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# BMJ Open

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

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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
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3 **The effectiveness of workplace exercise interventions in the treatment of**  
4 **musculoskeletal disorders in office workers. A systematic review.**  
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8 Carlos Tersa-Miralles<sup>1</sup>, Cristina Bravo<sup>1,2,4</sup>, Filip Bellon<sup>1,2</sup>, Roland Pastells-  
9 Peiró<sup>1,2</sup>, Esther Rubinat Arnaldo<sup>1,2,3,4</sup>, Francesc Rubí-Carnacea<sup>1,2,4</sup>.  
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11

12  
13 **E-mail Addresses** Carlos Tersa-Miralles; [carles.tersa@udl.cat](mailto:carles.tersa@udl.cat) Cristina Bravo;  
14 [cristina.bravo@udl.cat](mailto:cristina.bravo@udl.cat) Filip Bellon; [filip.bellon@udl.cat](mailto:filip.bellon@udl.cat) Roland Pastells-Peiró;  
15 [roland.pastells@udl.cat](mailto:roland.pastells@udl.cat) Esther Rubinat-Arnaldo; [esther.rubinat@udl.cat](mailto:esther.rubinat@udl.cat)  
16 Francesc Rubí-Carnacea; [francesc.rubi@udl.cat](mailto:francesc.rubi@udl.cat).  
17  
18  
19  
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22 **Affiliations**  
23  
24

- 25 1- Department of Nursing and Physiotherapy, University of Lleida, Lleida, Spain.  
26 2- Health Care Research Group, GRECS, Biomedical Research Institute of Lleida,  
27 Lleida, Spain.  
28 3- Center for Biomedical Research on Diabetes and Associated Metabolic  
29 Diseases, Health institute Carlos III, Barcelona, Spain.  
30 4- Group on Society Studies, Health, Education and Culture, University of Lleida,  
31 Lleida, Spain.  
32  
33  
34  
35  
36  
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39

40 **Correspondence to** Esther Rubinat Arnaldo; Carrer de Montserrat Roig, 2,  
41 25198 Lleida, Espanya; [esther.rubinat@udl.cat](mailto:esther.rubinat@udl.cat); +34 [973 70 24 43](tel:+34973702443).  
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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.<sup>[1,2]</sup> Sedentarism is a significant health issue; there is a strong association between sitting time and all-cause mortality.<sup>[3]</sup> 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.<sup>[4]</sup>

It is important to remark that sedentary behaviour is not the opposite of moderate to vigorous physical activity.<sup>[5]</sup> 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.<sup>[6,7]</sup> The average daily time spent in a seated position by the adult population is 346 minutes per day.<sup>[8]</sup> American and eastern Mediterranean countries have higher

