding external validity, it should be noted that interventions were carried out in the workplace, except for the Nakphet

study,[41] where the office was simulated in a laboratory to carry out a one-day intervention to gather surface myoelectric activity of the targeted muscles. This might be a limitation, as it is essential to carry out interventions on employees' workspaces so that the results can be easily extrapolated to the population that works in an office setting.[47]

More significant efforts should be made when carrying out participant recruitment and designing the intervention procedure, considering essential aspects to reduce biases such as blinding and losses in the follow-up.[48]

As previously mentioned, one of the most remarkable points of the review is the significant difference in the interventions that workers carried out in the different studies. The duration of the studies with physical exercise in clinical and nonclinical populations is commonly between one and three months so that the performance of the intervention and the economic costs would be viable.[46].

The studies reviewed showed no difference between longer or shorter sessions with greater frequency in exercise physiological adaptations regarding exercise volume and weekly frequency. Mainenti[13] showed that physical activity in a more extended session is not associated with decreased sedentarism levels. Therefore, using brief sessions with a high weekly frequency could provide office workers with significant improvements without a prolonged stoppage of their work activity.[49]

Evidence of workplace exercise interventions in the treatment of musculoskeletal disorders

Three studies that evaluated musculoskeletal pain in multiple body regions[38,39,44] concluded that workplace exercise interventions reduced pain compared with the control groups. Rodrigues' systematic review,[50] which also included Marangoni's study,[39] found that regarding the duration of the exercise program, performing strength exercises in the workplace three times a week for 20 minutes could reduce musculoskeletal pain in the different regions of the spine and the upper limbs. Another systematic review[51] focused on video display terminal workers with musculoskeletal pain, using a rehabilitation program with exercises, pain education, and ergonomic adjustments found a significant reduction in pain in different body areas, such as the wrist, shoulder and lower back regions.

Despite the anterior systematic review when analysing the best treatment for specific interventions in the neck and shoulder region, Bertozzi's systematic review[52] found a significant overall effect supporting exercise therapies alone on the reduction of pain in the short and intermediate term despite the results of the aforementioned systematic review in which different therapeutic strategies were combined.[51] The two studies analysed in this review that focused on the neck and shoulder region showed benefits in terms of ´decreasing intensity of pain and associated disability. Nakphet's study[41] concluded that performing a pause in the working hours, either with an exercise intervention or a passive pause, showed a reduction of the perception of pain. In Andersen,[42] with a 10-week intervention, the use of scapular function training with exercise reduced pain intensity in the neck and shoulder region. A former systematic review[29] reported a disparity of results associated with the differences between interventions aimed at treating neck disorders, concluding with strong evidence that interventions with strength and endurance programs were more effective at reducing neck pain.

When focusing on treating lower back pain among office workers, both studies analysed concluded there were positive effects on reducing musculoskeletal pain. There was a disparity between the workplace exercise interventions performed. The del Pozo-Cruz study[40] consisted of a 9-minute daily routine with strength, stretching and mobility exercises in a 9-month intervention, while Kaeding[43] performed 2.5 sessions a week of whole-body vibration training with 10-15-minute sessions during a 3-month intervention. These studies agree with the results indicated by the Sipaviciene study[53] that showed positive effects of performing stabilization exercises for the trunk and of muscle strength exercise program to reduce lower back pain. Additionally, the systematic review by Gordon[54] concluded that a general exercise programme with strength, flexibility and aerobic training would be beneficial for treating nonspecific, chronic lower back pain in the adult population.

Adherence to the exercise prescribed using compliance terminology was reported in more than 80% of the total interventions performed in three of the seven studies analysed.[40,42,43] There is no standardised definition of adherence to the therapeutic exercise for musculoskeletal pain due to lack of consistency in the literature, finding other synonyms such as compliance or concordance.[55]

A standard definition of therapeutic adherence reported in the studies reviewed by Bissonete, notes that: "Adherence can be defined as the extent to which patients follow the instructions they are given for prescribed treatments".[56] It is essential to consider the therapeutic adherence levels for participants with musculoskeletal pain when reporting the results of clinical trials.[55] Considering that adherence to exercise by the general population is ordinarily low,[57,58] strategies to enhance a higher rate of treatment adherence must be considered when designing the intervention procedure. The del Pozo-Cruz web-based intervention used a system in which the participants logged on to the sessions, with high compliance reported. The implementation of web-based interventions using customized push reminders via e-mail or cellular phone and regularly updating the content, such as Edney's Randomised Control Trial,[59] is also effective. Additionally, in Gram and collaborators,[60] no differences were found, where both intervention groups improved in terms of decreasing neck pain and headache with or without instructor supervision; being a web-based program with push reminders is probably being a feasible option for future interventions.

Ambrose's study[61] concludes that any exercise regimen is better than a sedentary lifestyle as long as there is sustainable progression. Additionally, exercise induces analgesia in healthy people due to the pain inhibition mechanism by the reaction of endogenous opioids and nociception inhibitory mechanisms. However, in people with chronic pain, these reactions seem to not occur in the same way, and pain relief requires time after the initial increase in pain has been overcome.[62] In Bravo's randomised control trial,[63] where therapeutic exercises were performed in fibromyalgia participants, a significant reduction in pain did not appear until 2 weeks after the intervention.

Hence, it is essential to consider specific items at the methodological level and a multidimensional approach[64,65] to carry out interventions with appropriate exercise regimens to achieve a low drop-out rate with high compliance with exercise interventions preferences, self-management and pain neuroscience education for the treatment of musculoskeletal disorders.[66,67]

Study limitations

The present study was limited by the small number of RCTs available that perform workplace exercise interventions to treat musculoskeletal disorders.

Only studies published in English and Spanish were analysed. Relevant articles published in other languages could be lost.

The great diversity in the methodological aspects of the different interventions performed in the trials could be a limitation. We found significant heterogeneity in the samples, in the type of interventions and in the period in which the studies' pre/post interventions were carried out. Additionally, heterogeneity was found in the outcomes, which did not allow us to perform a meta-analysis due to the different outcome measures for musculoskeletal disorders and pain used in the studies.

The review only focused on randomised control trials, excluding studies with interventions without a control group. The control groups' interventions analysed were heterogeneous, with no interventions, while others had other exercise interventions, or ergonomic and health guidelines.

The participants' sample was low in the majority of the studies[39–43] together with the use of nonvalidated scales,[38,39,41,42] which could be a limitation of the results obtained.

5. CONCLUSIONS

The present systematic review results conclude that workplace exercise interventions can effectively reduce musculoskeletal disorders in different body regions, such as the neck and shoulder, lower back and upper limbs, compared to other groups of ergonomic guidelines or control groups without interventions. However, heterogeneity in the intervention characteristics, the number of participants, outcome measures, and the low methodological quality of the included studies restricted our ability to draw firm conclusions.

Improvement in the quality of studies is required to strengthen the current evidence of workplace exercise interventions in office workers. There were significant differences between the workplace programs, such as the exercises performed, the session length, and the weekly frequency. A consensus is needed to find structured therapeutic exercise programs following a proper methodological assessment that can be optimal for office workers and other similar sedentary professions.

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Author Contributions The Systematic review was developed and conceived by CT involved in the entire process of writing this manuscript. RP was involved in the review of manuscript contributing to the methodological aspects and the search strategy. FB and FR were involved on the analysis of the risk of bias tool, CB in the extraction data and the redaction of the results, ER has been involved in the supervision and quality assurance of the Systematic Review. All authors read and approved the final manuscript.

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Conflicts of Interest None declared

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REFERENCES

1. Ng SW, Popkin BM. Time use and physical activity: a shift away from movement across the globe. Obes Rev 2012;13(8):659–80.
2. Proper KI, Singh AS, van Mechelen W, et al. Sedentary behaviors and health outcomes among adults. Am J Prev Med 2011;40(2):174–82.
3. Ku P-W, Steptoe A, Liao Y, et al. A cut-off of daily sedentary time and all-cause mortality in adults: a meta-regression analysis involving more than 1 million participants. BMC Med 2018;16(1):74.
4. Chandrasekaran B, Ganesan TB. Sedentarism and chronic disease risk in COVID 19 lockdown – a scoping review. Scott Med J 2020;
5. Rhodes RE, Mark RS, Temmel CP. Adult Sedentary Behavior: A systematic review. Am J Prev Med 2012;42(3):e3–28.
6. Rezende LFM de, Rey-López JP, Matsudo VKR, et al. Sedentary behavior and health outcomes among older adults: a systematic review. BMC Public Health 2014;14(1):333.
7. Guthold R, Stevens GA, Riley LM, et al. Worldwide trends in insufficient physical activity from 2001 to 2016: a pooled analysis of 358 population-based surveys with 1·9 million participants. Lancet Glob Heal 2018;6(10):e1077–86.
8. Bauman A, Ainsworth BE, Sallis JF, et al. The descriptive epidemiology of sitting: A 20-country comparison using the international physical activity questionnaire (IPAQ). Am J Prev Med 2011;41(2):228–35.
9. Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: Surveillance progress, pitfalls, and prospects. Lancet2012;380(9838):247–57.
10. Parry S, Straker L. The contribution of office work to sedentary behaviour associated risk. BMC Public Health 2013;13(1):296.
11. Teychenne M, Costigan SA, Parker K. The association between sedentary behaviour and risk of anxiety: a systematic review. BMC Public

Health 2015;15(1):513.

12. Ryan CG, Dall PM, Granat MH, et al. Sitting patterns at work: objective measurement of adherence to current recommendations. Ergonomics 2011;54(6):531–8.
13. Mainenti MRM, Felicio LR, Rodrigues É de C, et al. Pain, work-related characteristics, and psychosocial factors among computer workers at a university center. J Phys Ther Sci 2014;26(4):567–73.
14. Collins RM, Janse van Rensburg DC, Patricios JS. Common work-related musculoskeletal strains and injuries. South African Fam Pract 2011;53(3):240–6.
15. Mahmud N, Bahari SF, Zainudin NF. Psychosocial and ergonomics risk factors related to neck, shoulder and back complaints among Malaysia office workers. Int J Soc Sci Humanit 2014;4(4):260–3.
16. Kaliniene G, Ustinaviciene R, Skemiene L, et al. Associations between musculoskeletal pain and work-related factors among public service sector computer workers in Kaunas County, Lithuania. BMC Musculoskelet Disord 2016;17(1):1–12.
17. Sheahan PJ, Diesbourg TL, Fischer SL. The effect of rest break schedule on acute low back pain development in pain and non-pain developers during seated work. Appl Ergon 2016;53:64–70.
18. Gustafsson K, Marklund S. Consequences of sickness presence and sickness absence on health and work ability: A Swedish prospective cohort study. Int J Occup Med Environ Health 2011;24(2):153–65.
19. MacInnis MJ, Gibala MJ. Physiological adaptations to interval training and the role of exercise intensity. J Physiol 2017;595(9):2915–30.
20. Parry S, Straker L, Gilson ND, et al. Participatory Workplace Interventions Can Reduce Sedentary Time for Office Workers—A Randomised Controlled Trial. PLoS One 2013;8(11):e78957.
21. Kett AR, Sichting F. Sedentary behaviour at work increases muscle stiffness of the back: Why roller massage has potential as an active break intervention. Appl Ergon 2020;82:102947.
22. Waongenngarm P, Areerak K, Janwantanakul P. The effects of breaks on low back pain, discomfort, and work productivity in office workers: A systematic review of randomized and non-randomized controlled trials.

Appl. Ergon.2018;68:230–9.

23. Sihawong R, Janwantanakul P, Jiamjarasrangsi W. A prospective, cluster-randomized controlled trial of exercise program to prevent low back pain in office workers. Eur Spine J 2014;23(4):786–93.
24. Ma C, Szeto GP, Yan T, et al. Comparing biofeedback with active exercise and passive treatment for the management of work-related neck and shoulder Pain: A randomized controlled trial. Arch Phys Med Rehabil 2011;92(6):849–58.
25. Joshi V, Bellad A. Effect of yogic exercises on symptoms of musculoskeletal disorders of upper limbs among computer users: A randomised controlled trial. Indian J Med Sci 2011;65(10):424.
26. Phattharasupharerk S, Purepong N, Eksakulkla S, et al. Effects of Qigong practice in office workers with chronic non-specific low back pain: A randomized control trial. J Bodyw Mov Ther 2019;23(2):375–81.
27. Freitas-Swerts FCT de, Robazzi ML do CC. The effects of compensatory workplace exercises to reduce work-related stress and musculoskeletal pain. Rev Lat Am Enfermagem 2014;22(4):629–36.
28. Macedo AC, Trindade CS, Brito AP, et al. On the effects of a workplace fitness program upon pain perception: A case study encompassing office workers in a portuguese context. J Occup Rehabil 2011;21(2):228–33.
29. Sihawong R, Janwantanakul P, Sitthipornvorakul E, et al. Exercise therapy for office workers with nonspecific neck pain: A systematic review. J. Manipulative Physiol. Ther.2011;34(1):62–71.
30. Chen X, Coombes BK, Sjøgaard G, et al. Workplace-based interventions for neck pain in office workers: Systematic review and meta-analysis. Phys Ther 2018;98(1):40–62.
31. Goto E, Ishikawa H, Okuhara T, et al. Presenteeism among workers: health-related factors, work-related factors and health literacy. Occup Med (Chic Ill) 2020;70(8):564–9.
32. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71.
33. Tersa-Miralles C, Pastells-Peiró R, Rubí-Carnacea F, et al. Effectiveness of workplace exercise interventions in the treatment of musculoskeletal

disorders in office workers: A protocol of a systematic review. BMJ Open 2020;10(12):1–5.

34. McGowan J, Sampson M, Salzwedel DM, et al. PRESS peer review of electronic search strategies: 2015 guideline statement. J Clin Epidemiol 2016;75:40–6.

35. Covidence. Covidence - Better systematic review management [Internet]. Cochrane2019 [cited 2020 Jan 15];Available from: https://www.covidence.org/home

36. Higgins JPT, Green. Cochrane Handbook for systematic reviews of interventions. Wiley; 2008.

37. Sterne JAC, Savović J, Page MJ, et al. RoB 2: A revised tool for assessing risk of bias in randomised trials. BMJ 2019;366.

38. Andersen LL, Christensen KB, Holtermann A, et al. Effect of physical exercise interventions on musculoskeletal pain in all body regions among office workers: A one-year randomized controlled trial. Man Ther 2010;15(1):100–4.

39. Marangoni AH. Effects of intermittent stretching exercises at work on musculoskeletal pain associated with the use of a personal computer and the influence of media on outcomes. Work 2010;36(1):27–37.

40. del Pozo-Cruz B, Gusi N, del Pozo-Cruz J, et al. Clinical effects of a nine-month web-based intervention in subacute non-specific low back pain patients: a randomized controlled trial. Clin Rehabil 2013;27(1):28–39.

41. Nakphet N, Chaikumarn M, Janwantanakul P. Effect of different types of rest-break interventions on neck and shoulder muscle activity, perceived discomfort and productivity in symptomatic VDU operators: A randomized controlled trial. Int J Occup Saf Ergon 2014;20(2):339–53.

42. Andersen CH, Andersen LL, Zebis MK, et al. Effect of scapular function training on chronic pain in the neck/shoulder region: A randomized controlled trial. J Occup Rehabil 2014;24(2):316–24.

43. Kaeding TS, Karch A, Schwarz R, et al. Whole-body vibration training as a workplace-based sports activity for employees with chronic low-back pain. Scand J Med Sci Sport 2017;27(12):2027–39.

44. Shariat A, Cleland JA, Danaee M, et al. Effects of stretching exercise training and ergonomic modifications on musculoskeletal discomforts of

office workers: a randomized controlled trial. Brazilian J Phys Ther 2018;22(2):144–53.

45. Del Pozo-Cruz B, Gusi N, Del Pozo-Cruz J, et al. Clinical effects of a nine-month web-based intervention in subacute non-specific low back pain patients: A randomized controlled trial. Clin Rehabil 2013;27(1):28–39.

46. Hecksteden A, Faude O, Meyer T, et al. How to construct, conduct and analyze an exercise training study? Front. Physiol.2018;9(JUL).

47. Hoffmann TC, Maher CG, Briffa T, et al. Prescribing exercise interventions for patients with chronic conditions. Can Med Assoc J 2016;188(7):510–8.

48. Falagas ME, Grigori T, Ioannidou E. A systematic review of trends in the methodological quality of randomized controlled trials in various research fields. J. Clin. Epidemiol.2009;62(3):227-231.e9.

49. Ting J, Chen X, Johnston V. Workplace-based exercise intervention improves work ability in office workers: A cluster randomised controlled trial. Int J Environ Res Public Health 2019;16(15):2633.

50. Rodrigues EV, Gomes ARS, Tanhoffer AIP, et al. Effects of exercise on pain of musculoskeletal disorders: a systematic review. Acta Ortopédica Bras 2014;22(6):334–8.

51. Lee DH, Kang B, Choi S, et al. Change in musculoskeletal pain in patients with work-related musculoskeletal disorder after tailored rehabilitation education: A one-year follow-up survey. Ann Rehabil Med 2015;39(5):726.

52. Bertozzi L, Gardenghi I, Turoni F, et al. Effect of therapeutic exercise on pain and disability in the management of chronic nonspecific neck pain: Systematic review and meta-analysis of randomized trials. Phys Ther 2013;93(8):1026–36.

53. Sipaviciene S, Kliziene I. Effect of different exercise programs on non-specific chronic low back pain and disability in people who perform sedentary work. Clin Biomech 2020;73:17–27.

54. Gordon R, Bloxham S. A systematic review of the effects of exercise and physical activity on non-specific chronic low back pain. Healthcare 2016;4(2):22.

55. Bailey DL, Holden MA, Foster NE, et al. Defining adherence to therapeutic exercise for musculoskeletal pain: A systematic review. Br J Sports Med 2020;54(6):326–31.

56. Bissonnette JM. Adherence: a concept analysis. J Adv Nurs 2008;63(6):634–43.

57. Crandall S, Howlett S, Keysor JJ. Exercise adherence interventions for adults with chronic musculoskeletal pain. Phys Ther 2013;93(1):17–21.

58. Nielsen G, Wikman JM, Jensen CJ, et al. Health promotion: The impact of beliefs of health benefits, social relations and enjoyment on exercise continuation. Scand J Med Sci Sport 2014;24(SUPPL.1):66–75.

59. Edney S, Ryan JC, Olds T, et al. User engagement and attrition in an app-based physical activity intervention: Secondary analysis of a randomized controlled trial. J Med Internet Res 2019;21(11):e14645.

60. Gram B, Andersen C, Zebis MK, et al. Effect of training supervision on effectiveness of strength training for reducing neck/shoulder pain and headache in office workers: Cluster randomized controlled trial. Biomed Res Int 2014;2014:1–9.

61. Ambrose KR, Golightly YM. Physical exercise as non-pharmacological treatment of chronic pain: Why and when. Best Pract Res Clin Rheumatol 2015;29(1):120–30.

62. Nijs J, Kosek E, Van Oosterwijck J, et al. Dysfunctional endogenous analgesia during exercise in patients with chronic pain: to exercise or not to exercise? Pain Physician 2012;15(3 Suppl):ES205-13.

63. Bravo C, Skjaerven LH, Espart A, et al. Basic Body Awareness Therapy in patients suffering from fibromyalgia: A randomized clinical trial. Physiother Theory Pract 2019;35(10):919–29.

64. McPhail S, Schippers M, Marshall A, et al. Perceived barriers and facilitators to increasing physical activity among people with musculoskeletal disorders: a qualitative investigation to inform intervention development. Clin Interv Aging 2014;9:2113.

65. Meade LB, Bearne LM, Godfrey EL. “It’s important to buy in to the new lifestyle”: barriers and facilitators of exercise adherence in a population with persistent musculoskeletal pain. Disabil Rehabil 2021;43(4):468–78.

66. Devan H, Hale L, Hempel D, et al. What works and does not work in a

self-management intervention for people with chronic pain? Qualitative systematic review and meta-synthesis. Phys Ther 2018;98(5):381–97.

67. Louw A, Zimney K, Puentedura EJ, et al. The efficacy of pain neuroscience education on musculoskeletal pain: A systematic review of the literature. Physiother Theory Pract 2016;32(5):332–55.

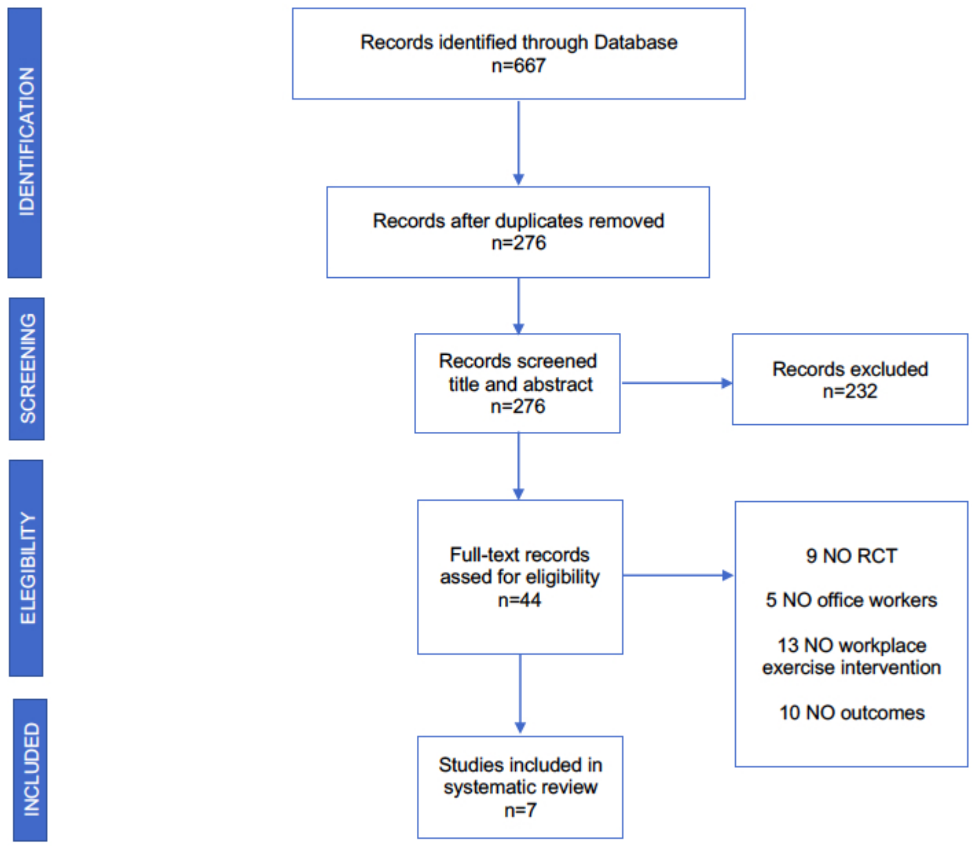

Figure 1. Flow diagram of trial selection, adapted from PRISMA

256x225mm (72 x 72 DPI)

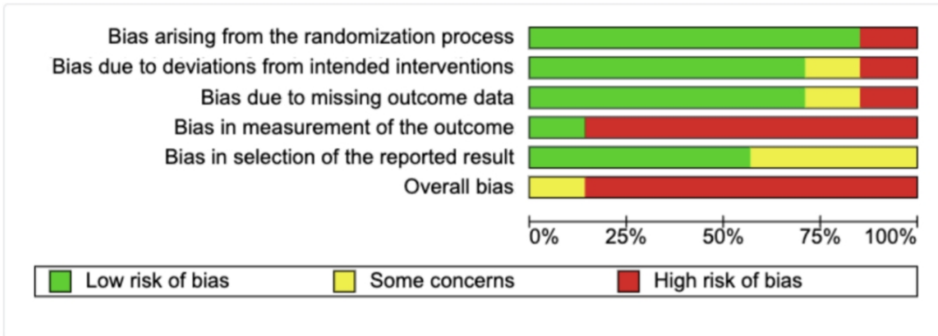

Figure 2. Risk of bias graph: review authors' judgements about risk of bias items presented as percentages across the included RCTs.

157x88mm (220 x 220 DPI)

Figure 3: Risk of bias summary: review authors' judgements about each risk of bias item for each included study. In green (Low risk), yellow (Some concerns) and red (High risk).

83x143mm (220 x 220 DPI)

Supplementary File 1: Search strategy in Pubmed

("Musculoskeletal Pain"[MeSH] OR "Musculoskeletal Pain"[tiab] OR "Musculoskeletal Diseases"[MeSH] OR "Musculoskeletal Diseases"[tiab] OR "Musculoskeletal Disease"[tiab] OR "Musculoskeletal Illness"[tiab] OR "Musculoskeletal Disorder"[tiab] OR "Musculoskeletal Disorders"[tiab] OR "Neck pain"[MeSH] OR "Neck pain"[tiab] OR "Low back pain"[MeSH] OR "Low back pain"[tiab] OR "Shoulder pain"[MeSH] OR "Shoulder pain"[tiab] OR "Low back pains"[tiab] OR "Lumbago"[tiab] OR "Lower Back Pain"[tiab] OR "Lower Back pains"[tiab] OR "Low Back Ache"[tiab] OR "Low Backache"[tiab] OR "Postural Low back pain"[tiab] OR "Recurrent Low back pain"[tiab] OR "Mechanical Low back pain"[tiab] OR "Neck pains"[tiab] OR "Neck Ache"[tiab] OR "Neckaches"[tiab] OR "Cervicalgia"[tiab] OR "Cervicalgias"[tiab] OR "Cervicodynia"[tiab] OR "Cervicodynias"[tiab] OR "Cervical Pain"[tiab] OR "Cervical Pains"[tiab] OR "Posterior Cervical Pain"[tiab] OR "Posterior Neck Pain"[tiab] OR "Anterior Cervical Pain"[tiab] OR "Posterior Neck Pain"[tiab] OR "Shoulder pains"[tiab]) AND ("Exercise Therapy"[MeSH] OR "Exercise Therapy"[tiab] OR "Circuit Based Exercise"[MeSH] "Circuit Based Exercise"[tiab] OR "Muscle Stretching Exercises"[MeSH] OR "Muscle Stretching Exercises"[tiab] OR "Muscle Stretching Exercise"[tiab] OR "Yoga"[MeSH] OR "Yoga"[tiab] OR "Exercise Therapy"[MeSH] OR "Exercise Therapy"[tiab] OR "Pilates Training"[tiab] OR "Active Rest"[tiab] OR "Active Rests"[tiab] OR "Active Pause"[tiab] OR "Active Pauses"[tiab] OR "Active Break"[tiab] OR "Active Breaks"[tiab] OR "Exercise Therapies"[tiab] OR "Remedial Exercise"[tiab] OR "Remedial Exercises"[tiab] OR "Rehabilitation Exercise"[tiab] OR "Rehabilitation Exercises"[tiab] OR "Incidental Physical activity"[tiab] OR "Standing breaks"[tiab] OR "Mobility exercise"[tiab]) AND ("Work Performance"[MeSH] OR "Work Performance"[tiab] OR "Administrative Personnel"[MeSH] OR "Administrative Personnel"[tiab] OR "Office Work"[tiab] OR "Office Worker"[tiab] OR "Office Workers"[tiab] OR "Desk Worker"[tiab] OR "Desk Workers"[tiab] OR "Computer Work"[tiab] OR "Computer Workers"[tiab] OR "Nonmanual Workers"[tiab] OR "sedentary workers"[tiab] OR "sedentary employees"[tiab] OR "Work Performances"[tiab] OR "Job Performance"[tiab] OR "Job Performances"[tiab] OR "Occupational Diseases"[Mesh] OR "Occupational

Disease*"[tiab] OR "Occupational Illness*"[tiab] OR "White Collar Worker"[tiab] OR "Administrative Worker"[tiab] OR "Corporate Workers"[tiab])

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	3-5
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	5
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	6
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	6
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Supplementary File 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	6
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	7
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Protocol
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Protocol
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	7
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Table 1
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	8
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	7
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	7
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	
Study characteristics	17	Cite each included study and present its characteristics.	8
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	13-14
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Table 1
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	13-17
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	13-17
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	13-17
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	17
	23b	Discuss any limitations of the evidence included in the review.	21
	23c	Discuss any limitations of the review processes used.	21
	23d	Discuss implications of the results for practice, policy, and future research.	21
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	2
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	6
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	22
Competing interests	26	Declare any competing interests of review authors.	22
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	

PRISMA 2020 Checklist

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71
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The effectiveness of workplace exercise interventions in the treatment of musculoskeletal disorders in office workers: A systematic review.

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The effectiveness of workplace exercise interventions in the treatment of musculoskeletal disorders in office workers: A systematic review.

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ABSTRACT

Objectives: Determine the effectiveness of workplace exercise interventions in the treatment of musculoskeletal disorders.

Design: Systematic Review of Randomised Control Trials.

Data Sources: Bibliographical databases PubMed, CINAHL Plus, Cochrane, Scopus, ISI WoS and PeDRO were searched, including studies from 1 of January 2010 to 31 of December 2020.

Eligibility criteria: We included randomised controlled trials (RCT) with at least an intervention group performing workplace exercises on office workers with musculoskeletal disorders. Only studies in English and Spanish language were analysed.

Data extraction and synthesis: Two independent reviewers extracted data and assessed the risk of bias. A narrative synthesis was carried with a tabular method specifying the study characteristics following the SWiM guideline for Synthesis without meta-analysis. The revised Cochrane Risk of Bias tool (RoB 2) was assessed to analyse the risk of bias of the included studies.

Results: Seven studies with a total of 967 participants met the inclusion criteria and were included in this review. Due to the heterogeneity of the different workplace exercise interventions, outcome measures and statistical analyses, It was not possible to conduct a meta-analysis and a narrative synthesis was performed. The interventions were classified into three categories: multiple body regions, neck and shoulder and lower back. The seven studies concluded that workplace exercise interventions were effective as a treatment to reduce musculoskeletal disorders and pain compared to other types of interventions or control groups with no interventions. Therefore, a high risk of bias was found in six of the seven studies using the RoB2 tool.

Conclusions: The most recent Randomized Controlled Trials related to workplace exercise interventions in treating musculoskeletal disorders in office workers were found to be effective. However, due to the high risk of bias of the included studies, no firm conclusions could be drawn, and more high-quality studies are needed.

Keywords Musculoskeletal disorders, Pain, Office Worker, Exercise, Workplace.

PROSPERO registration number CRD42020177462.

Article Summary

Strengths and limitations of this study

- The search strategy was developed in collaboration with an expert documentalist and included the following databases: PubMed, CINAHL Plus, Cochrane, Scopus, ISI WoS and PeDRO.
- A blinded peer review was conducted by the researcher to ensure rigorous and consistent sets of inclusion and exclusion criteria.
- This is an innovative review, as it focuses only on exercise interventions in employees' own workplaces, providing specific data on the most effective workplace exercise interventions (volume, intensity, time).
- The review is limited by the heterogeneity of study methodologies and outcome measures due to the diverse types of exercise interventions introduced to office workers.
- The risk of bias of the studies was high overall, making it difficult to draw firm conclusions.

INTRODUCTION

The exponential growth of a sedentary lifestyle in society is due to the great technological advances in recent years increasing the time spent sitting throughout the day.[1,2] Maintaining sitting, reclining and lying postures are sedentary behaviours with low energy expenditure (<1.5 METs).[3] It is important to remark that sedentary behaviour is not the same as physical inactivity,[4] describing people who are performing insufficient amounts of moderate (3-6 METs) and vigorous(>6 METS) intensity activity.[3] So strategies to improve both terms are necessary to have good health. Performing exercise 3 to 5 times a week, such as running or practising sports, does not guarantee an active lifestyle if the rest of the day is based on sedentary behaviour.

The average daily time spent in a seated position by the adult population is 346 minutes per day.[5] American and eastern Mediterranean countries have higher proportions of physical inactivity (43% of adult population); the worldwide average is lower but still surpasses 30%.[6] Moreover, these numbers may be worse due to COVID-19, where home confinement and mobility restrictions are necessary to reduce the spread of the virus, increasing sedentary behaviour.[7]

Even the association seems more than obvious; there is limited research relating sedentary behaviour and physical inactivity to suffering musculoskeletal disorders,[8] being one of the leading causes of health problems for the global population causing work disability, absenteeism, and work presentism.[9] The prevalence of disability due to musculoskeletal pain is predicted to increase exponentially over the next twenty years.[10]

Because the office workplace is an unfavourable environment in terms of high sedentary behaviour,[11] daily exercise is crucial to prevent pathologies caused by the lack of movement and poor posture while spending most of the workday in front of the computer.[12,13] In Kaliniene study[14] with 513 public service sector computer workers in Lithuania, the participants without rest breaks in their schedules had a higher prevalence (8,1-13%) of suffering musculoskeletal disorders in the elbow, wrist/hand, upper and lower back than participants with rest breaks every 2 hours. This higher prevalence of suffering pain is also due to working overtime, high quantitative and cognitive demands and not performing breaks during work hours, increasing the total time spent in a seated position[14,15]

Since productivity seems to be maintained by different standing breaks (5 minutes every 30 minutes of work to bouts of 50 seconds in 5 minutes of work) compared to not taking breaks in one hour of work,[16] performing exercise interventions may help reduce the effect of sickness presenteeism on musculoskeletal complaints and the ability to work.[17]

Having a daily schedule for exercise interventions at work might help reduce the time sitting and increase the daily physical activity of employees.[18] Helping them reach the recommendations from the physical activity guidelines suggested by the WHO's (at least 150' moderate- or 75' vigorous- physical activity) in the adult population,[19] preventing cardiovascular and metabolic illnesses and reducing musculoskeletal dysfunction of the back.[20]

Strength and aerobic exercises focusing on the reduction of the intensity, disability, and duration of neck and shoulder pain can be easily performed in work environments because they do not require equipment and can be performed with office worker's own bodyweight.[21] Regarding the type of exercises, the most common interventions use stretching and strength training exercises.[22,23] Additionally, the practice of disciplines such as yoga[24] or qigong[25], was implemented in the workplace together with home-based sessions that could be considered a feasible option in the treatment of musculoskeletal disorders related to their job demands.

Additionally, sedentary behaviour and its consequences for office workers concern multinational corporations regarding the levels of presentism due to the health issues of their employees, which is an occupational issue resulting in economic costs due to a reduction in productivity levels.[26]

However, to our knowledge, this is the first systematic review focusing exclusively on workplace exercise interventions in the treatment of musculoskeletal disorders in symptomatic office workers of any sector who spend most of their time in a seated position.

This review's practical implications aim to:

- Determine the effect of workplace exercise interventions in the treatment of musculoskeletal disorders.

- Describe the characteristics of workplace interventions to improve therapeutic exercise programs for office workers.

- Recommend future lines of research enhancing interventions for a more active lifestyle of sedentary workers.

2. METHODS

A systematic review of RCT published in English and Spanish between 1 of January 2010 and 31 of December 2020 was conducted according to the PRISMA standards.[27] The study protocol provides more specific details.[28]

Patient and public involvement

There was no patient and public involvement in the whole process of conducting this systematic review.

Data sources and search strategy

The search was generated using PubMed MeSH terms and keywords related to office workers, musculoskeletal pain and exercise interventions. Subsequently, the search was adapted in the following databases: CINAHL Plus, Cochrane, Scopus, ISI WoS and PeDRO. The full search strategy for all databases is available in supplementary file 1.

The strategy was reviewed in pairs and followed the criteria of the PRESS tool.[29] Two reviewers (RP and CT) performed a peer review of all the retrieved records by titles and abstracts and then by full text using the Covidence tool.[30]

Inclusion criteria and study selection

The selection criteria for conducting the review were as follows:

(1) RCT articles with at least one intervention through exercise at work.

(2) Studies with an entire sample carried out on office workers spending the majority of their working hours sitting.

(3) Evaluation of musculoskeletal disorders or pain in the intervention in all body regions or specific areas of the body.

(4) Exercise interventions in the workplace, excluding those with exercises prescribed at home or outside the office setting.

(5) Studies in which the intervention is by means of "Sit-Stand Workstations" or Guidelines of ergonomics and health education without a physical exercise program have been excluded.

Data extraction

Data extraction was performed by two reviewers (CT and CB), based on the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions.[31] Data extraction was carried out in a standardised way, following the characteristics of the studies' methodology taking into account participants, interventions, outcome measures and the results section. The consensus method was used to resolve differences between reviewers where it did not take a third reviewer (FR) to reach the full consensus.

Risk of bias assessment

The risk of bias of each article was independently assessed by two reviewers (FB, CT) using the Cochrane Risk of Bias 2 tool.[32] The sections where there was no coincidence were combined with a third reviewer (FR) to reach a consensus.

Data synthesis

It was not possible to conduct a meta-analysis due to the significant heterogeneity of the different workplace exercise interventions, the random-effects model of outcome measures and the statistical analysis. A narrative synthesis was carried out following Economic and Social Research Council guidance on the conduct of Narrative Synthesis[33] and the SWiM Checklist items.[34] The results of the included studies were summarised and regrouped into three categories according to bodily regions. A preliminary synthesis was performed, presented in a common rubric through tabulation.

RESULTS

3.1. Result of the search

The search results yielded 276 articles after removing duplicates. When screened by title and abstract, 232 were excluded, resulting in reading a total of 44 full-text studies. The search followed the aforementioned specified inclusion and exclusion criteria. In total, seven studies were included. More detailed information is presented in the adapted PRISMA flowchart (Figure 1).

Figure 1. Flow diagram of trial selection, adapted from PRISMA.

3.2. Characteristics of the studies

The seven studies that met the inclusion criteria ranged from 2010 to 2018: Andersen and Marangoni in 2010[35,36], del Pozo-Cruz in 2013[37], Nakphet and Andersen in 2014[38,39] Kaeding in 2017[40], and Shariat in 2018.[41] A total of 967 participants were included in the seven studies, from the smallest sample of 30 participants[38] to the largest with 549.[35] A summary of the different interventions, statistical analysis of the relevant outcomes and the results of the different studies are shown in Table 1.

Table 1. Summary of the results of the individual studies.

Authors	Country	Participants	Intervention group versus control	Relevant outcome	Results	Measurement tools	Effect adverse
Andersen *et al* (2010)[35]	Denmark	n=549 participants One-year of intervention	- Specific resistance training (SRT) (n=180). It consists in neck and shoulder strengthening exercises. - All-round physical exercise (APE) (n=187). It Suggests increase level of physical activity during leisure time and at work with physical activities for all-round strength and aerobic fitness. - Control group (REF) (n=182). It tries to improve health and working conditions; however no changes were implemented at the worksites.	There were main effects for Region (F=3.04, *P*<0.0005), group (F=2.93, *P*=0.05) and Status (F=905, *P*<0.0001). In relation to pain intensity decrease more in neck, low back, right elbow and right hand in SRT and APE groups (*P*<0.0001-0.05), also APE compared with REF had a preventative effect on development of pain symptoms in the right shoulder (*P*<0.05). In neck cases decreased in SRT (-0.73±0.36, *P*<0.05) and APE (-0.91±0.31, *P*<0.01).	Both specific resistance training and all-round physical exercise for office workers caused better effects than REF group in several regions of the upper body and number of pain regions in individuals with neck pain specifically.	Nordic Musculoskeletal Questionnaire, intensity of pain 0-9 last three months.	No
Andersen *et al* (2014)[39]	Denmark	**n=47 (10 ♂, 37 ♀)** Age=44 [12]; BMI =25 [4]	**-**Scapular Function Training (SFT) (n=24): 3x20 min training per week for 10 weeks during working-hours. It consists in a short warm-up, and exercises to activate the serratus anterior and lower trapezius muscles to a high extent with a low level of activation of the upper trapezius. -Control (n=23): not offered any physical training.	There was significant difference between groups in pain in the neck/shoulder region (*p*<0.01); also, on pressure pain threshold in the lower trapezius had an increase of 129 kPa (95% CI 31-227kPa) (*p*<0.01). In shoulder elevation and protraction strength SFT increased shoulder elevation strength 7.7Kg (95% CI 2.2; 13.3Kg) (*p*<0.01) more than control group.	SFT reduces pain intensity and increases shoulder elevation strength in adults with chronic non-specific pain in the neck/shoulder region.	Self-Rated Pain Intensity (0-9), Pressure Pain Threshold (PPT) with algometer, maximal muscle strength with dynamometer, adherence.	No
Authors	**Country**	**Participants**	**Intervention group versus control**	**Relevant outcome**	**Results**	**Measurement tools**	**Effect adverse**
Marangoni *et al* (2010)[36]	United States of America	**n=68 (8 ♂, 60♀)** Age= 43 **(21-62 years)**	- CASP Subjects (n=22) Performed a 10-15 seconds stretch from a Computer Assisted Stretching Program every 6 minutes while working on the computer. - FLIP Subjects (n=23) Performed a 10-15 seconds stretch from a Facsimile Lesson with Instructional Pictures Program every 6 minutes while working on the computer. - Control Subjects (n=23) non-treatment.	There were significant improvements in reduction of pain in the intervention groups (CASP Subjects VAS= -73%; PSA=-70% and FLIP Subjects VAS= -64%; PSA=-62%) compared to the control group that lightly increased VAS= 1%; PSA=1%).	Positive effect on the reduction in pain in the Interventions groups compared to the control group. No significant differences in the type of media used to prompt stretching exercises.	VAS scale. Pain Spot Assessment (PSA) created by the author.	No
Kaeding *et al* (2017)[40]	Germany	**n=41 (13 ♂, 28 ♀)** Age =45.5 [9.1], BMI =26.6 [5.2]	- Whole-body vibration training (WBV) (n=21): It consists training applying sinusoidal vibrations with 2.5 (30-45 min/wk) sessions per week for 3 months. - Control group (n=20): they received any training.	There were significant differences regarding RMQ and ODI between groups (*p*=0.027), *t* test (*p*=0.002, ANCOVA *P*<0.001), also SF36 physical scale (*t* test *P*=0.013, ANCOVA *P*=0.026) and finally Freiburger activity questionnaire showed significant difference using a Wilcoxon test (*P*=0.022). Also, sick-leave showed difference (*P*=0.008).	WBV training seems to be an effective, safe, and suitable intervention for seated working employees with CLBP.	Roland and Morris disability questionnaire (RMQ), Oswestry Disability Index (ODI), Work Ability Index Questionnaire (WAI), SF-36, Freiburger activity questionnaire, isokinetic performance, sick-leave, posturography.	No

Authors	Country	Participants	Intervention group versus control	Relevant outcome	Results	Measurement tools	Effect adverse
Del Pozo-Cruz *et al* (2013)[37]	Spain	**n=90 (24 ♂, 66 ♀)** Age CG =45.5 [7.02] and IG =46.83 [9.13] with diagnosis of sub-acute LBP	-Intervention group (n=46). It consists online session daily within postural reminders, stretching, exercises to improve postural stability, muscle strength, flexibility, mobility, and finally moderate stretching lasting nine months. -Control group (n=44): they had access to usual preventive medicine care only.	In the intervention group participants were more likely to exhibit improvements in functional disability (Oswestry Disability Index questionnaire clinical change, 85%, P = 0.001), risk of chronicity (SBST clinical change, 75%, P < 0.001), and most of the EQ-5D-3L components (visual analogue scale (VAS) 73%, P < 0.001; EQ-5D-3L utility score clinical change, 78%, P <0.001; mobility, 77%, P < 0.001; self-care, 79%,P = 0.003; pain/discomfort, 88%, P < 0.001 and anxiety/depression, 84%, P < 0.001).	A web-based occupational intervention in university administrative office is effective in improving quality of life and reducing the severity of low back pain.	Visual Analogue Scale from the Euroquol-5D (EQ-5D), ODI, STarT Back Screening Tool (SBST).	No
Shariat *et al* (2018)[41]	Malaysia	**n=142 (47 ♂, 95 ♀)** Age Ex. G =29.41 [1.16]; Erg. G =28.31 [0.92]; Com. G = 29.64[0.9] and CG=28.74 [0.82]	-Exercise group (n=43). It consists in stretching and flexibility exercises of muscles of the back, shoulders and neck joints. Once a day three times a week lasting 6 months. -Ergonomic modification (n=37). It contained the modification of working place -Combined group (n=34). It consists de combined of exercise and ergonomic intervention. -Control group (CG) (n=28).	After 6 months, there were significant differences in pain scores for neck [MD-10.55(-14.36 to -6.74)] right and left shoulder [MD-12.17(-16.87 to -7.47)]; [MD-11.1(-15.1 to -7.09)] and lower back [MD-7.8(-11.08 to -4.53)] between exercise and CG. Also, between combined group and CG in pain for neck, right and left shoulder and lower back [MD-9.99(-13.63 to -6.36)]; [MD-11.12(-15.59 to -6.65)]; [MD-10.67(-14.49 to -6.85)]; [MD-6.87(-10 to -3.74)].	The exercise modification was more effective in comparison with ergonomic modification after 4 months.	Cornell Musculoskeletal Disorders Questionnaire (CMDQ).	No
Authors	**Country**	**Participants**	**Intervention group versus control**	**Relevant outcome**	**Results**	**Measurement tools**	**Effect adverse**
Nakphet *et al* (2014)[38]	Thailand	**n=30 ♀ (18-40 years)** SG= 31.4 [5.9]; DCG=29.6 [5.9]; RG=27.6 [3.0]	- Stretching group (n=10) It consist in stretch of neck and shoulder muscles in their 3-min breaks. -Dynamic contractions (n=10) It consist to perform strength exercises of the neck and shoulders during each 3-min break. - Reference group (n=10) The participants were instructed to take their hands off the computer and relax sitting back on their chairs during the breaks.	There was significant time effect on myoelectric activity (MF) between three sessions of a 20-min computer typing task of Upper Trapezius F(1.59,42.81)= 5.35,*p*=0.013. However, no significant differences between groups there was.	Positive effect on the muscle discomfort on the three groups after the rest-break interventions. Rest breaks with a variation in activities did not decrease the level of muscle electrical activity in the neck and shoulder muscles during computer work.	Surface myoelectric activity (SEMG) Borg's CR-10 scale (0-10 scale for muscle discomfort) Productivity= Total number of correct words/Overall time of typing.	No

Abbreviations: CMDQ: Cornell Musculoskeletal Disorders Questionnaire; CVAS: Visual analogue scale; CLBP: chronic low back pain; EQ-5D: Euroquol-5D; MF: Myoelectric activity; ODI: Oswestry Disability Index; PSA: Pain Spot Assessment; PPT: Pressure Pain Threshold; RMQ: Roland and Morris disability questionnaire; SF-36: Short Form 36; SBST: STarT Back Screening Tool; SEMG: Surface myoelectric activity; WAI: Work Ability Index Questionnaire; wk: week.