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3 proportions of the population in physical inactivity, near half of their adult  
4 population (43%); the worldwide average is lower but still surpasses 30%.<sup>[9]</sup>  
5 Moreover, these numbers may be worse due to COVID-19, where home  
6 confinement and mobility restrictions are necessary to reduce the spread of the  
7 virus, increasing sedentary behaviour.<sup>[4]</sup>  
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12 Jobs that do not require physical activity, such as office workers, are traditionally  
13 considered a "low-risk" occupation in health outcomes. However, the overall  
14 accumulated sitting time at work may increase cardiovascular disease risk<sup>[10]</sup>  
15 and mental disorders.<sup>[11]</sup> Because the office workplace is an unfavourable  
16 environment in terms of high sedentary behaviour,<sup>[12]</sup> daily exercise is crucial to  
17 prevent pathologies caused by the lack of movement and poor posture while  
18 spending most of the workday in front of the computer.<sup>[13,14]</sup> Additionally, those  
19 who work overtime, without flexibility in schedules, perform demanding and  
20 decision-making tasks have a higher prevalence of musculoskeletal disorders in  
21 the neck, shoulder, and lower back region than if they had fixed schedules with  
22 rest breaks and jobs with no decision-making required by their bosses. This  
23 higher prevalence of suffering pain is due to working overtime with high  
24 quantitative demands and not performing breaks during work hours, increasing  
25 the total time spent in a seated position.<sup>[15,16]</sup>  
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38 Since productivity seems to be maintained by frequent standing and rest,<sup>[17]</sup>  
39 performing exercise interventions may help reduce the effect of sickness  
40 presenteeism on musculoskeletal complaints and the ability to work.<sup>[18]</sup>  
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43 With a small amount of time, approximately 22 minutes a day, it is possible to  
44 reduce sedentary behaviour.<sup>[19]</sup> Having a daily schedule for exercise interventions  
45 at work might help reduce the time sitting and increase the global physical activity  
46 of employees,<sup>[20]</sup> preventing cardiovascular and metabolic illnesses and reducing  
47 musculoskeletal dysfunction of the back.<sup>[21]</sup>  
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52 A systematic review<sup>[22]</sup> conducted on physical exercise in office workers states  
53 that the studies reviewed include a wide variety of interventions regarding the  
54 duration of the active breaks, the length of the physical program, or the type of  
55 exercise performed. Positive effects of active breaks with postural change were  
56 found for pain and discomfort of the lower back pain without affecting the office  
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workers' productivity. Regarding the type of exercises, the most common interventions use stretching and strength training exercises.<sup>[23,24]</sup> Additionally, the practice of disciplines such as yoga<sup>[25]</sup> or qigong<sup>[26]</sup>, 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<sup>[27,28]</sup> 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.<sup>[29]</sup>

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,<sup>[29,30]</sup> or evaluating various kinds of breaks at work in symptomatic and asymptomatic participants.<sup>[22]</sup>

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<sup>[31]</sup>.

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.<sup>[32]</sup> The study protocol provides more specific details.<sup>[33]</sup>

### 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.<sup>[34]</sup> 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.<sup>[35]</sup>

### 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.

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

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13 Data extraction was performed by two reviewers (CT and CB), based on the  
14 recommendations of the Cochrane Handbook for Systematic Reviews of  
15 Interventions.<sup>[36]</sup> Data extraction was carried out in a standardised way, following  
16 the characteristics of the studies' methodology taking into account participants,  
17 interventions, outcome measures and the results section. The consensus method  
18 was used to resolve differences between reviewers where it did not take a third  
19 reviewer (FR) to reach the full consensus.  
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### 28 **Risk of bias assessment**

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30 The risk of bias of each article was independently assessed by two reviewers  
31 (FB, CT) using the Cochrane Risk of Bias 2 tool.<sup>[37]</sup> The sections where there was  
32 no coincidence were combined with a third reviewer (FR) to reach a consensus.  
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### 38 **Data synthesis**

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

### 49 **3.1. Result of the search**

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53 The search results yielded 276 articles after removing duplicates. When screened  
54 by title and abstract, 232 were excluded, resulting in reading a total of 44 full-text  
55 studies. The search followed the aforementioned specified inclusion and  
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3 exclusion criteria. In total, seven studies were included. More detailed information  
4 is presented in the adapted PRISMA flowchart (Figure 1).  
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9 Figure 1. Flow diagram of trial selection, adapted from PRISMA.  
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### 13 **3.2. Characteristics of the studies**

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

Authors	Participants	Intervention group versus control	Relevant outcome	Results	Measurement tools	Effect adverse
Andersen <i>et al</i> (2010) <sup>[38]</sup>	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 ( $-0.73\pm0.36$ , $P<0.05$ ) and APE ( $-0.91\pm0.31$ , $P<0.01$ ).	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 <i>et al</i> (2014) <sup>[42]</sup>	<b>n=47 (10 ♂, 37 ♀)</b> 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

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-Control (n=23): not offered any physical training.

Authors	Participants	Intervention group versus control	Relevant outcome	Results	Measurement tools	Effect adverse
Marango ni <i>et al</i> (2010) <sup>[39]</sup>	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 <i>et al</i> (2017) <sup>[43]</sup>	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

1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19	Del Pozo-Cruz <i>et al</i> (2013) <sup>[45]</sup>	<b>n=90 (24 ♂, 66 ♀)</b> 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
20 21 22 23 24 25 26 27 28 29 30 31 32 33 34 35	Shariat <i>et al</i> (2018) <sup>[44]</sup>	<b>n=142 (47 ♂, 95 ♀)</b> 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
36 37 38 39 40 41 42 43 44 45 46	<b>Authors</b>	<b>Participants</b>	<b>Intervention group versus control</b>	<b>Relevant outcome</b>	<b>Results</b>	<b>Measurement tools</b>	<b>Effect adverse</b>
	Nakphet <i>et al</i> (2014) <sup>[41]</sup>	<b>n=30 ♀ (18-40 years)</b> 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

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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.
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**Abbreviations:** CMDQ: Cornell Musculoskeletal Disorders Questionnaire; CVAS: Visual analogue scale; CLBP: chronic low back pain; EQ-5D: Euroquo-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.

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4 Exercise interventions varied in each study, from 10- to 15-second stretch  
5 exercises every six minutes while working<sup>[39]</sup> to up to one-hour strengthening  
6 exercises for 2–3 sets of 10–15 repetitions, combined with 5-second static neck  
7 exercises once a week.<sup>[38]</sup> A three-minute breaks intervention in Nakphet<sup>[41]</sup> with  
8 a dynamic contraction group and a stretching group focused on the neck/shoulder  
9 region; Andersen and Shariat<sup>[42,44]</sup> with a three-days-a-week intervention,  
10 Andersen with 10- to 15-minutes stretching routine<sup>[44]</sup> and Shariat<sup>[42]</sup> with a 20-  
11 minutes strength routine with scapular training function. Kaeding's study<sup>[43]</sup> with  
12 whole-body interventions performed 2.5 sessions a week with 15 minutes of  
13 vibration training and del Pozo-Cruz<sup>[40]</sup> with a five-day-a-week exercise  
14 intervention of seven minutes of physical exercise combining postural stability  
15 strengthening, flexibility, mobility, and stretching.  
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25 Regarding the length of the interventions, prevail studies with medium- and long-  
26 term interventions, except for Nakphet,<sup>[41]</sup> were performed with a one-day  
27 intervention to observe the acute effects of two workplace exercise interventions  
28 compared with a passive pause and Marangoni<sup>[39]</sup> with a three-week intervention.  
29 The rest of the studies lasted from a 10-week intervention in the case of  
30 Andersen<sup>[42]</sup>, three months in the Kaeding<sup>[43]</sup> intervention, Shariat<sup>[44]</sup> with a six-  
31 month intervention, and the longest, with a nine-month intervention in the del  
32 Pozo-Cruz study<sup>[40]</sup> and a one-year intervention in Andersen's<sup>[38]</sup>.  
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39 There is great variety in the comparison groups that sort from control groups  
40 without intervention, the ergonomic guidelines in Marangoni, Andersen, Kaeding  
41 and Shariat,<sup>[39,42–44]</sup> ergonomic guidelines or health prevention in Andersen and  
42 del Pozo-Cruz,<sup>[38,40]</sup> and a passive pause intervention group taking hands off of  
43 the computer for a three-minutes rest period in Kaeding's study.<sup>[41]</sup>  
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### 50 **3.3. Risk of bias**