Interventions varied in each study, from 10- to 15-second stretch exercises every six minutes while working[36] to up to one-hour strengthening exercises for 2–3 sets of 10–15 repetitions, combined with 5-second static neck exercises once a week.[35] A three-minute breaks intervention in Nakphet[38] with a dynamic contraction group and a stretching group focused on the neck/shoulder region; Andersen and Shariat[39,41] with a three-days-a-week intervention, Andersen with 10- to 15-minutes stretching routine[41] and Shariat[39] with a 20-minutes strength routine with scapular training function. Kaeding's study[40] with whole-body interventions performed 2.5 sessions a week with 15 minutes of vibration training and del Pozo-Cruz[37] with a five-day-a-week exercise intervention of seven minutes of physical exercise combining postural stability strengthening, flexibility, mobility, and stretching.

Regarding the length of the interventions, prevail studies with medium- and long-term interventions, except for Nakphet,[38] were performed with a one-day intervention to observe the acute effects of two workplace exercise interventions compared with a passive pause and Marangoni[36] with a three-week intervention. The rest of the studies lasted from a 10-week intervention in the case of Andersen[39], three months in the Kaeding[40] intervention, Shariat[41] with a six-month intervention, a nine-month intervention in the del Pozo-Cruz study[37] and a one-year intervention in Andersen's[35].

There is great variety in the comparison groups that sort from control groups without intervention, the ergonomic guidelines in Marangoni, Andersen, Kaeding and Shariat,[36,39–41] ergonomic and health guidelines in Andersen and del Pozo-Cruz,[35,37] and a passive pause intervention group taking hands off of the computer for a three-minutes rest period in Kaeding's.[38]

3.3. Risk of bias

All of the studies, except for Andersen's,[35] had a "high risk" in the "measurement of the outcome" section because the participants and/or instructors were not blinded. The main difference in Andersen's[35] was that participants were blinded due to the cluster randomisation and the internet-based questionnaires.

In Marangoni, Nakphet and Shariat[36,38,41] we found "some concerns" in the section "selection of the reported results" due to the lack of a "prespecified analysis plan". Although all the studies were randomised, in the study of Nakphet,[38] the type of randomization was not specified and was considered "high risk" in the "randomization process". Another section to highlight is that in charge of evaluating "missing the outcome data", where, despite finding five articles with low adherence, Andersen and Shariat documented the cause of the dropout.[39,41] In Andersen[35] there is no information about why the participants dropped out of the study, and Marangoni[36] did not specify the number of participants or the reason for the drop out having a "high risk" of bias in this section. A summary of the risk of bias is shown in Figure 2 and Figure 3.

Figure 2. Risk of bias graph: review authors' judgements about risk of bias items presented as percentages across the included RCTs

Figure 3: Risk of bias summary: review authors' judgements about each risk of bias item for each included study. In green (Low risk), yellow (Some concerns) and red (High risk).

3.4. Effects of workplace exercise interventions in reducing musculoskeletal disorders and pain

In Andersen, Marangoni and Shariat,[35,36,41] the reduction of musculoskeletal pain in office workers was assessed in multiple body parts. Nakphet and Andersen[38,39] focused on the neck and shoulder area, while del Pozo-Cruz and Kaeding[37,40] assessed workplace interventions concerning disability caused by lower back pain.

3.4.1. Effects of workplace exercise interventions in reducing musculoskeletal disorders in multiple body regions

As mentioned above, Andersen, Marangoni and Shariat[35,36,41] evaluated workplace exercise interventions' effectiveness in reducing musculoskeletal pain

in more than one specific region. In Andersen's[35] Nordic Questionnaire was used to measure musculoskeletal symptoms, and the VAS scale was used to measure the participants' pain perception. The intensity of pain had a significant reduction in the neck, lower back, right elbow and right hand, in the two interventions, with exercise and physical activity compared to the reference group ($P< 0.0001–0.05$) main effects for region ($F=3.04$, $P<0.0005$), group ($F=2.93$, $P=0.05$) and status ($F=905$, $P<0.0001$). In the feet region, the group where participants were encouraged to perform physical activity on their own, had a greater decrease in pain perception than the workplace exercise intervention ($P< 0.001$) and the reference group ($P< 0.05$).

Marangoni's[36] exercise interventions found a positive effect on the reduction in pain in both intervention groups compared to the control group. The VAS scale (CASP Subjects = -73%; FLIP Subjects = -64%) and a pain spot assessment created by the author (CASP Subjects = -70%; FLIP Subjects = -62%) were used to measure the computer workers' pain reduction. There were no significant differences in pain reduction when using stretching exercises prompted via a software program ($p < 0.001$) or hard copy paper ($p < 0.001$) when compared to the control group, which had a slight increase in pain of 1%.

The Shariat study[41] found significant differences in pain reduction after 6 months of intervention using the Cornell Musculoskeletal Disorders Questionnaire in the groups with exercise sessions, compared to the control group without intervention in the neck [MD-10.55(-14.36 to -6.74)], right shoulder [MD-12.17(-16.87 to -7.47)], left shoulder [MD-11.1(-15.1 to -7.09)] and lower back [MD-7.8(-11.08 to -4.53)]. Additionally, significant differences were found with the combined group with exercises and ergonomic guidelines compared to the control group in the same regions, neck (-13.63 to -6.36)], right shoulder [MD-11.12 (-15.59 to -6.65)], left shoulder [MD-10.67 (-14.49 to -6.85)] and lower back [MD-6.87 (-10 to -3.74)]. Measures were taken every 2 months, and the most significant improvement in pain reduction was experienced from months 4 to 6 in the exercise group ($p < 0.05$).

3.4.2. Effects of workplace exercise interventions in reducing musculoskeletal disorders and pain in the neck and shoulder region

Nakphet and Andersen[38,39] carried out interventions where neck and shoulder pain were assessed. In Andersen's study,[42] there was a significant reduction in pain in the neck and shoulder region 2.0 (95% CI 0.4–3.6) ($p < 0.01$) and an increase in the lower trapezius pressure pain threshold 129 kPa (95% CI 31–227 kPa) ($p < 0.01$) in the active pause group compared to the control group that did not perform any intervention in the neck/shoulder region. No significant differences in the pressure pain threshold in the other body regions were measured.

Otherwise, in Nakphet,[38] for the assessment of pain, the Borg Scale for pain perception was used, and there was a reduction in neck discomfort in the three groups after each pause without significant differences between the active pauses and the passive pauses intervention group: neck: $F(6.16, 83.16) = 1.41$, $p = .221$; right shoulder: $F(4.97, 67.11) = 1.30$, $p = .273$; left shoulder: $F(6.56, 88.54) = 1.15$, $p = .342$; right elbow: $F(6.78, 91.76) = 0.91$, $p = .500$; left elbow: $F(5.29, 71.36) = 0.73$, $p = .613$; right wrist and hand: $F(5.45, 73.55) = 1.14$, $p = .347$; and left wrist and hand: $F(4.86, 65.59) = 1.39$, $p = .242$.

3.4.3. Effects of workplace exercise interventions in reducing musculoskeletal disorders and pain in disability caused by low back pain

The del Pozo-Cruz and Kaeding studies involved reducing disability and the intensity of lower back pain[37,40]. In Kaeding,[40] where the intervention was made through the use of a whole-body vibration machine, improvements were reported in reducing lower back disability compared to the control group in which there was no intervention. There was a mean difference between the two groups in the Roland Morris Questionnaire of 1.8 RMQ points (95% CI: [0.2, 3.4]) ($P = .027$), with an improvement in the training group of 1.5 (±2.6) RMQ points, while the control group worsened by an average of 0.3 (±2.6) RMQ points. Additionally, measures for the Oswestry Disability Index and changes at the end of the intervention were significantly higher in the training group, with a 4.5 (±6.6) improvement in relation to a −1.2± (3.2) worsening for the control group ($P = .002$).

There was also a reduction in disability caused by lower back pain in the del Pozo-Cruz study[37] among participants who performed a physical exercise intervention measured by the Oswestry Disability Index questionnaire, with a clinical change of 5.420 (1.707 to 17.216) 85%, P = 0.001) compared to the control group. Additionally, there was a reduction in the risk of chronicity (SBST clinical change, 75%, P < 0.001) and the EQ-5D-3 L pain- and disability-related components (visual analogue scale (VAS) 73%, P < 0.001; mobility, 77%, P < 0.001; self-care, 79%, P = 0.003; pain/discomfort, 88%, P < 0.001). However, the participants in the intervention group did not perceive an improvement in the performance of their daily tasks (P = 0.103). Additionally, in the nonphysical exercise group, an increase in disability and low back pain episodes was reported at the end of the intervention.

4. DISCUSSION

Based on the results of seven RCTsr, exercise has significant benefits in treating musculoskeletal disorders of the lower back, neck and general regions of the body. There was a wide variety of exercise routines performed in the different interventions, with supervised or unsupervised programs, different outcome measures, and the number of participants with musculoskeletal disorders who participated in each study. Diversity has also been found in comparative groups with other exercise interventions and ergonomic advice or control groups without intervention.

There is a lack of consistency in the outcomes, not allowing us to draw firm conclusions regarding the effectiveness of workplace exercise interventions in treating musculoskeletal disorders.

The trials' overall risk of bias was considered high, except for Andersen's,[35] which was the only study that blinded the instructor and the participants. The rest of the RCTs did not provide blinding of their participants or the exercise program's instructors, both being the most important aspects for quality assessment that can affect the internal validity of the results, despite being very complicated to implement in exercise interventions.[42] Regarding external validity, it should be noted that interventions were carried out in the workplace, except for the Nakphet

study,[38] where the office was simulated in a laboratory to carry out a one-day intervention to gather surface myoelectric activity of the targeted muscles. This might be a limitation, as it is essential to carry out interventions on employees' workspaces so that the results can be easily extrapolated to the population that works in an office setting.[43]

More significant efforts should be made when carrying out participant recruitment and designing the intervention procedure, considering essential aspects to reduce biases such as blinding and losses in the follow-up.[44]

As previously mentioned, one remarkable point of the review is the significant difference in the interventions that workers carried out in the different studies. The duration of the studies with physical exercise in clinical and nonclinical populations is commonly between one and three months so that the performance of the intervention and the economic costs would be viable.[42].

The studies reviewed showed no difference between longer or shorter sessions with greater frequency in exercise physiological adaptations regarding exercise volume and weekly frequency. Mainenti[12] showed that physical activity in a more extended session is not associated with decreased sedentarism levels. Therefore, using brief sessions with a high weekly frequency could provide office workers with significant improvements without a prolonged stoppage of their work activity.[45]

Evidence of workplace exercise interventions in the treatment of musculoskeletal disorders

Three studies that evaluated musculoskeletal pain in multiple body regions[35,36,41] concluded that workplace exercise interventions reduced pain compared with the control groups. Rodrigues' systematic review,[46] which also included Marangoni's study,[36] found that regarding the duration of the exercise program, performing strength exercises in the workplace three times a week for 20 minutes could reduce musculoskeletal pain in the different regions of the spine and the upper limbs. Another systematic review[47] focused on video display terminal workers with musculoskeletal pain, using a rehabilitation program with exercises, pain education, and ergonomic adjustments found a significant reduction in pain in different body areas, such as the wrist, shoulder and lower back regions.

Despite the anterior systematic review when analysing the best treatment for specific interventions in the neck and shoulder region, Bertozzi's systematic review[48] found a significant overall effect supporting exercise therapies alone on the reduction of pain in the short and intermediate term despite the results of the aforementioned systematic review in which different therapeutic strategies were combined.[47] The two studies analysed in this review that focused on the neck and shoulder region showed benefits in terms of decreasing intensity of pain and associated disability. Nakphet's study[38] concluded that performing a pause in the working hours, either with an exercise intervention or a passive pause, showed a reduction of the perception of pain. In Andersen,[39] with a 10-week intervention, the use of scapular function training with exercise reduced pain intensity in the neck and shoulder region. A former systematic review[21] reported a disparity of results associated with the differences between interventions aimed at treating neck disorders, concluding with strong evidence that interventions with strength and endurance programs were more effective at reducing neck pain.

When focusing on treating lower back pain among office workers, both studies analysed concluded there were positive effects on reducing musculoskeletal pain. There was a disparity between the workplace exercise interventions performed. The del Pozo-Cruz study[37] consisted of a 9-minute daily routine with strength, stretching and mobility exercises in a 9-month intervention, while Kaeding[40] performed 2.5 sessions a week of whole-body vibration training with 10-15-minute sessions during a 3-month intervention. These studies agree with the results indicated by the Sipaviciene study[49] that showed positive effects of performing stabilization exercises for the trunk and of muscle strength exercise program to reduce lower back pain. Additionally, the systematic review by Gordon[50] concluded that a general exercise programme with strength, flexibility and aerobic training would be beneficial for treating nonspecific, chronic lower back pain in the adult population.

Adherence to the exercise prescribed using compliance terminology was reported in more than 80% of the total interventions performed in three of the seven studies analysed.[37,39,40] There is no standardised definition of adherence to the therapeutic exercise for musculoskeletal pain due to lack of consistency in the literature, finding other synonyms such as compliance or concordance.[51]

A standard definition of therapeutic adherence reported in the studies reviewed by Bissonete, notes that: "Adherence can be defined as the extent to which patients follow the instructions they are given for prescribed treatments".[52] It is essential to consider the therapeutic adherence levels for participants with musculoskeletal pain when reporting the results of clinical trials.[51] Considering that adherence to exercise is ordinarily low,[53,54] strategies to enhance a higher rate of treatment adherence must be considered when designing the intervention procedure. The del Pozo-Cruz web-based intervention used a log-in system with high compliance reported. The implementation of web-based interventions using customized push reminders via e-mail or phone and regularly updating the content, such as Edney's study,[55] is also effective. Additionally, in Gram and collaborators,[56] no differences were found, where both intervention groups improved in terms of decreasing neck pain and headache with or without instructor supervision; being a web-based program with push reminders is probably being a feasible option for future interventions.

Ambrose's study[57] concludes that any exercise regimen is better than a sedentary lifestyle as long as there is sustainable progression. Additionally, exercise induces analgesia in healthy people due to the pain inhibition mechanism by the reaction of endogenous opioids and nociception inhibitory mechanisms. However, in people with chronic pain, these reactions seem to not occur in the same way, and pain relief requires time after the initial increase in pain has been overcome.[58] In Bravo's study,[59] where therapeutic exercises were performed in fibromyalgia participants, a significant reduction in pain did not appear until 2 weeks after the intervention.

Hence, it is essential to consider specific items at the methodological level and a multidimensional approach[60,61] to carry out interventions with appropriate exercise regimens to achieve a low drop-out rate with high compliance with exercise interventions preferences, self-management and pain neuroscience education for the treatment of musculoskeletal disorders.[62,63]

Study limitations

The present study was limited by the small number of RCTs available that perform workplace exercise interventions to treat musculoskeletal disorders.

Only studies published in English and Spanish were analysed. Relevant articles published in other languages could be lost.

The great diversity in the methodological aspects of the different interventions performed in the trials could be a limitation. We found significant heterogeneity in the samples, in the type of interventions and in the period in which the studies' pre/post interventions were carried out. Additionally, heterogeneity was found in the outcomes, which did not allow us to perform a meta-analysis due to the different outcome measures for musculoskeletal disorders and pain used in the studies.

Musculoskeletal conditions are a global concern.[10] More studies are needed to draw firm conclusions related to developed and developing countries where different factors can predict Musculoskeletal disorders in office workers.[64] The studies included in the review are conducted in developed with high income[35–37,39,40] and developing countries with middle-upper income[38,41]. Differences could be found when extrapolating results to low and middle-income countries because the prevalence of musculoskeletal disorders is rising exponentially.[10]

The review only focused on RCTs, excluding studies with interventions without a control group. The control groups' interventions analysed were heterogeneous, with no interventions, while others had other exercise interventions, or ergonomic and health guidelines.

The sample size of participants was low in the majority of the studies[36–40] together with the use of nonvalidated scales,[35,36,38,39] which could be a limitation of the results obtained.

5. CONCLUSIONS

The present systematic review results suggest that workplace exercise interventions can effectively reduce musculoskeletal disorders in different body regions, such as the neck and shoulder, lower back and upper limbs, compared to other groups of ergonomic guidelines or control groups without interventions. However, heterogeneity in the intervention characteristics, the number of participants, outcome measures, and the low methodological quality of the included studies restricted our ability to draw firm conclusions.

Improvement in the quality of studies is required to strengthen the current evidence of workplace exercise interventions in office workers. There were significant differences between the workplace programs, such as the exercises performed, the session length, and the weekly frequency. A consensus is needed to find structured therapeutic exercise programs following a proper methodological assessment that can be optimal for office workers and other similar sedentary professions.

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REFERENCES

1. Ng SW, Popkin BM. Time use and physical activity: a shift away from movement across the globe. Obes Rev 2012;13(8):659–80.
2. Proper KI, Singh AS, van Mechelen W, et al. Sedentary behaviors and health outcomes among adults. Am J Prev Med 2011;40(2):174–82.
3. Tremblay MS, Aubert S, Barnes JD, et al. Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. Int J Behav Nutr Phys Act 2017;14(1):1–17.
4. Rhodes RE, Mark RS, Temmel CP. Adult Sedentary Behavior: A systematic review. Am J Prev Med 2012;42(3):e3–28.
5. Bauman A, Ainsworth BE, Sallis JF, et al. The descriptive epidemiology of sitting: A 20-country comparison using the international physical activity questionnaire (IPAQ). Am J Prev Med 2011;41(2):228–35.
6. Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet 2012;380(9838):247–57.

7. Chandrasekaran B, Ganesan TB. Sedentarism and chronic disease risk in COVID 19 lockdown – a scoping review. Scott Med J 2021;66(1):3–10.
8. Stefansdottir R, Gudmundsdottir SL. Sedentary behavior and musculoskeletal pain: a five-year longitudinal Icelandic study. Public Health 2017;149:71–3.
9. Vos T, Abajobir AA, Abate KH, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 2017;390(10100):1211–59.
10. Blyth FM, Briggs AM, Schneider CH, et al. The global burden of musculoskeletal pain—where to from here? Am J Public Health 2019;109(1):35–40.
11. Ryan CG, Dall PM, Granat MH, et al. Sitting patterns at work: objective measurement of adherence to current recommendations. Ergonomics 2011;54(6):531–8.
12. Mainenti MRM, Felicio LR, Rodrigues É de C, et al. Pain, work-related characteristics, and psychosocial factors among computer workers at a university center. J Phys Ther Sci 2014;26(4):567–73.
13. Collins RM, Janse van Rensburg DC, Patricios JS. Common work-related musculoskeletal strains and injuries. South African Fam Pract 2011;53(3):240–6.
14. Kaliniene G, Ustinaviciene R, Skemiene L, et al. Associations between musculoskeletal pain and work-related factors among public service sector computer workers in Kaunas County, Lithuania. BMC Musculoskelet Disord 2016;17(1):1–12.
15. Mahmud N, Bahari SF, Zainudin NF. Psychosocial and ergonomics risk factors related to neck, shoulder and back complaints among Malaysia office workers. Int J Soc Sci Humanit 2014;4(4):260–3.
16. Sheahan PJ, Diesbourg TL, Fischer SL. The effect of rest break schedule on acute low back pain development in pain and non-pain developers during seated work. Appl Ergon 2016;53:64–70.
17. Gustafsson K, Marklund S. Consequences of sickness presence and sickness absence on health and work ability: A Swedish prospective cohort study. Int J Occup Med Environ Health 2011;24(2):153–65.

18. Parry S, Straker L, Gilson ND, et al. Participatory workplace interventions can reduce sedentary time for office workers—A randomised controlled trial. PLoS One 2013;8(11):e78957.
19. World Health Organisation. Global recommendations on physical activity for health. Geneva, 2010.
20. Kett AR, Sichting F. Sedentary behaviour at work increases muscle stiffness of the back: Why roller massage has potential as an active break intervention. Appl Ergon 2020;82:102947.
21. Sihawong R, Janwantanakul P, Sitthipornvorakul E, et al. Exercise therapy for office workers with nonspecific neck pain: A systematic review. J. Manipulative Physiol. Ther.2011;34(1):62–71.
22. Sihawong R, Janwantanakul P, Jiamjarasrangsi W. A prospective, cluster-randomized controlled trial of exercise program to prevent low back pain in office workers. Eur Spine J 2014;23(4):786–93.
23. Ma C, Szeto GP, Yan T, et al. Comparing biofeedback with active exercise and passive treatment for the management of work-related neck and shoulder Pain: A randomized controlled trial. Arch Phys Med Rehabil 2011;92(6):849–58.
24. Joshi V, Bellad A. Effect of yogic exercises on symptoms of musculoskeletal disorders of upper limbs among computer users: A randomised controlled trial. Indian J Med Sci 2011;65(10):424.
25. Phattharasupharerk S, Purepong N, Eksakulkla S, et al. Effects of Qigong practice in office workers with chronic non-specific low back pain: A randomized control trial. J Bodyw Mov Ther 2019;23(2):375–81.
26. Goto E, Ishikawa H, Okuhara T, et al. Presenteeism among workers: health-related factors, work-related factors and health literacy. Occup Med (Chic Ill) 2020;70(8):564–9.
27. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71.
28. Tersa-Miralles C, Pastells-Peiró R, Rubí-Carnacea F, et al. Effectiveness of workplace exercise interventions in the treatment of musculoskeletal disorders in office workers: A protocol of a systematic review. BMJ Open 2020;10(12):1–5.

29. McGowan J, Sampson M, Salzwedel DM, et al. PRESS peer review of electronic search strategies: 2015 guideline statement. J Clin Epidemiol 2016;75:40–6.
30. Covidence. Covidence - Better systematic review management [Internet]. Cochrane2019 [cited 2020 Jan 15];Available from: https://www.covidence.org/home
31. Higgins JPT, Green. Cochrane Handbook for systematic reviews of interventions. Wiley; 2008.
32. Sterne JAC, Savović J, Page MJ, et al. RoB 2: A revised tool for assessing risk of bias in randomised trials. BMJ 2019;366.
33. Popay J, Roberts H, Sowden A, et al. Guidance on the conduct of narrative synthesis in systematic reviews: a product of the ESRC methods programme (Version I). Lancaster, UK: University of Lancaster, 2006.
34. Campbell M, McKenzie JE, Sowden A, et al. Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline. BMJ 2020;368:l6890.
35. Andersen LL, Christensen KB, Holtermann A, et al. Effect of physical exercise interventions on musculoskeletal pain in all body regions among office workers: A one-year randomized controlled trial. Man Ther 2010;15(1):100–4.
36. Marangoni AH. Effects of intermittent stretching exercises at work on musculoskeletal pain associated with the use of a personal computer and the influence of media on outcomes. Work 2010;36(1):27–37.
37. del Pozo-Cruz B, Gusi N, del Pozo-Cruz J, et al. Clinical effects of a nine-month web-based intervention in subacute non-specific low back pain patients: a randomized controlled trial. Clin Rehabil 2013;27(1):28–39.
38. Nakphet N, Chaikumarn M, Janwantanakul P. Effect of different types of rest-break interventions on neck and shoulder muscle activity, perceived discomfort and productivity in symptomatic VDU operators: A randomized controlled trial. Int J Occup Saf Ergon 2014;20(2):339–53.
39. Andersen CH, Andersen LL, Zebis MK, et al. Effect of scapular function training on chronic pain in the neck/shoulder region: A randomized controlled trial. J Occup Rehabil 2014;24(2):316–24.
40. Kaeding TS, Karch A, Schwarz R, et al. Whole-body vibration training as

a workplace-based sports activity for employees with chronic low-back pain. Scand J Med Sci Sport 2017;27(12):2027–39.

41. Shariat A, Cleland JA, Danaee M, et al. Effects of stretching exercise training and ergonomic modifications on musculoskeletal discomforts of office workers: a randomized controlled trial. Brazilian J Phys Ther 2018;22(2):144–53.

42. Hecksteden A, Faude O, Meyer T, et al. How to construct, conduct and analyze an exercise training study? Front. Physiol.2018;9(JUL).

43. Hoffmann TC, Maher CG, Briffa T, et al. Prescribing exercise interventions for patients with chronic conditions. Can Med Assoc J 2016;188(7):510–8.

44. Falagas ME, Grigori T, Ioannidou E. A systematic review of trends in the methodological quality of randomized controlled trials in various research fields. J Clin Epidemiol 2009;62(3):227-231.e9.

45. Ting J, Chen X, Johnston V. Workplace-based exercise intervention improves work ability in office workers: A cluster randomised controlled trial. Int J Environ Res Public Health 2019;16(15):2633.

46. Rodrigues EV, Gomes ARS, Tanhoffer AIP, et al. Effects of exercise on pain of musculoskeletal disorders: a systematic review. Acta Ortopédica Bras 2014;22(6):334–8.

47. Lee DH, Kang B, Choi S, et al. Change in musculoskeletal pain in patients with work-related musculoskeletal disorder after tailored rehabilitation education: A one-year follow-up survey. Ann Rehabil Med 2015;39(5):726.

48. Bertozzi L, Gardenghi I, Turoni F, et al. Effect of therapeutic exercise on pain and disability in the management of chronic nonspecific neck pain: Systematic review and meta-analysis of randomized trials. Phys Ther 2013;93(8):1026–36.

49. Sipaviciene S, Kliziene I. Effect of different exercise programs on non-specific chronic low back pain and disability in people who perform sedentary work. Clin Biomech 2020;73:17–27.

50. Gordon R, Bloxham S. A systematic review of the effects of exercise and physical activity on non-specific chronic low back pain. Healthcare 2016;4(2):22.

51. Bailey DL, Holden MA, Foster NE, et al. Defining adherence to therapeutic exercise for musculoskeletal pain: A systematic review. Br J Sports Med 2020;54(6):326–31.

52. Bissonnette JM. Adherence: a concept analysis. J Adv Nurs 2008;63(6):634–43.

53. Crandall S, Howlett S, Keysor JJ. Exercise adherence interventions for adults with chronic musculoskeletal pain. Phys Ther 2013;93(1):17–21.

54. Nielsen G, Wikman JM, Jensen CJ, et al. Health promotion: The impact of beliefs of health benefits, social relations and enjoyment on exercise continuation. Scand J Med Sci Sport 2014;24(1):66–75.

55. Edney S, Ryan JC, Olds T, et al. User engagement and attrition in an app-based physical activity intervention: Secondary analysis of a randomized controlled trial. J Med Internet Res 2019;21(11):e14645.

56. Gram B, Andersen C, Zebis MK, et al. Effect of training supervision on effectiveness of strength training for reducing neck/shoulder pain and headache in office workers: Cluster randomized controlled trial. Biomed Res Int 2014;2014:1–9.

57. Ambrose KR, Golightly YM. Physical exercise as non-pharmacological treatment of chronic pain: Why and when. Best Pract Res Clin Rheumatol 2015;29(1):120–30.

58. Nijs J, Kosek E, Van Oosterwijck J, et al. Dysfunctional endogenous analgesia during exercise in patients with chronic pain: to exercise or not to exercise? Pain Physician 2012;15:ES205-13.

59. Bravo C, Skjaerven LH, Espart A, et al. Basic Body Awareness Therapy in patients suffering from fibromyalgia: A randomized clinical trial. Physiother Theory Pract 2019;35(10):919–29.

60. McPhail S, Schippers M, Marshall A, et al. Perceived barriers and facilitators to increasing physical activity among people with musculoskeletal disorders: a qualitative investigation to inform intervention development. Clin Interv Aging 2014;9:2113.

61. Meade LB, Bearne LM, Godfrey EL. “It’s important to buy in to the new lifestyle”: barriers and facilitators of exercise adherence in a population with persistent musculoskeletal pain. Disabil Rehabil 2021;43(4):468–78.

62. Devan H, Hale L, Hempel D, et al. What works and does not work in a

self-management intervention for people with chronic pain? Qualitative systematic review and meta-synthesis. Phys Ther 2018;98(5):381–97.

63. Louw A, Zimney K, Puentedura EJ, et al. The efficacy of pain neuroscience education on musculoskeletal pain: A systematic review of the literature. Physiother Theory Pract 2016;32(5):332–55.

64. Maakip I, Keegel T, Oakman J. Prevalence and predictors for musculoskeletal discomfort in Malaysian office workers: Investigating explanatory factors for a developing country. Appl Ergon 2016;53:252–7.

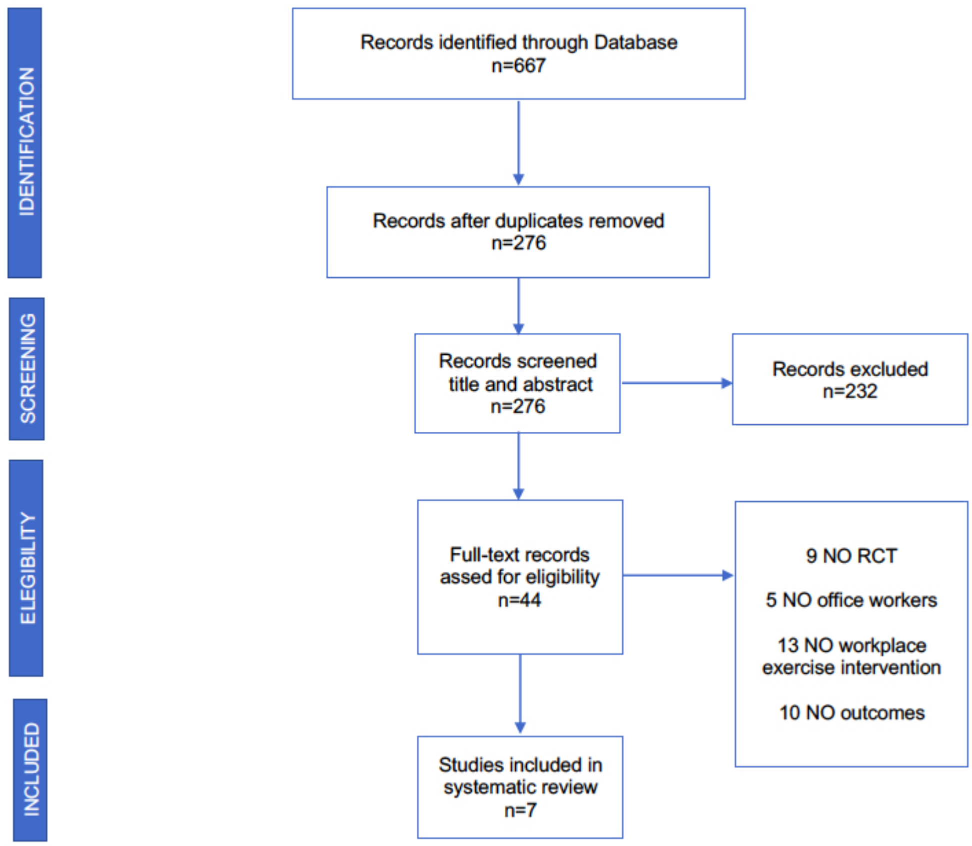

Figure 1. Flow diagram of trial selection, adapted from PRISMA

256x225mm (72 x 72 DPI)

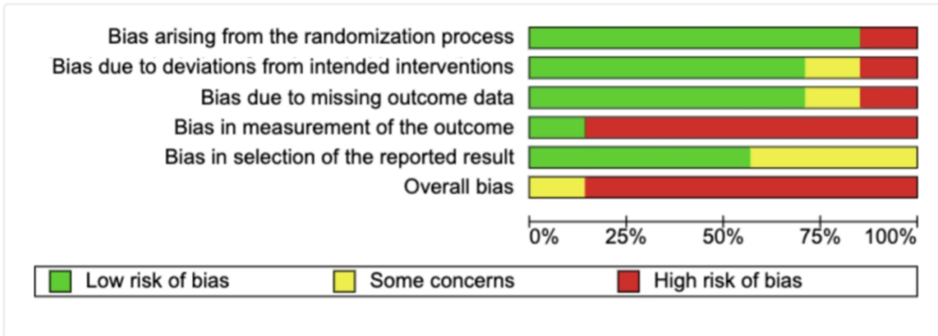

Figure 2. Risk of bias graph: review authors' judgements about risk of bias items presented as percentages across the included RCTs.

157x88mm (220 x 220 DPI)

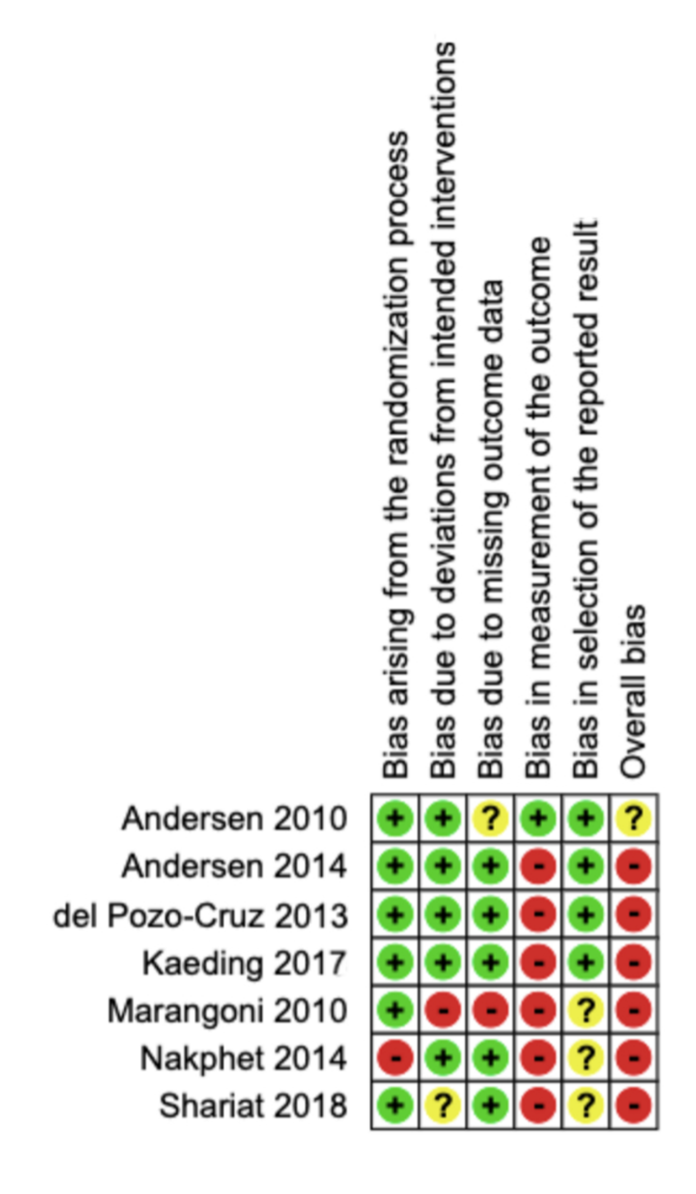

Figure 3: Risk of bias summary: review authors' judgements about each risk of bias item for each included study. In green (Low risk), yellow (Some concerns) and red (High risk).

83x143mm (220 x 220 DPI)

Supplementary File 1. Full search strategy

Database	Search terms
Pubmed	1. ("Office Work"[tiab] OR "Office Worker"[tiab] OR "Office Workers"[tiab] OR "Desk Worker"[tiab] OR "Desk Workers"[tiab] OR "Computer Work"[tiab] OR "Computer Workers"[tiab] OR "Nonmanual Workers"[tiab] OR "Administrative Personnel"[MeSH] OR "Administrative Personnel"[tiab] OR "sedentary workers"[tiab] OR "sedentary personnel"[tiab] OR "sedentary employees"[tiab] OR "Work Performance"[MeSH] OR "Work Performance"[tiab] OR "Work Performances"[MeSH] OR "Work Performances"[tiab] OR "Job Performance"[MeSH] OR "Job Performance"[tiab] OR "Job Performances"[MeSH] OR "Job Performances"[tiab] OR "Occupational Diseases"[Mesh] OR "Occupational Disease*"[tiab] OR "Occupational Illness*"[tiab] OR "Administrative Personnel"[MeSH] OR "Administrative Personnel"[tiab] OR "White Collar Worker"[tiab] OR "Administrative Worker"[tiab] OR "Corporate Workers"[tiab] OR "Video Display terminal workers"[tiab] OR "Video Display Visual operators"[tiab] OR "Clerical workers"[tiab]) 2. ("Musculoskeletal Illness"[MeSH] OR "Musculoskeletal Illness"[tiab] OR "Musculoskeletal Pain"[MeSH] OR "Musculoskeletal Pain"[tiab] OR "Musculoskeletal Pain"[MeSH] OR "Musculoskeletal Pain"[tiab] OR "Musculoskeletal Disease"[MeSH] OR "Musculoskeletal Disease"[tiab] OR "Musculoskeletal Diseases"[MeSH] OR "Musculoskeletal Diseases"[tiab] OR "Musculoskeletal Disorder"[tiab] OR "Musculoskeletal Disorders"[tiab] OR "Musculoskeletal Disfunction"[tiab] OR "Musculoskeletal Disfunctions"[tiab] OR "Low back pain"[MeSH] OR "Low back pain"[tiab] OR "Low back pains"[tiab] OR "Lumbago"[tiab] OR "Lower Back Pain"[tiab] OR "Lower Back pains"[tiab] OR "Low Back Ache"[tiab] OR "Low Back Aches"[tiab] OR "Low Backache"[tiab] OR "Low Backaches"[tiab] OR "Postural Low back pain"[tiab] OR "Posterior Compartment Low back pain"[tiab] OR "Recurrent Low back pain"[tiab] OR "Mechanical Low back pain"[tiab] OR "Neck pain"[MeSH] OR "Neck pain"[tiab] OR "Neck pains"[tiab] OR "Neck Ache"[tiab] OR "NeckAches"[tiab] OR "Cervicalgia"[tiab] OR "Cervicalgias"[tiab] OR "Cervicodynia"[tiab] OR "Cervicodynias"[tiab] OR "Cervical Pain"[tiab] OR "Cervical Pains"[tiab] OR "Posterior Cervical Pain"[tiab] OR "Posterior Cervical Pains"[tiab] OR "Posterior Neck Pain"[tiab] OR "Posterior Neck Pains"[tiab] OR "Anterior Cervical Pain"[tiab] OR "Anterior Cervical Pains"[tiab] OR "Posterior Neck Pain"[tiab] OR "Posterior Neck Pains"[tiab] OR "Shoulder pain"[MeSH] OR "Shoulder pain"[tiab] OR "Shoulder pains"[tiab]) 3. ("Exercise movement Therapy"[MeSH] OR "Exercise movement Therapy"[tiab] OR "Exercise Therapy"[MeSH] OR "Exercise Therapy"[tiab] OR "Circuit Based Exercise"[MeSH] "Circuit Based Exercise"[tiab] OR "Stretching Exercise"[MeSH] OR "Stretching Exercise"[tiab] OR Yoga[MeSH] OR Yoga[tiab] OR "Pilates Training"[tiab] OR "Active Rest"[tiab] OR "Active Rests"[tiab] OR "Active Pause"[tiab] OR "Active Pauses"[tiab] OR "Active Break"[tiab] OR "Active Breaks"[tiab] OR "Exercise Therapies"[tiab] OR "Remedial Exercise"[tiab] OR "Remedial Exercises"[tiab] OR "Rehabilitation Exercise"[tiab] OR "Rehabilitation Exercises"[tiab] OR "Incidental Physical activity"[tiab] OR "Standing breaks"[tiab] OR "Stretching breaks"[tiab] OR "Mobility exercise"[tiab] OR "Workplace exercise intervention"[tiab]) 4. 1 AND 2 AND 3 - Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only
CINHAL	1. TI (("Musculoskeletal Illness" OR "Musculoskeletal Pain" OR "Musculoskeletal Pain" OR "Musculoskeletal Disease" OR "Musculoskeletal Diseases" OR "Musculoskeletal Disorder" OR "Musculoskeletal Disorders" OR "Musculoskeletal Disfunction" OR "Musculoskeletal Disfunctions" OR "Low back pain" OR "Low back pains" OR "Lumbago" OR "Lower Back Pain" OR "Lower Back pains" OR "Low Back Ache" OR "Low Back Aches" OR "Low Backache" OR "Low Backaches" OR "Postural Low back pain" OR "Posterior Compartment Low back pain" OR "Recurrent Low back pain" OR "Mechanical Low back pain" OR "Neck pain" OR "Neck pains" OR "Neck Ache" OR "NeckAches" OR "Cervicalgia" OR "Cervicalgias" OR "Cervicodynia" OR "Cervicodynias" OR "Cervical Pain" OR "Cervical Pains" OR "Posterior Cervical Pain" OR "Posterior Cervical Pains" OR "Posterior Neck Pain" OR "Posterior Neck Pains" OR "Anterior Cervical Pain" OR "Anterior

	Cervical Pains” OR “Posterior Neck Pain” OR “Posterior Neck Pains” OR “Shoulder pain” OR “Shoulder pain” OR “Shoulder pains”)) 2. AB ((Musculoskeletal Illness” OR “Musculoskeletal Pain” OR “Musculoskeletal Pain” OR “Musculoskeletal Disease” OR “Musculoskeletal Diseases” OR “Musculoskeletal Disorder” OR “Musculoskeletal Disorders” OR “Musculoskeletal Disfunction” OR “Musculoskeletal Disfunctions” OR “Low back pain” OR “Low back pains” OR “Lumbago” OR “Lower Back Pain” OR “Lower Back pains” OR “Low Back Ache” OR “Low Back Aches” OR “Low Backache” OR “Low Backaches” OR “Postural Low back pain” OR “Posterior Compartment Low back pain” OR “Recurrent Low back pain” OR “Mechanical Low back pain” OR “Neck pain” OR “Neck pains” OR “Neck Ache” OR “NeckAches” OR “Cervicalgia” OR “Cervicalgias” OR “Cervicodynia” OR “Cervicodynias” OR “Cervical Pain” OR “Cervical Pains” OR “Posterior Cervical Pain” OR “Posterior Cervical Pains” OR “Posterior Neck Pain” OR “Posterior Neck Pains” OR “Anterior Cervical Pain” OR “Anterior Cervical Pains” OR “Posterior Neck Pain” OR “Posterior Neck Pains” OR “Shoulder pain” OR “Shoulder pain” OR “Shoulder pains”)) 3. TI ((“Office Work” OR “Office Worker” OR “Office Workers” OR “Desk Worker” OR “Desk Workers” OR “Computer Work” OR “Computer Workers” OR “Nonmanual Workers” OR “Administrative Personnel” OR “sedentary workers” OR “sedentary personnel” OR “sedentary employees” OR “Work Performance” OR “Work Performances” OR “Job Performance” OR “Job Performances” OR "Occupational Diseases" OR "Occupational Disease*" OR "Occupational Illness*" OR “Administrative Personnel” OR “White Collar Worker” OR “Administrative Worker” OR “Corporate Workers” OR “Video Display terminal workers” OR “Video Display Visual operators” OR “Clerical workers”)) 4. AB ((“Office Work” OR “Office Worker” OR “Office Workers” OR “Desk Worker” OR “Desk Workers” OR “Computer Work” OR “Computer Workers” OR “Nonmanual Workers” OR “Administrative Personnel” OR “sedentary workers” OR “sedentary personnel” OR “sedentary employees” OR “Work Performance” OR “Work Performances” OR “Job Performance” OR “Job Performances” OR "Occupational Diseases" OR "Occupational Disease*" OR "Occupational Illness*" OR “Administrative Personnel” OR “White Collar Worker” OR “Administrative Worker” OR “Corporate Workers” OR “Video Display terminal workers” OR “Video Display Visual operators” OR “Clerical workers”)) 5. TI ((“Exercise Movement Therapy” OR “Exercise Therapy” OR “Circuit Based Exercise” OR “Stretching Exercise” OR Yoga OR “Pilates Training” OR “Active Rest” OR “Active Rests” OR “Active Pause” OR “Active Pauses” OR “Active Break” OR “Active Breaks” OR “Exercise Therapies” OR “Remedial Exercise” OR “Remedial Exercises” OR “Rehabilitation Exercise” OR “Rehabilitation Exercises” OR “Incidental Physical Activity” OR “Standing Breaks” OR “Stretching Breaks” OR “Mobility Exercise” OR “Workplace Exercise Intervention”)) 6. AB ((“Exercise Movement Therapy” OR “Exercise Therapy” OR “Circuit Based Exercise” OR “Stretching Exercise” OR Yoga OR “Pilates Training” OR “Active Rest” OR “Active Rests” OR “Active Pause” OR “Active Pauses” OR “Active Break” OR “Active Breaks” OR “Exercise Therapies” OR “Remedial Exercise” OR “Remedial Exercises” OR “Rehabilitation Exercise” OR “Rehabilitation Exercises” OR “Incidental Physical Activity” OR “Standing Breaks” OR “Stretching Breaks” OR “Mobility Exercise” OR “Workplace Exercise Intervention”)) 7. 1 OR 2 AND 3 OR 4 AND 5 OR 6 - Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only
Cochrane	1. ((“Musculoskeletal Illness” OR “Musculoskeletal Pain” OR “Musculoskeletal Pain” OR “Musculoskeletal Disease” OR “Musculoskeletal Diseases” OR “Musculoskeletal Disorder” OR “Musculoskeletal Disorders” OR “Musculoskeletal Disfunction” OR “Musculoskeletal Disfunctions” OR “Low back pain” OR “Low back pains” OR “Lumbago” OR “Lower Back Pain” OR “Lower Back pains” OR “Low Back Ache” OR “Low Back Aches” OR “Low Backache” OR “Low Backaches” OR “Postural Low back pain” OR “Posterior Compartment Low back pain” OR “Recurrent Low back pain” OR “Mechanical Low back pain” OR “Neck pain” OR “Neck pains” OR “Neck Ache” OR “NeckAches” OR “Cervicalgia” OR “Cervicalgias” OR “Cervicodynia” OR “Cervicodynias” OR “Cervical Pain” OR “Cervical Pains” OR “Posterior Cervical Pain” OR “Posterior Cervical Pains” OR “Posterior Neck Pain” OR “Posterior Neck Pains” OR “Anterior Cervical Pain” OR “Anterior