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52 All of the studies, except for Andersen's,<sup>[38]</sup> had a "high risk" in the "measurement  
53 of the outcome" section because the participants and/or instructors were not  
54 blinded. The main difference in Andersen's<sup>[38]</sup> was that participants were blinded  
55 due to the cluster randomisation and the internet-based questionnaires.  
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3 In Marangoni, Nakphet and Shariat<sup>[39,41,44]</sup> we found "some concerns" in the  
4 section "selection of the reported results" due to the lack of a "prespecified  
5 analysis plan". Although all the studies were randomised, in the study of  
6 Nakphet,<sup>[41]</sup> the type of randomization was not specified and was considered  
7 "high risk" in the "randomization process". Another section to highlight is that in  
8 charge of evaluating "missing the outcome data", where, despite finding five  
9 articles with low adherence, Andersen and Shariat documented the cause of the  
10 dropout.<sup>[42,44]</sup> In Andersen<sup>[38]</sup> there is no information about why the participants  
11 dropped out of the study, and Marangoni<sup>[39]</sup> did not specify the number of  
12 participants or the reason for the drop out having a "high risk" of bias in this  
13 section. A summary of the risk of bias is shown in Figure 2 and Figure 3.  
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24 Figure 2. Risk of bias graph: review authors' judgements about risk of bias items  
25 presented as percentages across the included RCTs  
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30 Figure 3: Risk of bias summary: review authors' judgements about each risk of  
31 bias item for each included study. In green (Low risk), yellow (Some concerns)  
32 and red (High risk).  
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### 38 **3.4. Effects of workplace exercise interventions in reducing** 39 **musculoskeletal disorders and pain** 40

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42 In Andersen, Marangoni and Shariat,<sup>[38,39,44]</sup> the reduction of musculoskeletal  
43 pain in office workers was assessed in multiple body parts. Nakphet and  
44 Andersen<sup>[41,42]</sup> focused on the neck and shoulder area, while del Pozo-Cruz and  
45 Kaeding<sup>[40,43]</sup> assessed workplace interventions concerning disability caused by  
46 lower back pain.  
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#### 52 **3.4.1. Effects of workplace exercise interventions in reducing** 53 **musculoskeletal disorders in multiple body regions** 54

55 As mentioned above, Andersen, Marangoni and Shariat<sup>[38,39,44]</sup> evaluated  
56 workplace exercise interventions' effectiveness in reducing musculoskeletal pain  
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3 in more than one specific region. In Andersen's<sup>[38]</sup> Nordic Questionnaire was used  
4 to measure musculoskeletal symptoms, and the VAS scale was used to measure  
5 the participants' pain perception. The intensity of pain had a significant reduction  
6 in the neck, lower back, right elbow and right hand, in the two interventions, with  
7 exercise and physical activity compared to the reference group ( $P < 0.0001-0.05$ )  
8 main effects for region ( $F=3.04$ ,  $P < 0.0005$ ), group ( $F=2.93$ ,  $P=0.05$ ) and status  
9 ( $F=905$ ,  $P < 0.0001$ ). In the feet region, the group where participants were  
10 encouraged to perform physical activity on their own, had a greater decrease in  
11 pain perception than the workplace exercise intervention ( $P < 0.001$ ) and the  
12 reference group ( $P < 0.05$ ).

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

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36 The Shariat study<sup>[44]</sup> found significant differences in pain reduction after 6 months  
37 of intervention using the Cornell Musculoskeletal Disorders Questionnaire in the  
38 groups with exercise sessions, compared to the control group without intervention  
39 in the neck [MD-10.55(-14.36 to -6.74)], right shoulder [MD-12.17(-16.87 to -  
40 7.47)], left shoulder [MD-11.1(-15.1 to -7.09)] and lower back [MD-7.8(-11.08 to -  
41 4.53)]. Additionally, significant differences were found with the combined group  
42 with exercises and ergonomic guidelines compared to the control group in the  
43 same regions, neck (-13.63 to -6.36)], right shoulder [MD-11.12 (-15.59 to -6.65)],  
44 left shoulder [MD-10.67 (-14.49 to -6.85)] and lower back [MD-6.87 (-10 to -3.74)].  
45 Measures were taken every 2 months, and the most significant improvement in  
46 pain reduction was experienced from months 4 to 6 in the exercise group ( $p <$   
47 0.05).