	Cervical Pains” OR “Posterior Neck Pain” OR “Posterior Neck Pains” OR “Shoulder pain” OR “Shoulder pain” OR “Shoulder pains”)):ti,ab,kw 2. ((“Office Work” OR “Office Worker” OR “Office Workers” OR “Desk Worker” OR “Desk Workers” OR “Computer Work” OR “Computer Workers” OR “Nonmanual Workers” OR “Administrative Personnel” OR “sedentary workers” OR “sedentary personnel” OR “sedentary employees” OR “Work Performance” OR “Work Performances” OR “Job Performance” OR “Job Performances” OR "Occupational Diseases" OR "Occupational Disease*" OR "Occupational Illness*" OR “Administrative Personnel” OR “White Collar Worker” OR “Administrative Worker” OR “Corporate Workers” OR “Video Display terminal workers” OR “Video Display Visual operators” OR “Clerical wokers”)):ti,ab,kw 3. ((“Exercise movement Therapy” OR “Exercise Therapy” OR “Circuit Based Exercise” OR “Stretching Exercise” OR Yoga OR “Pilates Training” OR “Active Rest” OR “Active Rests” OR “Active Pause” OR “Active Pauses” OR “Active Break” OR “Active Breaks” OR “Exercise Therapies” OR “Remedial Exercise” OR “Remedial Exercises” OR “Rehabilitation Exercise” OR “Rehabilitation Exercises” OR “Incidental Physical Activity” OR “Standing Breaks” OR “Stretching Breaks” OR “Mobility Exercise” OR “Workplace Exercise Intervention”)):ti,ab,kw 4. 1 AND 2 AND 3 - Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only
Scopus	1. TITLE-ABS-KEY (“Musculoskeletal Illness” OR “Musculoskeletal Pain” OR “Musculoskeletal Pain” OR “Musculoskeletal Disease” OR “Musculoskeletal Diseases” OR “Musculoskeletal Disorder” OR “Musculoskeletal Disorders” OR “Musculoskeletal Disfunction” OR “Musculoskeletal Disfunctions” OR “Low back pain” OR “Low back pains” OR “Lumbago” OR “Lower Back Pain” OR “Lower Back pains” OR “Low Back Ache” OR “Low Back Aches” OR “Low Backache” OR “Low Backaches” OR “Postural Low back pain” OR “Posterior Compartment Low back pain” OR “Recurrent Low back pain” OR “Mechanical Low back pain” OR “Neck pain” OR “Neck pains” OR “Neck Ache” OR “NeckAches” OR “Cervicalgia” OR “Cervicalgias” OR “Cervicodynia” OR “Cervicodynias” OR “Cervical Pain” OR “Cervical Pains” OR “Posterior Cervical Pain” OR “Posterior Cervical Pains” OR “Posterior Neck Pain” OR “Posterior Neck Pains” OR “Anterior Cervical Pain” OR “Anterior Cervical Pains” OR “Posterior Neck Pain” OR “Posterior Neck Pains” OR “Shoulder pain” OR “Shoulder pain” OR “Shoulder pains”) 2. TITLE-ABS-KEY(“Office Work” OR “Office Worker” OR “Office Workers” OR “Desk Worker” OR “Desk Workers” OR “Computer Work” OR “Computer Workers” OR “Nonmanual Workers” OR “Administrative Personnel” OR “sedentary workers” OR “sedentary personnel” OR “sedentary employees” OR “Work Performance” OR “Work Performances” OR “Job Performance” OR “Job Performances” OR "Occupational Diseases" OR "Occupational Disease*" OR "Occupational Illness*" OR “Administrative Personnel” OR “White Collar Worker” OR “Administrative Worker” OR “Corporate Workers” OR “Video Display terminal workers” OR “Video Display Visual operators” OR “Clerical workers”) 3. TITLE-ABS-KEY(“Exercise movement Therapy” OR “Exercise Therapy” OR “Circuit Based Exercise” OR “Stretching Exercise” OR Yoga OR “Pilates Training” OR “Active Rest” OR “Active Rests” OR “Active Pause” OR “Active Pauses” OR “Active Break” OR “Active Breaks” OR “Exercise Therapies” OR “Remedial Exercise” OR “Remedial Exercises” OR “Rehabilitation Exercise” OR “Rehabilitation Exercises” OR “Incidental Physical activity” OR “Standing breaks” OR “Stretching breaks” OR “Mobility exercise” OR “Workplace exercise intervention”) 4. 1 AND 2 AND 3 - Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only
ISI WoS	1. (Musculoskeletal Illness OR Musculoskeletal Pain OR Musculoskeletal Pain OR Musculoskeletal Disease OR Musculoskeletal Diseases OR Musculoskeletal Disorder OR Musculoskeletal Disorders OR Musculoskeletal Disfunction OR Musculoskeletal Disfunctions OR Low back pain OR Low back pains OR Lumbago OR Lower Back Pain OR Lower Back pains OR Low Back Ache OR Low Back Aches OR Low Backache OR Low Backaches OR Postural Low back pain OR Posterior Compartment Low back pain OR

	Recurrent Low back pain OR Mechanical Low back pain OR Neck pain OR Neck pains OR Neck Ache OR NeckAches OR Cervicalgia OR Cervicalgias OR Cervicodynia OR Cervicodynias OR Cervical Pain OR Cervical Pains OR Posterior Cervical Pain OR Posterior Cervical Pains OR Posterior Neck Pain OR Posterior Neck Pains OR Anterior Cervical Pain OR Anterior Cervical Pains OR Posterior Neck Pain OR Posterior Neck Pains OR Shoulder pain OR Shoulder pain OR Shoulder pains) 2. (Office Work OR Office Worker OR Office Workers OR Desk Worker OR Desk Workers OR Computer Work OR Computer Workers OR Nonmanual Workers OR Administrative Personnel OR Sedentary workers OR Sedentary personnel OR Sedentary employees OR Work Performance OR Work Performances OR Job Performance OR Job Performances OR Occupational Disease* OR Occupational Illness* OR Administrative Personnel OR White Collar Worker OR Administrative Worker OR Corporate Workers OR Video Display terminal workers OR Video Display Visual operators OR Clerical workers) 3. (Exercise movement Therapy OR Exercise Therapy OR Circuit Based Exercise OR Stretching Exercise OR Yoga OR Pilates Training OR Active Rest OR Active Rests OR Active Pause OR Active Pauses OR Active Break OR Active Breaks OR Exercise Therapies OR Remedial Exercise OR Remedial Exercises OR Rehabilitation Exercise OR Rehabilitation Exercises OR Incidental Physical activity OR Standing Breaks OR Stretching Breaks OR Mobility Exercise OR Workplace Exercise Intervention) 4. 1 AND 2 AND 3 AND - Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only
PeDRO	A simple search of the different terms and their synonyms: 1. Musculoskeletal Disorders 2. Office workers 3. Exercise Therapy

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	3-5
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	5
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	6
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	6
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Supplementary File 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	6
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	7
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Protocol
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Protocol
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	7
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Table 1
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	8
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	7
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	7
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	
Study characteristics	17	Cite each included study and present its characteristics.	8
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	13-14
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Table 1
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	13-17
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	13-17
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	13-17
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	17
	23b	Discuss any limitations of the evidence included in the review.	21
	23c	Discuss any limitations of the review processes used.	21
	23d	Discuss implications of the results for practice, policy, and future research.	21
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	2
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	6
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	22
Competing interests	26	Declare any competing interests of review authors.	22
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	

PRISMA 2020 Checklist

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71
For more information, visit: http://www.prisma-statement.org/

Synthesis Without Meta-analysis (SWiM) reporting items

The citation for the Synthesis Without Meta-analysis explanation and elaboration article is: Campbell M, McKenzie JE, Sowden A, Katikireddi SV, Brennan SE, Ellis S, Hartmann-Boyce J, Ryan R, Shepperd S, Thomas J, Welch V, Thomson H. Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline BMJ 2020;368:l6890 http://dx.doi.org/10.1136/bmj.l6890

SWiM is intended to complement and be used as an extension to PRISMA			
SWiM reporting item	**Item description**	**Page in manuscript where item is reported**	**Other***
Methods			
1 Grouping studies for synthesis	1a) Provide a description of, and rationale for, the groups used in the synthesis (e.g., groupings of populations, interventions, outcomes, study design)	7	
	1b) Detail and provide rationale for any changes made subsequent to the protocol in the groups used in the synthesis		
2 Describe the standardised metric and transformation methods used	Describe the standardised metric for each outcome. Explain why the metric(s) was chosen, and describe any methods used to transform the intervention effects, as reported in the study, to the standardised metric, citing any methodological guidance consulted.	7	
3 Describe the synthesis methods	Describe and justify the methods used to synthesise the effects for each outcome when it was not possible to undertake a meta-analysis of effect estimates.	7	
4 Criteria used to prioritise results for summary and synthesis	Where applicable, provide the criteria used, with supporting justification, to select the particular studies, or a particular study, for the main synthesis or to draw conclusions from the synthesis (e.g., based on study design, risk of bias assessments, directness in relation to the review question)	7	

Synthesis Without Meta-analysis (SWiM) reporting items

SWiM reporting item	Item description	Page in manuscript where item is reported	Other*
5 Investigation of heterogeneity in reported effects	State the method(s) used to examine heterogeneity in reported effects when it was not possible to undertake a meta-analysis of effect estimates and its extensions to investigate heterogeneity	7-8	
6 Certainty of evidence	Describe the methods used to assess certainty of the synthesis findings	7	
7 Data presentation methods	Describe the graphical and tabular methods used to present the effects (e.g., tables, forest plots, harvest plots). Specify key study characteristics (e.g., study design, risk of bias) used to order the studies, in the text and any tables or graphs, clearly referencing the studies included	8	
Results			
8 Reporting results	For each comparison and outcome, provide a description of the synthesised findings, and the certainty of the findings. Describe the result in language that is consistent with the question the synthesis addresses, and indicate which studies contribute to the synthesis	8-17	
Discussion			
9 Limitations of the synthesis	Report the limitations of the synthesis methods used and/or the groupings used in the synthesis, and how these affect the conclusions that can be drawn in relation to the original review question	21	

PRISMA=Preferred Reporting Items for Systematic Reviews and Meta-Analyses.
*If the information is not provided in the systematic review, give details of where this information is available (e.g., protocol, other published papers (provide citation details), or website (provide the URL)).

BMJ Open

The effectiveness of workplace exercise interventions in the treatment of musculoskeletal disorders in office workers: A systematic review.

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-054288.R2
Article Type:	Original research
Date Submitted by the Author:	14-Dec-2021
Complete List of Authors:	Tersa Miralles, Carlos; University of Lleida, Nursing and Physiotherapy Bravo, Cristina; University of Lleida, Nursing and Physiotherapy Bellon, Filip; University of Lleida, Nursing and Physiotherapy Pastells-Peiró, Roland; University of Lleida, Nursing and Physiotherapy Rubinat Arnaldo, Esther; University of Lleida, esther.rubinat@udl.cat. Rubí Carnacea, Francesc; University of Lleida, francesc.rubi@udl.cat
Primary Subject Heading:	Rehabilitation medicine
Secondary Subject Heading:	Evidence based practice, Sports and exercise medicine
Keywords:	Musculoskeletal disorders < ORTHOPAEDIC & TRAUMA SURGERY, Pain management < ANAESTHETICS, OCCUPATIONAL & INDUSTRIAL MEDICINE, REHABILITATION MEDICINE

The effectiveness of workplace exercise interventions in the treatment of musculoskeletal disorders in office workers: a systematic review

Carlos Tersa-Miralles[1], Cristina Bravo[1,2,4], Filip Bellon[1,2], Roland Pastells-Peiró[1,2], Esther Rubinat Arnaldo[1,2,3,4], Francesc Rubí-Carnacea[1,2,4].

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Word count 4371

ABSTRACT

Objectives: To determine the effectiveness of workplace exercise interventions in the treatment of musculoskeletal disorders.

Design: Systematic review of randomised controlled trials (RCTs).

Data Sources: The bibliographical databases PubMed, CINAHL Plus, Cochrane, Scopus, ISI WoS, and PeDRO were searched, with studies from Jan 1 2010 to Dec 31, 2020 eligible for inclusion.

Eligibility criteria: We included RCTs, reported in English or Spanish, with at least an intervention group performing workplace exercises on office workers with musculoskeletal disorders.

Data extraction and synthesis: Two independent reviewers extracted data and assessed the risk of bias. A narrative synthesis was carried with a tabular method specifying the study characteristics following the SWiM guideline for synthesis without meta-analysis. The revised Cochrane Risk of Bias tool (RoB 2) was used to analyse the risk of bias of the included studies.

Results: Seven studies with a total of 967 participants met the inclusion criteria and were included in this review. Due to the heterogeneity of the different workplace exercise interventions, outcome measures and statistical analyses, it was not possible to conduct a meta-analysis and a narrative synthesis was performed. The interventions were classified into three categories: multiple body regions, neck and shoulder and lower back. The seven studies concluded that workplace exercise interventions were effective as a treatment to reduce musculoskeletal disorders and pain compared to other types of interventions or control groups with no interventions. A high risk of bias was found in six of the seven studies using the RoB2 tool.

Conclusions: The findings of the RCTs of workplace exercise interventions suggested these interventions were effective at treating musculoskeletal disorders in office workers. However, due to the high risk of bias of the included studies, no firm conclusions could be drawn, and more high-quality studies are needed.

Keywords Musculoskeletal disorders, Pain, Office Worker, Exercise, Workplace.

PROSPERO registration number CRD42020177462.

Article Summary

Strengths and limitations of this study

- The search strategy was developed in collaboration with an expert documentalist and included the following databases: PubMed, CINAHL Plus, Cochrane, Scopus, ISI WoS and PeDRO.
- We ensured rigorous and consistent sets of inclusion and exclusion criteria.
- This is an innovative review, as it focuses only on exercise interventions in employees' own workplaces, providing specific data on the most effective workplace exercise interventions (volume, intensity, time).
- The review is limited by the heterogeneity of study methodologies, interventions and outcome measures.
- The risk of bias of the studies was high overall, making it difficult to draw firm conclusions.

INTRODUCTION

The exponential growth of a sedentary lifestyle in society is due to the great technological advances in recent years, increasing the time spent sitting throughout the day.[1,2] Maintaining sitting, reclining and lying postures are sedentary behaviours with low energy expenditure (<1.5 METs).[3] It is important to remark that sedentary behaviour and physical inactivity have different meanings,[4] being the latter the result of performing insufficient amounts of moderate (3-6 METs) and vigorous(>6 METS) intensity activity.[3] It is therefore critical for strategies to improve physical activity and reduce sedentary behaviour to enhance health.

American and eastern Mediterranean countries have higher proportions of physical inactivity, where 43% of the adult population does not reach the recommendations from the physical activity guidelines suggested by the WHO's (at least 150’ moderate- or 75’ vigorous- physical activity, per week);[5] the worldwide average is lower but still surpasses 30%.[6] Moreover, these numbers may be worse due to COVID-19, where home confinement and mobility restrictions are necessary to reduce the spread of the virus, increasing sedentary behaviour.[7]

Even though the association seems obvious, there is limited evidence that physically active individuals have less prevalence of suffering from chronic musculoskeletal complaints.[8] More high-quality studies are required to determine the cause/effect of sedentary behaviour and its association with musculoskeletal pain.[9] This condition is one of the leading causes of health problems for the global population, causing work disability, absenteeism, and work presentism.[10]

Because the office workplace is an unfavourable environment in terms of high sedentary behaviour,[11] daily exercise is crucial to prevent pathologies caused by the lack of movement and poor posture while spending most of the workday in front of the computer.[12,13] In a study by Kaliniene[14] with 513 public service sector computer workers in Lithuania, the participants without rest breaks in their schedules had a higher prevalence (8,1-13%) of suffering from musculoskeletal disorders in the elbow, wrist/hand, upper and lower back than participants with rest breaks every 2 hours. This higher prevalence of suffering pain is also due to working overtime, high quantitative and cognitive demands and not performing breaks during work hours, increasing the total time spent in a seated position.[14,15]

Since productivity seems to be maintained by different standing breaks (5 minutes every 30 minutes of work to bouts of 50 seconds in 5 minutes of work) compared to not taking breaks in one hour of work,[16] performing exercise interventions may help reduce the effect of sickness presenteeism on musculoskeletal complaints and the ability to work.[17]

Having a daily schedule for exercise interventions at work might help reduce the time spent sitting and increase the daily physical activity of employees,[18] preventing cardiovascular and metabolic illnesses and reducing musculoskeletal dysfunction of the back.[19]

Strength and aerobic exercises focusing on the reduction of the intensity, disability, and duration of neck and shoulder pain can be easily performed in work environments because they do not require equipment and can be performed with office worker's own bodyweight.[20] Regarding the type of exercises, the most common interventions use stretching and strength training exercises.[21,22] Additionally, the practice of disciplines such as yoga[23] or qigong,[24] was implemented in the workplace together with home-based sessions that could be considered a feasible option in the treatment of musculoskeletal disorders related to their job demands.

However, to our knowledge, this is the first systematic review focusing exclusively on workplace exercise interventions in the treatment of musculoskeletal disorders in symptomatic office workers of any sector who spend most of their time in a seated position.

This review's practical implications aim to:

- Determine the effect of workplace exercise interventions in the treatment of musculoskeletal disorders.
- Describe the characteristics of workplace interventions to improve therapeutic exercise programs for office workers.
- Recommend future lines of research enhancing interventions for a more active lifestyle of sedentary workers.

2. METHODS

A systematic review of RCTs published in English and Spanish between Jan 1, 2010 and Dec 31, 2020 was conducted according to the PRISMA standards.[25] The study protocol provides more specific details.[26]

Data sources and search strategy

The search was generated using PubMed MeSH terms and keywords related to office workers, musculoskeletal pain and exercise interventions. Subsequently, the search was adapted in the following databases: CINAHL Plus, Cochrane, Scopus, ISI WoS and PeDRO. The full search strategy for all databases is available in supplementary file 1.

The strategy was reviewed in pairs and followed the criteria of the PRESS tool.[27] Two reviewers (RP and CT) performed a peer review of all the retrieved records by titles and abstracts and then by full text using the Covidence tool.[28]

Inclusion criteria and study selection

The selection criteria for conducting the review were as follows:

(1) RCT articles with at least one intervention through exercise at work.

(2) Studies with an entire sample carried out on office workers spending the majority of their working hours sitting.

(3) Evaluation of musculoskeletal disorders or pain in the intervention in all body regions or specific areas of the body.

(4) Exercise interventions in the workplace, excluding those with exercises prescribed at home or outside the office setting.

(5) Studies in which the intervention is by means of "Sit-Stand Workstations" or Guidelines of ergonomics and health education without a physical exercise program have been excluded.

Data extraction

Data extraction was performed by two reviewers (CT and CB), based on the recommendations of the Cochrane Handbook for Systematic Reviews of Interventions.[29] Data extraction was carried out in a standardised way, following the characteristics of the studies' methodology taking into account participants, interventions, outcome measures and the results section. The consensus method was used to resolve differences between reviewers where it did not take a third reviewer (FR) to reach the full consensus.

Risk of bias assessment

The risk of bias of each article was independently assessed by two reviewers (FB, CT) using the Cochrane Risk of Bias 2 tool.[30] The sections where there was no coincidence were combined with a third reviewer (FR) to reach a consensus.

Data synthesis

It was not possible to conduct a meta-analysis due to the significant heterogeneity of the different workplace exercise interventions, the random-effects model of outcome measures and the statistical analysis. A narrative synthesis was carried out following Economic and Social Research Council guidance on the conduct of Narrative Synthesis[31] and the SWiM Checklist items.[32] The results of the included studies were summarised and regrouped into three categories according to bodily regions. A preliminary synthesis was performed, presented in a common rubric through tabulation.

Patient and public involvement

There was no patient or public involvement.

RESULTS

3.1. Result of the search

The search results yielded 276 articles after removing duplicates. When screened by title and abstract, 232 were excluded, resulting in reading a total of 44 full-text studies. The search followed the aforementioned specified inclusion and exclusion criteria. In total, seven studies were included. More detailed information is presented in the adapted PRISMA flowchart (Figure 1).

Figure 1. Flow diagram of trial selection, adapted from PRISMA.

3.2. Characteristics of the studies

The seven studies that met the inclusion criteria ranged from 2010 to 2018: Andersen and Marangoni in 2010[33,34], del Pozo-Cruz in 2013[35], Nakphet and Andersen in 2014[36,37] Kaeding in 2017[38], and Shariat in 2018.[39] A total of 967 participants were included in the seven studies, from the smallest sample of 30 participants[36] to the largest with 549.[33] A summary of the different interventions, statistical analysis of the relevant outcomes and the results of the different studies are shown in Table 1.

Table 1. Summary of the results of the individual studies.

Authors	Country	Participants	Intervention group versus control	Relevant outcome	Results	Measurement tools	Effect adverse
Andersen *et al* (2010)[33]	Denmark	**n=549** **(**616 participants in the baseline test 219♂Age=45.7, 397♀ Age=44.6)	- Specific resistance training (SRT) (n=180). It consists in neck and shoulder strengthening exercises. - All-round physical exercise (APE) (n=187). It suggests increasing the level of physical activity during leisure time and at work with physical activities for all-round strength and aerobic fitness. - Control group (REF) (n=182). It tries to improve health and working conditions; however, no changes were implemented at the worksites.	There were main effects for Region (F=3.04, *P*<0.0005), group (F=2.93, *P*=0.05) and Status (F=905, *P*<0.0001). In relation to pain intensity decrease more in neck, low back, right elbow and right hand in SRT and APE groups (*P*<0.0001-0.05), also APE compared with REF had a preventative effect on development of pain symptoms in the right shoulder (*P*<0.05). In neck cases decreased in SRT (-0.73±0.36, *P*<0.05) and APE (-0.91±0.31, *P*<0.01).	Both specific resistance training and all-round physical exercise for office workers caused better effects than REF group in several regions of the upper body and number of pain regions in individuals with neck pain specifically.	Nordic Musculoskeletal Questionnaire, intensity of pain 0-9 last three months.	No
Andersen *et al* (2014)[37]	Denmark	**n=47 (10 ♂, 37 ♀)** Age=44 [12]; BMI =25 [4]	**-**Scapular Function Training (SFT) (n=24): 3x20 min training per week for 10 weeks during working-hours. It consists in a short warm-up, and exercises to activate the serratus anterior and lower trapezius muscles, to a high extent with a low level of activation of the upper trapezius. -Control (n=23): not offered any physical training.	There was significant difference between groups in pain in the neck/shoulder region (*p*<0.01); also, on pressure pain threshold in the lower trapezius had an increase of 129 kPa (95% CI 31-227kPa) (*p*<0.01). In shoulder elevation and protraction strength SFT increased shoulder elevation strength 7.7Kg (95% CI 2.2; 13.3Kg) (*p*<0.01) more than control group.	SFT reduces pain intensity and increases shoulder elevation strength in adults with chronic non-specific pain in the neck/shoulder region.	Self-Rated Pain Intensity (0-9), Pressure Pain Threshold (PPT) with algometer, maximal muscle strength with dynamometer, adherence.	No
Marangoni *et al* (2010)[34]	United States of America	**n=68 (8 ♂, 60♀)** Age= 43 (21-62 years)	- CASP Subjects (n=22) Performed 10-15 seconds stretch from a Computer Assisted Stretching Program every 6 minutes while working on the computer. - FLIP Subjects (n=23) Performed 10-15 seconds stretch from a Facsimile Lesson with Instructional Pictures Program every 6 minutes while working on the computer. - Control Subjects (n=23) non-treatment.	There were significant improvements in reduction of pain in the intervention groups (CASP Subjects VAS= -73%; PSA=-70% and FLIP Subjects VAS= -64%; PSA=-62%) compared to the control group that lightly increased VAS= 1%; PSA=1%).	Positive effect on the reduction in pain in the intervention groups compared to the control group. No significant differences in the type of media used to prompt stretching exercises.	VAS scale. Pain Spot Assessment (PSA) created by the author.	No
Kaeding *et al* (2017)[38]	Germany	**n=41 (13 ♂, 28 ♀)** Age =45.5 [9.1], BMI =26.6 [5.2]	- Whole-body vibration training (WBV) (n=21): It consists of training applying sinusoidal vibrations with 2.5 (30-45 min/wk) sessions per week for 3 months. - Control group (n=20): they received any training.	There were significant differences regarding RMQ and ODI between groups (*p*=0.027), *t* test (*p*=0.002, ANCOVA *P*<0.001), also SF36 physical scale (*t* test *P*=0.013, ANCOVA *P*=0.026) and finally Freiburger activity questionnaire showed significant difference using a Wilcoxon test (*P*=0.022). Also, sick leave showed difference (*P*=0.008).	WBV training seems to be an effective, safe, and suitable intervention for seated working employees with CLBP.	Roland and Morris disability questionnaire (RMQ), Oswestry Disability Index (ODI), Work Ability Index Questionnaire (WAI), SF-36, Freiburger activity questionnaire, isokinetic performance, sick-	No

						leave, posturography.	
Del Pozo-Cruz *et al* (2013)[35]	Spain	**n=90 (24 ♂, 66 ♀)** Age CG =45.5 [7.02] and IG =46.83 [9.13] with diagnosis of sub-acute LBP	-Intervention group (n=46). It consists online session daily within postural reminders, stretching, exercises to improve postural stability, muscle strength, flexibility, mobility, and finally moderate stretching lasting nine months. -Control group (n=44): they had access to usual preventive medicine care only.	In the intervention group participants were more likely to exhibit improvements in functional disability (Oswestry Disability Index questionnaire clinical change, 85%, P = 0.001), risk of chronicity (SBST clinical change, 75%, P < 0.001), and most of the EQ-5D-3L components (visual analogue scale (VAS) 73%, P < 0.001; EQ-5D-3L utility score clinical change, 78%, P <0.001; mobility, 77%, P < 0.001; self-care, 79%,P = 0.003; pain/discomfort, 88%, P < 0.001 and anxiety/depression, 84%, P < 0.001).	A web-based occupational intervention in university administrative office is effective in improving quality of life and reducing the severity of low back pain.	Visual Analogue Scale from the Euroquol-5D (EQ-5D), ODI, STarT Back Screening Tool (SBST).	No
Shariat *et al* (2018)[39]	Malaysia	**n=142 (47 ♂, 95 ♀)** Age Ex. G =29.41 [1.16]; Erg. G =28.31 [0.92]; Com. G = 29.64[0.9] and CG=28.74 [0.82]	-Exercise group (n=43). It consists in stretching and flexibility exercises of muscles of the back, shoulders and neck joints. Once a day three times a week lasting 6 months. -Ergonomic modification (n=37). It contained the modification of working place -Combined group (n=34). It consists of combining exercise and an ergonomic intervention. -Control group (CG) (n=28).	After 6 months, there were significant differences in pain scores for neck [MD-10.55(-14.36 to -6.74)] right and left shoulder [MD-12.17(-16.87 to -7.47)]; [MD-11.1(-15.1 to -7.09)] and lower back [MD-7.8(-11.08 to -4.53)] between exercise and CG. Also, between combined group and CG in pain for neck, right and left shoulder and lower back [MD-9.99(-13.63 to -6.36)]; [MD-11.12(-15.59 to -6.65)]; [MD-10.67(-14.49 to -6.85)]; [MD-6.87(-10 to -3.74)].	The exercise modification was more effective in comparison with ergonomic modification group after 4 months.	Cornell Musculoskeletal Disorders Questionnaire (CMDQ).	No
Nakphet *et al* (2014)[36]	Thailand	**n=30 ♀ (18-40 years)** SG= 31.4 [5.9]; DCG=29.6 [5.9]; RG=27.6 [3.0]	- Stretching group (n=10) It consist in stretch of neck and shoulder muscles in their 3-min breaks. -Dynamic contractions (n=10) It consist of performing strength exercises of the neck and shoulders during each 3-min break. - Reference group (n=10) The participants were instructed to take their hands off the computer and relax sitting back on their chairs during the breaks.	There was significant time effect on myoelectric activity (MF) between three sessions of a 20-min computer typing task of Upper Trapezius $F(1.59,42.81)= 5.35, p=0.013$. However, no significant differences between groups.	Positive effect on the muscle discomfort on the three groups after the rest-break interventions. Rest breaks with a variation in activities did not decrease the level of muscle electrical activity in the neck and shoulder muscles during computer work.	Surface myoelectric activity (SEMG) Borg's CR-10 scale (0-10 scale for muscle discomfort) Productivity= Total number of correct words/Overall time of typing.	No
		Abbreviations: CMDQ: Cornell Musculoskeletal Disorders Questionnaire; CVAS: Visual analogue scale; CLBP: chronic low back pain; EQ-5D: Euroquol-5D; MF: Myoelectric activity; ODI: Oswestry Disability Index; PSA: Pain Spot Assessment; PPT: Pressure Pain Threshold; RMQ: Roland and Morris disability questionnaire; SF-36: Short Form 36; SBST: STarT Back Screening Tool; SEMG: Surface myoelectric activity; WAI: Work Ability Index Questionnaire; wk: week.					

Interventions varied in each study, from 10- to 15-second stretch exercises every six minutes while working[34] to up to one-hour strengthening exercises for 2–3 sets of 10–15 repetitions, combined with 5-second static neck exercises once a week.[33] A three-minute breaks intervention in Nakphet[36] with a dynamic contraction group and a stretching group focused on the neck/shoulder region; Andersen and Shariat[37,39] with a three-days-a-week intervention, Andersen with 10- to 15-minutes stretching routine[39] and Shariat[37] with a 20-minutes strength routine with scapular training function. Kaeding's study[38] with whole-body interventions performed 2.5 sessions a week with 15 minutes of vibration training and del Pozo-Cruz[35] with a five-day-a-week exercise intervention of seven minutes of physical exercise combining postural stability strengthening, flexibility, mobility, and stretching.

Regarding the length of the interventions, prevail studies with medium- and long-term interventions, except for Nakphet,[36] were performed with a one-day intervention to observe the acute effects of two workplace exercise interventions compared with a passive pause and Marangoni[34] with a three-week intervention. The rest of the studies lasted from a 10-week intervention in the case of Andersen[37], three months in the Kaeding[38] intervention, Shariat[39] with a six-month intervention, a nine-month intervention in the del Pozo-Cruz study[35] and a one-year intervention in Andersen's[33].

There is great variety in the comparison groups that sort from control groups without intervention, the ergonomic guidelines in Marangoni, Andersen, Kaeding and Shariat,[34,37–39] ergonomic and health guidelines in Andersen and del Pozo-Cruz,[33,35] and a passive pause intervention group taking hands off of the computer for a three-minutes rest period in Kaeding's.[36]

3.3. Risk of bias

All of the studies, except for Andersen's,[33] had a "high risk" in the "measurement of the outcome" section because the participants and/or instructors were not blinded. The main difference in Andersen's[33] was that participants were blinded due to the cluster randomisation and the internet-based questionnaires.

In Marangoni, Nakphet and Shariat[34,36,39] we found "some concerns" in the section "selection of the reported results" due to the lack of a "prespecified analysis plan". Although all the studies were randomised, in the study of Nakphet,[36] the type of randomisation was not specified and was considered "high risk" in the "randomisation process". Another section to highlight is that in charge of evaluating "missing the outcome data", where, despite finding five articles with low adherence, Andersen and Shariat documented the cause of the dropout.[37,39] In Andersen[33] there is no information about why the participants dropped out of the study, and Marangoni[34] did not specify the number of participants or the reason for the drop out having a "high risk" of bias in this section. A summary of the risk of bias is shown in Figure 2 and Figure 3.

Figure 2. Risk of bias graph: review authors' judgements about risk of bias items presented as percentages across the included RCTs.

Figure 3: Risk of bias summary: review authors' judgements about each risk of bias item for each included study. In green (Low risk), yellow (Some concerns) and red (High risk).

3.4. Effects of workplace exercise interventions in reducing musculoskeletal disorders and pain

In Andersen, Marangoni and Shariat,[33,34,39] the reduction of musculoskeletal pain in office workers was assessed in multiple body parts. Nakphet and Andersen[36,37] focused on the neck and shoulder area, while del Pozo-Cruz and Kaeding[35,38] assessed workplace interventions concerning disability caused by lower back pain.

3.4.1. Effects of workplace exercise interventions in reducing musculoskeletal disorders in multiple body regions

As mentioned above, Andersen, Marangoni and Shariat[33,34,39] evaluated workplace exercise interventions' effectiveness in reducing musculoskeletal pain

in more than one specific region. In Andersen's[33] Nordic Questionnaire was used to measure musculoskeletal symptoms, and the VAS scale was used to measure the participants' pain perception. The intensity of pain had a significant reduction in the neck, lower back, right elbow and right hand, in the two interventions, with exercise and physical activity compared to the reference group ($P < 0.0001$–0.05) main effects for region ($F=3.04$, $P<0.0005$), group ($F=2.93$, $P=0.05$) and status ($F=905$, $P<0.0001$). In the feet region, the group where participants were encouraged to perform physical activity on their own, had a greater decrease in pain perception than the workplace exercise intervention ($P < 0.001$) and the reference group ($P < 0.05$).

Marangoni's[34] exercise interventions found a positive effect on the reduction in pain in both intervention groups compared to the control group. The VAS scale (CASP Subjects = -73%; FLIP Subjects = -64%) and a pain spot assessment created by the author (CASP Subjects = -70%; FLIP Subjects = -62%) were used to measure the computer workers' pain reduction. There were no significant differences in pain reduction when using stretching exercises prompted via a software program ($p < 0.001$) or hard copy paper ($p < 0.001$) when compared to the control group, which had a slight increase in pain of 1%.

The Shariat study[39] found significant differences in pain reduction after 6 months of intervention using the Cornell Musculoskeletal Disorders Questionnaire in the groups with exercise sessions, compared to the control group without intervention in the neck [MD-10.55(-14.36 to -6.74)], right shoulder [MD-12.17(-16.87 to -7.47)], left shoulder [MD-11.1(-15.1 to -7.09)] and lower back [MD-7.8(-11.08 to -4.53)]. Additionally, significant differences were found with the combined group with exercises and ergonomic guidelines compared to the control group in the same regions, neck (-13.63 to -6.36)], right shoulder [MD-11.12 (-15.59 to -6.65)], left shoulder [MD-10.67 (-14.49 to -6.85)] and lower back [MD-6.87 (-10 to -3.74)]. Measures were taken every 2 months, and the most significant improvement in pain reduction was experienced from months 4 to 6 in the exercise group ($p < 0.05$).

3.4.2. Effects of workplace exercise interventions in reducing musculoskeletal disorders and pain in the neck and shoulder region

Nakphet and Andersen[36,37] carried out interventions where neck and shoulder pain were assessed. In Andersen's study,[37] there was a significant reduction in pain in the neck and shoulder region 2.0 (95% CI 0.4–3.6) ($p < 0.01$) and an increase in the lower trapezius pressure pain threshold 129 kPa (95% CI 31–227 kPa) ($p < 0.01$) in the active pause group compared to the control group that did not perform any intervention in the neck/shoulder region. No significant differences in the pressure pain threshold in the other body regions were measured.

Otherwise, in Nakphet,[36] for the assessment of pain, the Borg Scale for pain perception was used, and there was a reduction in neck discomfort in the three groups after each pause without significant differences between the active pauses and the passive pauses intervention group: neck: $F(6.16, 83.16) = 1.41$, $p = .221$; right shoulder: $F(4.97, 67.11) = 1.30$, $p = .273$; left shoulder: $F(6.56, 88.54) = 1.15$, $p = .342$; right elbow: $F(6.78, 91.76) = 0.91$, $p = .500$; left elbow: $F(5.29, 71.36) = 0.73$, $p = .613$; right wrist and hand: $F(5.45, 73.55) = 1.14$, $p = .347$; and left wrist and hand: $F(4.86, 65.59) = 1.39$, $p = .242$.

3.4.3. Effects of workplace exercise interventions in reducing musculoskeletal disorders and pain in disability caused by low back pain

The del Pozo-Cruz and Kaeding studies involved reducing disability and the intensity of lower back pain[35,38]. In Kaeding,[38] where the intervention was made through the use of a whole-body vibration machine, improvements were reported in reducing lower back disability compared to the control group in which there was no intervention. There was a mean difference between the two groups in the Roland Morris Questionnaire of 1.8 RMQ points (95% CI: [0.2, 3.4]) ($P = .027$), with an improvement in the training group of 1.5 (±2.6) RMQ points, while the control group worsened by an average of 0.3 (±2.6) RMQ points. Additionally, measures for the Oswestry Disability Index and changes at the end of the intervention were significantly higher in the training group, with a 4.5 (±6.6) improvement in relation to a −1.2± (3.2) worsening for the control group ($P = .002$).

There was also a reduction in disability caused by lower back pain in the del Pozo-Cruz study[35] among participants who performed a physical exercise intervention measured by the Oswestry Disability Index questionnaire, with a clinical change of 5.420 (1.707 to 17.216) 85%, P = 0.001) compared to the control group. Additionally, there was a reduction in the risk of chronicity (SBST clinical change, 75%, P < 0.001) and the EQ-5D-3 L pain- and disability-related components (visual analogue scale (VAS) 73%, P < 0.001; mobility, 77%, P < 0.001; self-care, 79%, P = 0.003; pain/discomfort, 88%, P < 0.001). However, the participants in the intervention group did not perceive an improvement in the performance of their daily tasks (P = 0.103). Additionally, in the nonphysical exercise group, an increase in disability and low back pain episodes was reported at the end of the intervention.

4. DISCUSSION

Based on the results of seven RCTs, exercise has significant benefits in treating musculoskeletal disorders of the lower back, neck and general regions of the body. There was a wide variety of exercise routines performed in the different interventions, with supervised or unsupervised programs, different outcome measures, and the number of participants with musculoskeletal disorders who participated in each study. Diversity has also been found in comparative groups with other exercise interventions and ergonomic advice or control groups without intervention.

There is a lack of consistency in the outcomes, not allowing us to draw firm conclusions regarding the effectiveness of workplace exercise interventions in treating musculoskeletal disorders.

The trials' overall risk of bias was considered high, except for Andersen's,[33] which was the only study that blinded the instructor and the participants. The rest of the RCTs did not provide blinding of their participants or the exercise program's instructors, both being the most important aspects for quality assessment that can affect the internal validity of the results, despite being very complicated to implement in exercise interventions.[40] Regarding external validity, it should be noted that interventions were carried out in the workplace, except for the Nakphet

study,[36] where the office was simulated in a laboratory to carry out a one-day intervention to gather surface myoelectric activity of the targeted muscles. This might be a limitation, as it is essential to carry out interventions on employees' workspaces so that the results can be easily extrapolated to the population that works in an office setting.[41]

More significant efforts should be made when carrying out participant recruitment and designing the intervention procedure, considering essential aspects to reduce biases such as blinding and losses in the follow-up.[42]

As previously mentioned, one remarkable point of the review is the significant difference in the interventions that workers carried out in the different studies. The duration of the studies with physical exercise in clinical and nonclinical populations is commonly between one and three months so that the performance of the intervention and the economic costs would be viable.[40]

The studies reviewed showed no difference between longer or shorter sessions with greater frequency in exercise physiological adaptations regarding exercise volume and weekly frequency; however, further investigation is required to draw firm conclusions. Mainenti[12] showed that physical activity in a more extended session is not associated with decreased sedentarism levels. Therefore, using brief sessions with a high weekly frequency could provide office workers with significant improvements without a prolonged stoppage of their work activity.[43]

Evidence of workplace exercise interventions in the treatment of musculoskeletal disorders

As inclusion criteria of the search, one of the key points was that study interventions should be exclusively at the workplace. It is difficult to determine if the musculoskeletal disorders are work-related or there may be other leading causes. However, even in non-work-related musculoskeletal disorders, the implementation of workplace exercise interventions could help reduce the symptoms that might worsen by prolonged sitting and working without rest breaks in their schedule.

Three studies that evaluated musculoskeletal pain in multiple body regions[33,34,39] concluded that workplace exercise interventions reduced pain compared with the control groups. Rodrigues' systematic review,[44] which also included Marangoni's study,[34] found that regarding the duration of the exercise program, performing strength exercises in the workplace three times a week for 20 minutes could reduce musculoskeletal pain in the different regions of the spine and the upper limbs. Another systematic review[45] focused on video display terminal workers with musculoskeletal pain, using a rehabilitation program with exercises, pain education, and ergonomic adjustments found a significant reduction in pain in different body areas, such as the wrist, shoulder and lower back regions.

Despite the aforementioned systematic review when analysing the best treatment for specific interventions in the neck and shoulder region, Bertozzi's systematic review[46] found a significant overall effect supporting exercise therapies alone on the reduction of pain in the short and intermediate term despite the results of the aforementioned systematic review in which different therapeutic strategies were combined.[45] The two studies analysed in this review that focused on the neck and shoulder region showed benefits in terms of decreasing intensity of pain and associated disability. Nakphet's study[36] concluded that performing a pause in the working hours, either with an exercise intervention or a passive pause, showed a reduction of the perception of pain. In Andersen,[37] with a 10-week intervention, the use of scapular function training with exercise reduced pain intensity in the neck and shoulder region. A former systematic review[20] reported a disparity of results associated with the differences between interventions aimed at treating neck disorders, concluding with strong evidence that interventions with strength and endurance programs were more effective at reducing neck pain.

When focusing on treating lower back pain among office workers, both studies analysed concluded there were positive effects on reducing musculoskeletal pain. There was a disparity between the workplace exercise interventions performed. The del Pozo-Cruz study[35] consisted of a 9-minute daily routine with strength, stretching and mobility exercises in a 9-month intervention, while Kaeding[38] performed 2.5 sessions a week of whole-body vibration training with 10-15-minute sessions during a 3-month intervention. These studies agree with the results indicated by the Sipaviciene study[47] that showed positive effects of performing stabilization exercises for the trunk and of muscle strength exercise program to reduce lower back pain. Additionally, the systematic review by

Gordon[48] concluded that a general exercise programme with strength, flexibility and aerobic training would be beneficial for treating nonspecific, chronic lower back pain in the adult population.