#### 58 **3.4.2. Effects of workplace exercise interventions in reducing** 59 **musculoskeletal disorders and pain in the neck and shoulder region** 60

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3 Nakphet and Andersen<sup>[41,42]</sup> carried out interventions where neck and shoulder  
4 pain were assessed. In Andersen's study,<sup>[42]</sup> there was a significant reduction in  
5 pain in the neck and shoulder region 2.0 (95% CI 0.4–3.6) ( $p < 0.01$ ) and an  
6 increase in the lower trapezius pressure pain threshold 129 kPa (95% CI 31–227  
7 kPa) ( $p < 0.01$ ) in the active pause group compared to the control group that did  
8 not perform any intervention in the neck/shoulder region. No significant  
9 differences in the pressure pain threshold in the other body regions were  
10 measured.  
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20 Otherwise, in Nakphet,<sup>[41]</sup> for the assessment of pain, the Borg Scale for pain  
21 perception was used, and there was a reduction in neck discomfort in the three  
22 groups after each pause without significant differences between the active  
23 pauses and the passive pauses intervention group: neck:  $F(6.16, 83.16) = 1.41$ ,  
24  $p = .221$ ; right shoulder:  $F(4.97, 67.11) = 1.30$ ,  $p = .273$ ; left shoulder:  $F(6.56,$   
25  $88.54) = 1.15$ ,  $p = .342$ ; right elbow:  $F(6.78, 91.76) = 0.91$ ,  $p = .500$ ; left elbow:  
26  $F(5.29, 71.36) = 0.73$ ,  $p = .613$ ; right wrist and hand:  $F(5.45, 73.55) = 1.14$ ,  $p =$   
27  $.347$ ; and left wrist and hand:  $F(4.86, 65.59) = 1.39$ ,  $p = .242$ .  
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### 36 **3.4.3. Effects of workplace exercise interventions in reducing** 37 **musculoskeletal disorders and pain in disability caused by low back pain**

38 The del Pozo-Cruz and Kaeding studies involved reducing disability and the  
39 intensity of lower back pain<sup>[40,43]</sup>. In Kaeding,<sup>[43]</sup> where the intervention was made  
40 through the use of a whole-body vibration machine, improvements were reported  
41 in reducing lower back disability compared to the control group in which there  
42 was no intervention. There was a mean difference between the two groups in  
43 the Roland Morris Questionnaire of 1.8 RMQ points (95% CI: [0.2, 3.4]) ( $P = .027$ ),  
44 with an improvement in the training group of 1.5 ( $\pm 2.6$ ) RMQ points, while the  
45 control group worsened by an average of 0.3 ( $\pm 2.6$ ) RMQ points. Additionally,  
46 measures for the Oswestry Disability Index and changes at the end of the  
47 intervention were significantly higher in the training group, with a 4.5 ( $\pm 6.6$ )  
48 improvement in relation to a  $-1.2 \pm (3.2)$  worsening for the control group ( $P =$   
49  $.002$ ).  
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3 There was also a reduction in disability caused by lower back pain in the del  
4 Pozo-Cruz study<sup>[40]</sup> among participants who performed a physical exercise  
5 intervention measured by the Oswestry Disability Index questionnaire, with a  
6 clinical change of 5.420 (1.707 to 17.216) 85%,  $P = 0.001$ ) compared to the  
7 control group. Additionally, there was a reduction in the risk of chronicity (SBST  
8 clinical change, 75%,  $P < 0.001$ ) and the EQ-5D-3 L pain- and disability-related  
9 components (visual analogue scale (VAS) 73%,  $P < 0.001$ ; mobility, 77%,  $P <$   
10 0.001; self-care, 79%,  $P = 0.003$ ; pain/discomfort, 88%,  $P < 0.001$ ). However, the  
11 participants in the intervention group did not perceive an improvement in the  
12 performance of their daily tasks ( $P = 0.103$ ). Additionally, in the nonphysical  
13 exercise group, an increase in disability and low back pain episodes was reported  
14 at the end of the intervention.  
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#### 27 4. DISCUSSION