Adherence to the exercise prescribed using compliance terminology was reported in more than 80% of the total interventions performed in three of the seven studies analysed.[35,37,38] There is no standardised definition of adherence to the therapeutic exercise for musculoskeletal pain due to lack of consistency in the literature, finding other synonyms such as compliance or concordance.[49]

A standard definition of therapeutic adherence reported in the studies reviewed by Bissonete, notes that: "Adherence can be defined as the extent to which patients follow the instructions they are given for prescribed treatments".[50] It is essential to consider the therapeutic adherence levels for participants with musculoskeletal pain when reporting the results of clinical trials.[49] Considering that adherence to exercise is ordinarily low,[51,52] strategies to enhance a higher rate of treatment adherence must be considered when designing the intervention procedure. The del Pozo-Cruz web-based intervention used a log-in system with high compliance reported. The implementation of web-based interventions using customized push reminders via e-mail or phone and regularly updating the content, such as Edney's study,[53] is also effective. Additionally, in Gram and collaborators,[54] no differences were found, where both intervention groups improved in terms of decreasing neck pain and headache with or without instructor supervision; as a web-based program with push reminders, it is likely a feasible option for future interventions.

Ambrose's study[55] concludes that any exercise regimen is better than a sedentary lifestyle as long as there is sustainable progression. Additionally, exercise induces analgesia in healthy people due to the pain inhibition mechanism by the reaction of endogenous opioids and nociception inhibitory mechanisms. However, in people with chronic pain, these reactions seem to not occur in the same way, and pain relief requires time after the initial increase in pain has been overcome.[56] In Bravo's study,[57] where therapeutic exercises were performed in fibromyalgia participants, a significant reduction in pain did not appear until 2 weeks after the intervention.

Hence, it is essential to consider specific items at the methodological level and a multidimensional approach[58,59] to carry out interventions with appropriate exercise regimens to achieve a low drop-out rate with high compliance with exercise interventions preferences, self-management and pain neuroscience education for the treatment of musculoskeletal disorders.[60,61]

Study limitations

The present study was limited by the small number of RCTs available that perform workplace exercise interventions to treat musculoskeletal disorders. Only studies published in English and Spanish were analysed. Relevant articles published in other languages could be lost.

The great diversity in the methodological aspects of the different interventions performed in the trials could be a limitation. We found significant heterogeneity in the samples, in the type of interventions and in the period in which the studies' pre/post interventions were carried out. Additionally, heterogeneity was found in the outcomes, which did not allow us to perform a meta-analysis due to the different outcome measures for musculoskeletal disorders and pain used in the studies.

Musculoskeletal conditions are a global concern.[62] More studies are needed to draw firm conclusions related to developed and developing countries where different factors can predict Musculoskeletal disorders in office workers.[63] The studies included in the review are conducted in developed with high income[33–35,37,38] and developing countries with middle-upper income.[36,39] Differences could be found when extrapolating results to low and middle-income countries because the prevalence of musculoskeletal disorders is rising exponentially.[62]

The review only focused on RCTs, excluding studies with interventions without a control group. The control groups' interventions analysed were heterogeneous, with no interventions, while others had other exercise interventions, or ergonomic and health guidelines.

The sample size of participants was low in the majority of the studies[34–38] together with the use of nonvalidated scales,[33,34,36,37] which could be a limitation of the results obtained.

5. CONCLUSIONS

The present systematic review results suggest that workplace exercise interventions can effectively reduce musculoskeletal disorders in different body regions, such as the neck and shoulder, lower back and upper limbs, compared to other groups of ergonomic guidelines or control groups without interventions. However, heterogeneity in the intervention characteristics, the number of participants, outcome measures, and the low methodological quality of the included studies restricted our ability to draw firm conclusions.

Improvement in the quality of studies is required to strengthen the current evidence of workplace exercise interventions in office workers. There were significant differences between the workplace programs, such as the exercises performed, the session length, and the weekly frequency. A consensus is needed to find structured therapeutic exercise programs following a proper methodological assessment that can be optimal for office workers and other similar sedentary professions.

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REFERENCES

1. Ng SW, Popkin BM. Time use and physical activity: a shift away from movement across the globe. Obes Rev 2012;13(8):659–80.
2. Proper KI, Singh AS, van Mechelen W, et al. Sedentary behaviors and health outcomes among adults. Am J Prev Med 2011;40(2):174–82.
3. Tremblay MS, Aubert S, Barnes JD, et al. Sedentary Behavior Research Network (SBRN) - Terminology Consensus Project process and outcome. Int J Behav Nutr Phys Act 2017;14(1):1–17.
4. Rhodes RE, Mark RS, Temmel CP. Adult Sedentary Behavior: A

systematic review. Am J Prev Med 2012;42(3):e3–28.

5. Bull FC, Al-Ansari SS, Biddle S, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. Br J Sports Med 2020;54(24):1451–62.

6. Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet 2012;380(9838):247–57.

7. Chandrasekaran B, Ganesan TB. Sedentarism and chronic disease risk in COVID 19 lockdown – a scoping review. Scott Med J 2021;66(1):3–10.

8. Nilsen TIL, Holtermann A, Mork PJ. Physical exercise, body mass index, and risk of chronic pain in the low back and neck/shoulders: Longitudinal data from the nord-trøndelag health study. Am J Epidemiol 2011;174(3):267–73.

9. Stefansdottir R, Gudmundsdottir SL. Sedentary behavior and musculoskeletal pain: a five-year longitudinal Icelandic study. Public Health 2017;149:71–3.

10. Vos T, Abajobir AA, Abate KH, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. Lancet 2017;390(10100):1211–59.

11. Ryan CG, Dall PM, Granat MH, et al. Sitting patterns at work: objective measurement of adherence to current recommendations. Ergonomics 2011;54(6):531–8.

12. Mainenti MRM, Felicio LR, Rodrigues É de C, et al. Pain, work-related characteristics, and psychosocial factors among computer workers at a university center. J Phys Ther Sci 2014;26(4):567–73.

13. Collins RM, Janse van Rensburg DC, Patricios JS. Common work-related musculoskeletal strains and injuries. South African Fam Pract 2011;53(3):240–6.

14. Kaliniene G, Ustinaviciene R, Skemiene L, et al. Associations between musculoskeletal pain and work-related factors among public service sector computer workers in Kaunas County, Lithuania. BMC Musculoskelet Disord 2016;17(1):1–12.

15. Mahmud N, Bahari SF, Zainudin NF. Psychosocial and ergonomics risk

factors related to neck, shoulder and back complaints among Malaysia office workers. Int J Soc Sci Humanit 2014;4(4):260–3.

16. Sheahan PJ, Diesbourg TL, Fischer SL. The effect of rest break schedule on acute low back pain development in pain and non-pain developers during seated work. Appl Ergon 2016;53:64–70.

17. Gustafsson K, Marklund S. Consequences of sickness presence and sickness absence on health and work ability: A Swedish prospective cohort study. Int J Occup Med Environ Health 2011;24(2):153–65.

18. Parry S, Straker L, Gilson ND, et al. Participatory workplace interventions can reduce sedentary time for office workers—A randomised controlled trial. PLoS One 2013;8(11):e78957.

19. Kett AR, Sichting F. Sedentary behaviour at work increases muscle stiffness of the back: Why roller massage has potential as an active break intervention. Appl Ergon 2020;82:102947.

20. Sihawong R, Janwantanakul P, Sitthipornvorakul E, et al. Exercise therapy for office workers with nonspecific neck pain: A systematic review. J. Manipulative Physiol. Ther.2011;34(1):62–71.

21. Sihawong R, Janwantanakul P, Jiamjarasrangsi W. A prospective, cluster-randomized controlled trial of exercise program to prevent low back pain in office workers. Eur Spine J 2014;23(4):786–93.

22. Ma C, Szeto GP, Yan T, et al. Comparing biofeedback with active exercise and passive treatment for the management of work-related neck and shoulder Pain: A randomized controlled trial. Arch Phys Med Rehabil 2011;92(6):849–58.

23. Joshi V, Bellad A. Effect of yogic exercises on symptoms of musculoskeletal disorders of upper limbs among computer users: A randomised controlled trial. Indian J Med Sci 2011;65(10):424.

24. Phattharasupharerk S, Purepong N, Eksakulkla S, et al. Effects of Qigong practice in office workers with chronic non-specific low back pain: A randomized control trial. J Bodyw Mov Ther 2019;23(2):375–81.

25. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: An updated guideline for reporting systematic reviews. BMJ 2021;372:n71.

26. Tersa-Miralles C, Pastells-Peiró R, Rubí-Carnacea F, et al. Effectiveness

of workplace exercise interventions in the treatment of musculoskeletal disorders in office workers: A protocol of a systematic review. BMJ Open 2020;10(12):1–5.

27. McGowan J, Sampson M, Salzwedel DM, et al. PRESS peer review of electronic search strategies: 2015 guideline statement. J Clin Epidemiol 2016;75:40–6.

28. Covidence. Covidence - Better systematic review management [Internet]. Cochrane2019 [cited 2020 Jan 15];Available from: https://www.covidence.org/home

29. Higgins JPT, Green. Cochrane Handbook for systematic reviews of interventions. Wiley; 2008.

30. Sterne JAC, Savović J, Page MJ, et al. RoB 2: A revised tool for assessing risk of bias in randomised trials. BMJ 2019;366.

31. Popay J, Roberts H, Sowden A, et al. Narrative synthesis in systematic reviews: A product from the ESRC methods programme. ESRC Methods Program 2006;(2006):93.

32. Campbell M, McKenzie JE, Sowden A, et al. Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline. BMJ 2020;368:l6890.

33. Andersen LL, Christensen KB, Holtermann A, et al. Effect of physical exercise interventions on musculoskeletal pain in all body regions among office workers: A one-year randomized controlled trial. Man Ther 2010;15(1):100–4.

34. Marangoni AH. Effects of intermittent stretching exercises at work on musculoskeletal pain associated with the use of a personal computer and the influence of media on outcomes. Work 2010;36(1):27–37.

35. del Pozo-Cruz B, Gusi N, del Pozo-Cruz J, et al. Clinical effects of a nine-month web-based intervention in subacute non-specific low back pain patients: a randomized controlled trial. Clin Rehabil 2013;27(1):28–39.

36. Nakphet N, Chaikumarn M, Janwantanakul P. Effect of different types of rest-break interventions on neck and shoulder muscle activity, perceived discomfort and productivity in symptomatic VDU operators: A randomized controlled trial. Int J Occup Saf Ergon 2014;20(2):339–53.

37. Andersen CH, Andersen LL, Zebis MK, et al. Effect of scapular function

training on chronic pain in the neck/shoulder region: A randomized controlled trial. J Occup Rehabil 2014;24(2):316–24.

38. Kaeding TS, Karch A, Schwarz R, et al. Whole-body vibration training as a workplace-based sports activity for employees with chronic low-back pain. Scand J Med Sci Sport 2017;27(12):2027–39.

39. Shariat A, Cleland JA, Danaee M, et al. Effects of stretching exercise training and ergonomic modifications on musculoskeletal discomforts of office workers: A randomized controlled trial. Brazilian J Phys Ther 2018;22(2):144–53.

40. Hecksteden A, Faude O, Meyer T, et al. How to construct, conduct and analyze an exercise training study? Front. Physiol.2018;9(JUL).

41. Hoffmann TC, Maher CG, Briffa T, et al. Prescribing exercise interventions for patients with chronic conditions. Can Med Assoc J 2016;188(7):510–8.

42. Falagas ME, Grigori T, Ioannidou E. A systematic review of trends in the methodological quality of randomized controlled trials in various research fields. J Clin Epidemiol 2009;62(3):227-231.e9.

43. Ting J, Chen X, Johnston V. Workplace-based exercise intervention improves work ability in office workers: A cluster randomised controlled trial. Int J Environ Res Public Health 2019;16(15):2633.

44. Rodrigues EV, Gomes ARS, Tanhoffer AIP, et al. Effects of exercise on pain of musculoskeletal disorders: A systematic review. Acta Ortopédica Bras 2014;22(6):334–8.

45. Lee DH, Kang B, Choi S, et al. Change in musculoskeletal pain in patients with work-related musculoskeletal disorder after tailored rehabilitation education: A one-year follow-up survey. Ann Rehabil Med 2015;39(5):726.

46. Bertozzi L, Gardenghi I, Turoni F, et al. Effect of therapeutic exercise on pain and disability in the management of chronic nonspecific neck pain: Systematic review and meta-analysis of randomized trials. Phys Ther 2013;93(8):1026–36.

47. Sipaviciene S, Kliziene I. Effect of different exercise programs on non-specific chronic low back pain and disability in people who perform sedentary work. Clin Biomech 2020;73:17–27.

48. Gordon R, Bloxham S. A systematic review of the effects of exercise and physical activity on non-specific chronic low back pain. Healthcare 2016;4(2):22.
49. Bailey DL, Holden MA, Foster NE, et al. Defining adherence to therapeutic exercise for musculoskeletal pain: A systematic review. Br J Sports Med 2020;54(6):326–31.
50. Bissonnette JM. Adherence: A concept analysis. J Adv Nurs 2008;63(6):634–43.
51. Crandall S, Howlett S, Keysor JJ. Exercise adherence interventions for adults with chronic musculoskeletal pain. Phys Ther 2013;93(1):17–21.
52. Nielsen G, Wikman JM, Jensen CJ, et al. Health promotion: The impact of beliefs of health benefits, social relations and enjoyment on exercise continuation. Scand J Med Sci Sport 2014;24(SUPPL.1):66–75.
53. Edney S, Ryan JC, Olds T, et al. User engagement and attrition in an app-based physical activity intervention: Secondary analysis of a randomized controlled trial. J Med Internet Res 2019;21(11):e14645.
54. Gram B, Andersen C, Zebis MK, et al. Effect of training supervision on effectiveness of strength training for reducing neck/shoulder pain and headache in office workers: Cluster randomized controlled trial. Biomed Res Int 2014;2014:1–9.
55. Ambrose KR, Golightly YM. Physical exercise as non-pharmacological treatment of chronic pain: Why and when. Best Pract Res Clin Rheumatol 2015;29(1):120–30.
56. Nijs J, Kosek E, Van Oosterwijck J, et al. Dysfunctional endogenous analgesia during exercise in patients with chronic pain: To exercise or not to exercise? Pain Physician 2012;15(3 Suppl):ES205-13.
57. Bravo C, Skjaerven LH, Espart A, et al. Basic Body Awareness Therapy in patients suffering from fibromyalgia: A randomized clinical trial. Physiother Theory Pract 2019;35(10):919–29.
58. McPhail S, Schippers M, Marshall A, et al. Perceived barriers and facilitators to increasing physical activity among people with musculoskeletal disorders: a qualitative investigation to inform intervention development. Clin Interv Aging 2014;9:2113.
59. Meade LB, Bearne LM, Godfrey EL. "It's important to buy in to the new

lifestyle": barriers and facilitators of exercise adherence in a population with persistent musculoskeletal pain. Disabil Rehabil 2021;43(4):468–78.

60. Devan H, Hale L, Hempel D, et al. What works and does not work in a self-management intervention for people with chronic pain? Qualitative systematic review and meta-synthesis. Phys Ther 2018;98(5):381–97.

61. Louw A, Zimney K, Puentedura EJ, et al. The efficacy of pain neuroscience education on musculoskeletal pain: A systematic review of the literature. Physiother Theory Pract 2016;32(5):332–55.

62. Blyth FM, Briggs AM, Schneider CH, et al. The global burden of musculoskeletal pain—Where to from here? Am J Public Health 2019;109(1):35–40.

63. Maakip I, Keegel T, Oakman J. Prevalence and predictors for musculoskeletal discomfort in Malaysian office workers: Investigating explanatory factors for a developing country. Appl Ergon 2016;53(March):252–7.

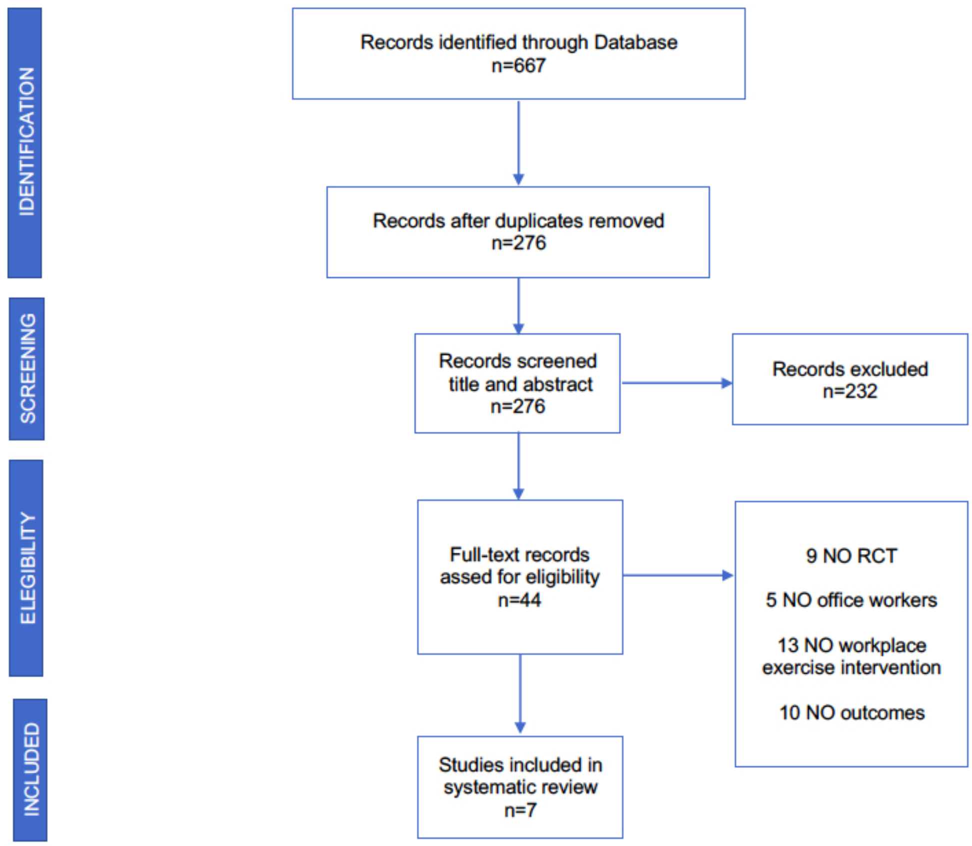

Figure 1. Flow diagram of trial selection, adapted from PRISMA

256x225mm (72 x 72 DPI)

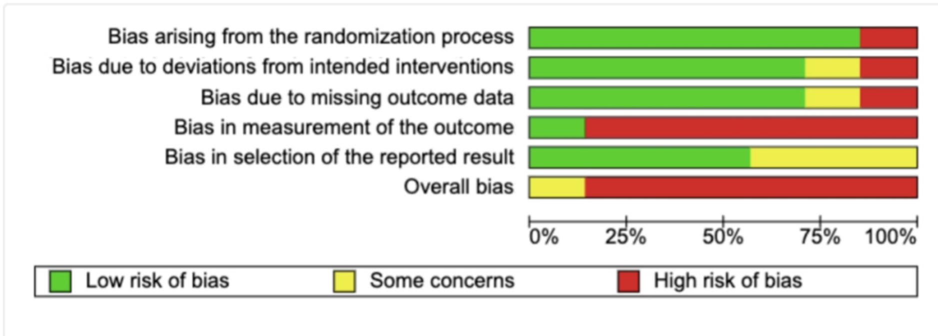

Figure 2. Risk of bias graph: review authors' judgements about risk of bias items presented as percentages across the included RCTs.

157x88mm (220 x 220 DPI)

Figure 3: Risk of bias summary: review authors' judgements about each risk of bias item for each included study. In green (Low risk), yellow (Some concerns) and red (High risk).

83x143mm (220 x 220 DPI)

Supplementary File 1. Full search strategy

Database	Search terms
Pubmed	1. ("Office Work"[tiab] OR "Office Worker"[tiab] OR "Office Workers"[tiab] OR "Desk Worker"[tiab] OR "Desk Workers"[tiab] OR "Computer Work"[tiab] OR "Computer Workers"[tiab] OR "Nonmanual Workers"[tiab] OR "Administrative Personnel"[MeSH] OR "Administrative Personnel"[tiab] OR "sedentary workers"[tiab] OR "sedentary personnel"[tiab] OR "sedentary employees"[tiab] OR "Work Performance"[MeSH] OR "Work Performance"[tiab] OR "Work Performances"[MeSH] OR "Work Performances"[tiab] OR "Job Performance"[MeSH] OR "Job Performance"[tiab] OR "Job Performances"[MeSH] OR "Job Performances"[tiab] OR "Occupational Diseases"[Mesh] OR "Occupational Disease*"[tiab] OR "Occupational Illness*"[tiab] OR "Administrative Personnel"[MeSH] OR "Administrative Personnel"[tiab] OR "White Collar Worker"[tiab] OR "Administrative Worker"[tiab] OR "Corporate Workers"[tiab] OR "Video Display terminal workers"[tiab] OR "Video Display Visual operators"[tiab] OR "Clerical workers"[tiab]) 2. ("Musculoskeletal Illness"[MeSH] OR "Musculoskeletal Illness"[tiab] OR "Musculoskeletal Pain"[MeSH] OR "Musculoskeletal Pain"[tiab] OR "Musculoskeletal Pain"[MeSH] OR "Musculoskeletal Pain"[tiab] OR "Musculoskeletal Disease"[MeSH] OR "Musculoskeletal Disease"[tiab] OR "Musculoskeletal Diseases"[MeSH] OR "Musculoskeletal Diseases"[tiab] OR "Musculoskeletal Disorder"[tiab] OR "Musculoskeletal Disorders"[tiab] OR "Musculoskeletal Disfunction"[tiab] OR "Musculoskeletal Disfunctions"[tiab] OR "Low back pain"[MeSH] OR "Low back pain"[tiab] OR "Low back pains"[tiab] OR "Lumbago"[tiab] OR "Lower Back Pain"[tiab] OR "Lower Back pains"[tiab] OR "Low Back Ache"[tiab] OR "Low Back Aches"[tiab] OR "Low Backache"[tiab] OR "Low Backaches"[tiab] OR "Postural Low back pain"[tiab] OR "Posterior Compartment Low back pain"[tiab] OR "Recurrent Low back pain"[tiab] OR "Mechanical Low back pain"[tiab] OR "Neck pain"[MeSH] OR "Neck pain"[tiab] OR "Neck pains"[tiab] OR "Neck Ache"[tiab] OR "NeckAches"[tiab] OR "Cervicalgia"[tiab] OR "Cervicalgias"[tiab] OR "Cervicodynia"[tiab] OR "Cervicodynias"[tiab] OR "Cervical Pain"[tiab] OR "Cervical Pains"[tiab] OR "Posterior Cervical Pain"[tiab] OR "Posterior Cervical Pains"[tiab] OR "Posterior Neck Pain"[tiab] OR "Posterior Neck Pains"[tiab] OR "Anterior Cervical Pain"[tiab] OR "Anterior Cervical Pains"[tiab] OR "Posterior Neck Pain"[tiab] OR "Posterior Neck Pains"[tiab] OR "Shoulder pain"[MeSH] OR "Shoulder pain"[tiab] OR "Shoulder pains"[tiab]) 3. ("Exercise movement Therapy"[MeSH] OR "Exercise movement Therapy"[tiab] OR "Exercise Therapy"[MeSH] OR "Exercise Therapy"[tiab] OR "Circuit Based Exercise"[MeSH] "Circuit Based Exercise"[tiab] OR "Stretching Exercise"[MeSH] OR "Stretching Exercise"[tiab] OR Yoga[MeSH] OR Yoga[tiab] OR "Pilates Training"[tiab] OR "Active Rest"[tiab] OR "Active Rests"[tiab] OR "Active Pause"[tiab] OR "Active Pauses"[tiab] OR "Active Break"[tiab] OR "Active Breaks"[tiab] OR "Exercise Therapies"[tiab] OR "Remedial Exercise"[tiab] OR "Remedial Exercises"[tiab] OR "Rehabilitation Exercise"[tiab] OR "Rehabilitation Exercises"[tiab] OR "Incidental Physical activity"[tiab] OR "Standing breaks"[tiab] OR "Stretching breaks"[tiab] OR "Mobility exercise"[tiab] OR "Workplace exercise intervention"[tiab]) 4. 1 AND 2 AND 3 - Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only
CINHAL	1. TI (("Musculoskeletal Illness" OR "Musculoskeletal Pain" OR "Musculoskeletal Pain" OR "Musculoskeletal Disease" OR "Musculoskeletal Diseases" OR "Musculoskeletal Disorder" OR "Musculoskeletal Disorders" OR "Musculoskeletal Disfunction" OR "Musculoskeletal Disfunctions" OR "Low back pain" OR "Low back pains" OR "Lumbago" OR "Lower Back Pain" OR "Lower Back pains" OR "Low Back Ache" OR "Low Back Aches" OR "Low Backache" OR "Low Backaches" OR "Postural Low back pain" OR "Posterior Compartment Low back pain" OR "Recurrent Low back pain" OR "Mechanical Low back pain" OR "Neck pain" OR "Neck pains" OR "Neck Ache" OR "NeckAches" OR "Cervicalgia" OR "Cervicalgias" OR "Cervicodynia" OR "Cervicodynias" OR "Cervical Pain" OR "Cervical Pains" OR "Posterior Cervical Pain" OR "Posterior Cervical Pains" OR "Posterior Neck Pain" OR "Posterior Neck Pains" OR "Anterior Cervical Pain" OR "Anterior

	Cervical Pains" OR "Posterior Neck Pain" OR "Posterior Neck Pains" OR "Shoulder pain" OR "Shoulder pain" OR "Shoulder pains")) 2. AB ((Musculoskeletal Illness" OR "Musculoskeletal Pain" OR "Musculoskeletal Pain" OR "Musculoskeletal Disease" OR "Musculoskeletal Diseases" OR "Musculoskeletal Disorder" OR "Musculoskeletal Disorders" OR "Musculoskeletal Disfunction" OR "Musculoskeletal Disfunctions" OR "Low back pain" OR "Low back pains" OR "Lumbago" OR "Lower Back Pain" OR "Lower Back pains" OR "Low Back Ache" OR "Low Back Aches" OR "Low Backache" OR "Low Backaches" OR "Postural Low back pain" OR "Posterior Compartment Low back pain" OR "Recurrent Low back pain" OR "Mechanical Low back pain" OR "Neck pain" OR "Neck pains" OR "Neck Ache" OR "NeckAches" OR "Cervicalgia" OR "Cervicalgias" OR "Cervicodynia" OR "Cervicodynias" OR "Cervical Pain" OR "Cervical Pains" OR "Posterior Cervical Pain" OR "Posterior Cervical Pains" OR "Posterior Neck Pain" OR "Posterior Neck Pains" OR "Anterior Cervical Pain" OR "Anterior Cervical Pains" OR "Posterior Neck Pain" OR "Posterior Neck Pains" OR "Shoulder pain" OR "Shoulder pain" OR "Shoulder pains")) 3. TI (("Office Work" OR "Office Worker" OR "Office Workers" OR "Desk Worker" OR "Desk Workers" OR "Computer Work" OR "Computer Workers" OR "Nonmanual Workers" OR "Administrative Personnel" OR "sedentary workers" OR "sedentary personnel" OR "sedentary employees" OR "Work Performance" OR "Work Performances" OR "Job Performance" OR "Job Performances" OR "Occupational Diseases" OR "Occupational Disease*" OR "Occupational Illness*" OR "Administrative Personnel" OR "White Collar Worker" OR "Administrative Worker" OR "Corporate Workers" OR "Video Display terminal workers" OR "Video Display Visual operators" OR "Clerical workers")) 4. AB (("Office Work" OR "Office Worker" OR "Office Workers" OR "Desk Worker" OR "Desk Workers" OR "Computer Work" OR "Computer Workers" OR "Nonmanual Workers" OR "Administrative Personnel" OR "sedentary workers" OR "sedentary personnel" OR "sedentary employees" OR "Work Performance" OR "Work Performances" OR "Job Performance" OR "Job Performances" OR "Occupational Diseases" OR "Occupational Disease*" OR "Occupational Illness*" OR "Administrative Personnel" OR "White Collar Worker" OR "Administrative Worker" OR "Corporate Workers" OR "Video Display terminal workers" OR "Video Display Visual operators" OR "Clerical workers")) 5. TI (("Exercise Movement Therapy" OR "Exercise Therapy" OR "Circuit Based Exercise" OR "Stretching Exercise" OR Yoga OR "Pilates Training" OR "Active Rest" OR "Active Rests" OR "Active Pause" OR "Active Pauses" OR "Active Break" OR "Active Breaks" OR "Exercise Therapies" OR "Remedial Exercise" OR "Remedial Exercises" OR "Rehabilitation Exercise" OR "Rehabilitation Exercises" OR "Incidental Physical Activity" OR "Standing Breaks" OR "Stretching Breaks" OR "Mobility Exercise" OR "Workplace Exercise Intervention")) 6. AB (("Exercise Movement Therapy" OR "Exercise Therapy" OR "Circuit Based Exercise" OR "Stretching Exercise" OR Yoga OR "Pilates Training" OR "Active Rest" OR "Active Rests" OR "Active Pause" OR "Active Pauses" OR "Active Break" OR "Active Breaks" OR "Exercise Therapies" OR "Remedial Exercise" OR "Remedial Exercises" OR "Rehabilitation Exercise" OR "Rehabilitation Exercises" OR "Incidental Physical Activity" OR "Standing Breaks" OR "Stretching Breaks" OR "Mobility Exercise" OR "Workplace Exercise Intervention")) 7. 1 OR 2 AND 3 OR 4 AND 5 OR 6 - Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only
Cochrane	1. (("Musculoskeletal Illness" OR "Musculoskeletal Pain" OR "Musculoskeletal Pain" OR "Musculoskeletal Disease" OR "Musculoskeletal Diseases" OR "Musculoskeletal Disorder" OR "Musculoskeletal Disorders" OR "Musculoskeletal Disfunction" OR "Musculoskeletal Disfunctions" OR "Low back pain" OR "Low back pains" OR "Lumbago" OR "Lower Back Pain" OR "Lower Back pains" OR "Low Back Ache" OR "Low Back Aches" OR "Low Backache" OR "Low Backaches" OR "Postural Low back pain" OR "Posterior Compartment Low back pain" OR "Recurrent Low back pain" OR "Mechanical Low back pain" OR "Neck pain" OR "Neck pains" OR "Neck Ache" OR "NeckAches" OR "Cervicalgia" OR "Cervicalgias" OR "Cervicodynia" OR "Cervicodynias" OR "Cervical Pain" OR "Cervical Pains" OR "Posterior Cervical Pain" OR "Posterior Cervical Pains" OR "Posterior Neck Pain" OR "Posterior Neck Pains" OR "Anterior Cervical Pain" OR "Anterior

	Cervical Pains” OR “Posterior Neck Pain” OR “Posterior Neck Pains” OR “Shoulder pain” OR “Shoulder pain” OR “Shoulder pains”)):ti,ab,kw 2. ((“Office Work” OR “Office Worker” OR “Office Workers” OR “Desk Worker” OR “Desk Workers” OR “Computer Work” OR “Computer Workers” OR “Nonmanual Workers” OR “Administrative Personnel” OR “sedentary workers” OR “sedentary personnel” OR “sedentary employees” OR “Work Performance” OR “Work Performances” OR “Job Performance” OR “Job Performances” OR "Occupational Diseases" OR "Occupational Disease*" OR "Occupational Illness*" OR “Administrative Personnel” OR “White Collar Worker” OR “Administrative Worker” OR “Corporate Workers” OR “Video Display terminal workers” OR “Video Display Visual operators” OR “Clerical wokers”)):ti,ab,kw 3. ((“Exercise movement Therapy” OR “Exercise Therapy” OR “Circuit Based Exercise” OR “Stretching Exercise” OR Yoga OR “Pilates Training” OR “Active Rest” OR “Active Rests” OR “Active Pause” OR “Active Pauses” OR “Active Break” OR “Active Breaks” OR “Exercise Therapies” OR “Remedial Exercise” OR “Remedial Exercises” OR “Rehabilitation Exercise” OR “Rehabilitation Exercises” OR “Incidental Physical Activity” OR “Standing Breaks” OR “Stretching Breaks” OR “Mobility Exercise” OR “Workplace Exercise Intervention”)):ti,ab,kw 4. 1 AND 2 AND 3 - Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only
Scopus	1. TITLE-ABS-KEY (“Musculoskeletal Illness” OR “Musculoskeletal Pain” OR “Musculoskeletal Pain” OR “Musculoskeletal Disease” OR “Musculoskeletal Diseases” OR “Musculoskeletal Disorder” OR “Musculoskeletal Disorders” OR “Musculoskeletal Disfunction” OR “Musculoskeletal Disfunctions” OR “Low back pain” OR “Low back pains” OR “Lumbago” OR “Lower Back Pain” OR “Lower Back pains” OR “Low Back Ache” OR “Low Back Aches” OR “Low Backache” OR “Low Backaches” OR “Postural Low back pain” OR “Posterior Compartment Low back pain” OR “Recurrent Low back pain” OR “Mechanical Low back pain” OR “Neck pain” OR “Neck pains” OR “Neck Ache” OR “NeckAches” OR “Cervicalgia” OR “Cervicalgias” OR “Cervicodynia” OR “Cervicodynias” OR “Cervical Pain” OR “Cervical Pains” OR “Posterior Cervical Pain” OR “Posterior Cervical Pains” OR “Posterior Neck Pain” OR “Posterior Neck Pains” OR “Anterior Cervical Pain” OR “Anterior Cervical Pains” OR “Posterior Neck Pain” OR “Posterior Neck Pains” OR “Shoulder pain” OR “Shoulder pain” OR “Shoulder pains”) 2. TITLE-ABS-KEY(“Office Work” OR “Office Worker” OR “Office Workers” OR “Desk Worker” OR “Desk Workers” OR “Computer Work” OR “Computer Workers” OR “Nonmanual Workers” OR “Administrative Personnel” OR “sedentary workers” OR “sedentary personnel” OR “sedentary employees” OR “Work Performance” OR “Work Performances” OR “Job Performance” OR “Job Performances” OR "Occupational Diseases" OR "Occupational Disease*" OR "Occupational Illness*" OR “Administrative Personnel” OR “White Collar Worker” OR “Administrative Worker” OR “Corporate Workers” OR “Video Display terminal workers” OR “Video Display Visual operators” OR “Clerical workers”) 3. TITLE-ABS-KEY(“Exercise movement Therapy” OR “Exercise Therapy” OR “Circuit Based Exercise” OR “Stretching Exercise” OR Yoga OR “Pilates Training” OR “Active Rest” OR “Active Rests” OR “Active Pause” OR “Active Pauses” OR “Active Break” OR “Active Breaks” OR “Exercise Therapies” OR “Remedial Exercise” OR “Remedial Exercises” OR “Rehabilitation Exercise” OR “Rehabilitation Exercises” OR “Incidental Physical activity” OR “Standing breaks” OR “Stretching breaks” OR “Mobility exercise” OR “Workplace exercise intervention”) 4. 1 AND 2 AND 3 - Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only
ISI WoS	1. (Musculoskeletal Illness OR Musculoskeletal Pain OR Musculoskeletal Pain OR Musculoskeletal Disease OR Musculoskeletal Diseases OR Musculoskeletal Disorder OR Musculoskeletal Disorders OR Musculoskeletal Disfunction OR Musculoskeletal Disfunctions OR Low back pain OR Low back pains OR Lumbago OR Lower Back Pain OR Lower Back pains OR Low Back Ache OR Low Back Aches OR Low Backache OR Low Backaches OR Postural Low back pain OR Posterior Compartment Low back pain OR

	Recurrent Low back pain OR Mechanical Low back pain OR Neck pain OR Neck pains OR Neck Ache OR NeckAches OR Cervicalgia OR Cervicalgias OR Cervicodynia OR Cervicodynias OR Cervical Pain OR Cervical Pains OR Posterior Cervical Pain OR Posterior Cervical Pains OR Posterior Neck Pain OR Posterior Neck Pains OR Anterior Cervical Pain OR Anterior Cervical Pains OR Posterior Neck Pain OR Posterior Neck Pains OR Shoulder pain OR Shoulder pain OR Shoulder pains) 2. (Office Work OR Office Worker OR Office Workers OR Desk Worker OR Desk Workers OR Computer Work OR Computer Workers OR Nonmanual Workers OR Administrative Personnel OR Sedentary workers OR Sedentary personnel OR Sedentary employees OR Work Performance OR Work Performances OR Job Performance OR Job Performances OR Occupational Disease* OR Occupational Illness* OR Administrative Personnel OR White Collar Worker OR Administrative Worker OR Corporate Workers OR Video Display terminal workers OR Video Display Visual operators OR Clerical workers) 3. (Exercise movement Therapy OR Exercise Therapy OR Circuit Based Exercise OR Stretching Exercise OR Yoga OR Pilates Training OR Active Rest OR Active Rests OR Active Pause OR Active Pauses OR Active Break OR Active Breaks OR Exercise Therapies OR Remedial Exercise OR Remedial Exercises OR Rehabilitation Exercise OR Rehabilitation Exercises OR Incidental Physical activity OR Standing Breaks OR Stretching Breaks OR Mobility Exercise OR Workplace Exercise Intervention) 4. 1 AND 2 AND 3 AND - Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only
PeDRO	A simple search of the different terms and their synonyms: 1. Musculoskeletal Disorders 2. Office workers 3. Exercise Therapy

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
TITLE			
Title	1	Identify the report as a systematic review.	1
ABSTRACT			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of existing knowledge.	3-5
Objectives	4	Provide an explicit statement of the objective(s) or question(s) the review addresses.	5
METHODS			
Eligibility criteria	5	Specify the inclusion and exclusion criteria for the review and how studies were grouped for the syntheses.	6
Information sources	6	Specify all databases, registers, websites, organisations, reference lists and other sources searched or consulted to identify studies. Specify the date when each source was last searched or consulted.	6
Search strategy	7	Present the full search strategies for all databases, registers and websites, including any filters and limits used.	Supplementary File 1
Selection process	8	Specify the methods used to decide whether a study met the inclusion criteria of the review, including how many reviewers screened each record and each report retrieved, whether they worked independently, and if applicable, details of automation tools used in the process.	6
Data collection process	9	Specify the methods used to collect data from reports, including how many reviewers collected data from each report, whether they worked independently, any processes for obtaining or confirming data from study investigators, and if applicable, details of automation tools used in the process.	7
Data items	10a	List and define all outcomes for which data were sought. Specify whether all results that were compatible with each outcome domain in each study were sought (e.g. for all measures, time points, analyses), and if not, the methods used to decide which results to collect.	Protocol
	10b	List and define all other variables for which data were sought (e.g. participant and intervention characteristics, funding sources). Describe any assumptions made about any missing or unclear information.	Protocol
Study risk of bias assessment	11	Specify the methods used to assess risk of bias in the included studies, including details of the tool(s) used, how many reviewers assessed each study and whether they worked independently, and if applicable, details of automation tools used in the process.	7
Effect measures	12	Specify for each outcome the effect measure(s) (e.g. risk ratio, mean difference) used in the synthesis or presentation of results.	Table 1
Synthesis methods	13a	Describe the processes used to decide which studies were eligible for each synthesis (e.g. tabulating the study intervention characteristics and comparing against the planned groups for each synthesis (item #5)).	
	13b	Describe any methods required to prepare the data for presentation or synthesis, such as handling of missing summary statistics, or data conversions.	
	13c	Describe any methods used to tabulate or visually display results of individual studies and syntheses.	8
	13d	Describe any methods used to synthesize results and provide a rationale for the choice(s). If meta-analysis was performed, describe the model(s), method(s) to identify the presence and extent of statistical heterogeneity, and software package(s) used.	7
	13e	Describe any methods used to explore possible causes of heterogeneity among study results (e.g. subgroup analysis, meta-regression).	7
	13f	Describe any sensitivity analyses conducted to assess robustness of the synthesized results.	
Reporting bias assessment	14	Describe any methods used to assess risk of bias due to missing results in a synthesis (arising from reporting biases).	

PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
Certainty assessment	15	Describe any methods used to assess certainty (or confidence) in the body of evidence for an outcome.	
RESULTS			
Study selection	16a	Describe the results of the search and selection process, from the number of records identified in the search to the number of studies included in the review, ideally using a flow diagram.	Figure 1
	16b	Cite studies that might appear to meet the inclusion criteria, but which were excluded, and explain why they were excluded.	
Study characteristics	17	Cite each included study and present its characteristics.	8
Risk of bias in studies	18	Present assessments of risk of bias for each included study.	13-14
Results of individual studies	19	For all outcomes, present, for each study: (a) summary statistics for each group (where appropriate) and (b) an effect estimate and its precision (e.g. confidence/credible interval), ideally using structured tables or plots.	Table 1
Results of syntheses	20a	For each synthesis, briefly summarise the characteristics and risk of bias among contributing studies.	13-17
	20b	Present results of all statistical syntheses conducted. If meta-analysis was done, present for each the summary estimate and its precision (e.g. confidence/credible interval) and measures of statistical heterogeneity. If comparing groups, describe the direction of the effect.	13-17
	20c	Present results of all investigations of possible causes of heterogeneity among study results.	13-17
	20d	Present results of all sensitivity analyses conducted to assess the robustness of the synthesized results.	
Reporting biases	21	Present assessments of risk of bias due to missing results (arising from reporting biases) for each synthesis assessed.	
Certainty of evidence	22	Present assessments of certainty (or confidence) in the body of evidence for each outcome assessed.	
DISCUSSION			
Discussion	23a	Provide a general interpretation of the results in the context of other evidence.	17
	23b	Discuss any limitations of the evidence included in the review.	21
	23c	Discuss any limitations of the review processes used.	21
	23d	Discuss implications of the results for practice, policy, and future research.	21
OTHER INFORMATION			
Registration and protocol	24a	Provide registration information for the review, including register name and registration number, or state that the review was not registered.	2
	24b	Indicate where the review protocol can be accessed, or state that a protocol was not prepared.	6
	24c	Describe and explain any amendments to information provided at registration or in the protocol.	
Support	25	Describe sources of financial or non-financial support for the review, and the role of the funders or sponsors in the review.	22
Competing interests	26	Declare any competing interests of review authors.	22
Availability of data, code and other materials	27	Report which of the following are publicly available and where they can be found: template data collection forms; data extracted from included studies; data used for all analyses; analytic code; any other materials used in the review.	

PRISMA 2020 Checklist

From: Page MJ, McKenzie JE, Bossuyt PM, Boutron I, Hoffmann TC, Mulrow CD, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021;372:n71. doi: 10.1136/bmj.n71
For more information, visit: http://www.prisma-statement.org/

Synthesis Without Meta-analysis (SWiM) reporting items

The citation for the Synthesis Without Meta-analysis explanation and elaboration article is: Campbell M, McKenzie JE, Sowden A, Katikireddi SV, Brennan SE, Ellis S, Hartmann-Boyce J, Ryan R, Shepperd S, Thomas J, Welch V, Thomson H. Synthesis without meta-analysis (SWiM) in systematic reviews: reporting guideline BMJ 2020;368:l6890 http://dx.doi.org/10.1136/bmj.l6890

SWiM is intended to complement and be used as an extension to PRISMA			
SWiM reporting item	**Item description**	**Page in manuscript where item is reported**	**Other***
Methods			
1 Grouping studies for synthesis	1a) Provide a description of, and rationale for, the groups used in the synthesis (e.g., groupings of populations, interventions, outcomes, study design)	7	
	1b) Detail and provide rationale for any changes made subsequent to the protocol in the groups used in the synthesis		
2 Describe the standardised metric and transformation methods used	Describe the standardised metric for each outcome. Explain why the metric(s) was chosen, and describe any methods used to transform the intervention effects, as reported in the study, to the standardised metric, citing any methodological guidance consulted.	7	
3 Describe the synthesis methods	Describe and justify the methods used to synthesise the effects for each outcome when it was not possible to undertake a meta-analysis of effect estimates.	7	
4 Criteria used to prioritise results for summary and synthesis	Where applicable, provide the criteria used, with supporting justification, to select the particular studies, or a particular study, for the main synthesis or to draw conclusions from the synthesis (e.g., based on study design, risk of bias assessments, directness in relation to the review question)	7	

Synthesis Without Meta-analysis (SWiM) reporting items

SWiM reporting item	Item description	Page in manuscript where item is reported	Other*
5 Investigation of heterogeneity in reported effects	State the method(s) used to examine heterogeneity in reported effects when it was not possible to undertake a meta-analysis of effect estimates and its extensions to investigate heterogeneity	7-8	
6 Certainty of evidence	Describe the methods used to assess certainty of the synthesis findings	7	
7 Data presentation methods	Describe the graphical and tabular methods used to present the effects (e.g., tables, forest plots, harvest plots). Specify key study characteristics (e.g., study design, risk of bias) used to order the studies, in the text and any tables or graphs, clearly referencing the studies included	8	
Results			
8 Reporting results	For each comparison and outcome, provide a description of the synthesised findings, and the certainty of the findings. Describe the result in language that is consistent with the question the synthesis addresses, and indicate which studies contribute to the synthesis	8-17	
Discussion			
9 Limitations of the synthesis	Report the limitations of the synthesis methods used and/or the groupings used in the synthesis, and how these affect the conclusions that can be drawn in relation to the original review question	21	

PRISMA=Preferred Reporting Items for Systematic Reviews and Meta-Analyses.
*If the information is not provided in the systematic review, give details of where this information is available (e.g., protocol, other published papers (provide citation details), or website (provide the URL)).