28 Based on the results of seven randomised controlled trials, exercise has  
29 significant benefits in treating musculoskeletal disorders of the lower back, neck  
30 and general regions of the body. There was a wide variety of exercise routines  
31 performed in the different interventions, with supervised or unsupervised  
32 programs, different outcome measures, and the number of participants with  
33 musculoskeletal disorders who participated in each study. Diversity has also  
34 been found in comparative groups with other exercise interventions and  
35 ergonomic advice or control groups without intervention.  
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43 There is a lack of consistency in the outcomes, not allowing us to draw firm  
44 conclusions regarding the effectiveness of workplace exercise interventions in  
45 treating musculoskeletal disorders.  
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48 The trials' overall risk of bias was considered high, except for Andersen's,<sup>[38]</sup>  
49 which was the only study that blinded the instructor and the participants. The rest  
50 of the RCTs did not provide blinding of their participants or the exercise program's  
51 instructors, both being the most important aspects for quality assessment that  
52 can affect the internal validity of the results, despite being very complicated to  
53 implement in exercise interventions.<sup>[46]</sup> Regarding external validity, it should be  
54 noted that interventions were carried out in the workplace, except for the Nakphet  
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3 study,<sup>[41]</sup> where the office was simulated in a laboratory to carry out a one-day  
4 intervention to gather surface myoelectric activity of the targeted muscles. This  
5 might be a limitation, as it is essential to carry out interventions on employees'  
6 workspaces so that the results can be easily extrapolated to the population that  
7 works in an office setting.<sup>[47]</sup>  
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12 More significant efforts should be made when carrying out participant recruitment  
13 and designing the intervention procedure, considering essential aspects to  
14 reduce biases such as blinding and losses in the follow-up.<sup>[48]</sup>  
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18 As previously mentioned, one of the most remarkable points of the review is the  
19 significant difference in the interventions that workers carried out in the different  
20 studies. The duration of the studies with physical exercise in clinical and  
21 nonclinical populations is commonly between one and three months so that the  
22 performance of the intervention and the economic costs would be viable.<sup>[46]</sup>  
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26 The studies reviewed showed no difference between longer or shorter sessions  
27 with greater frequency in exercise physiological adaptations regarding exercise  
28 volume and weekly frequency. Mainenti<sup>[13]</sup> showed that physical activity in a more  
29 extended session is not associated with decreased sedentarism levels.  
30 Therefore, using brief sessions with a high weekly frequency could provide office  
31 workers with significant improvements without a prolonged stoppage of their work  
32 activity.<sup>[49]</sup>  
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## 42 **Evidence of workplace exercise interventions in the treatment of** 43 **musculoskeletal disorders** 44

45 Three studies that evaluated musculoskeletal pain in multiple body regions<sup>[38,39,44]</sup>  
46 concluded that workplace exercise interventions reduced pain compared with the  
47 control groups. Rodrigues' systematic review,<sup>[50]</sup> which also included Marangoni's  
48 study,<sup>[39]</sup> found that regarding the duration of the exercise program, performing  
49 strength exercises in the workplace three times a week for 20 minutes could  
50 reduce musculoskeletal pain in the different regions of the spine and the upper  
51 limbs. Another systematic review<sup>[51]</sup> focused on video display terminal workers  
52 with musculoskeletal pain, using a rehabilitation program with exercises, pain  
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3 education, and ergonomic adjustments found a significant reduction in pain in  
4 different body areas, such as the wrist, shoulder and lower back regions.  
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7 Despite the anterior systematic review when analysing the best treatment for  
8 specific interventions in the neck and shoulder region, Bertozzi's systematic  
9 review<sup>[52]</sup> found a significant overall effect supporting exercise therapies alone on  
10 the reduction of pain in the short and intermediate term despite the results of the  
11 aforementioned systematic review in which different therapeutic strategies were  
12 combined.<sup>[51]</sup> The two studies analysed in this review that focused on the neck  
13 and shoulder region showed benefits in terms of 'decreasing intensity of pain and  
14 associated disability. Nakphet's study<sup>[41]</sup> concluded that performing a pause in  
15 the working hours, either with an exercise intervention or a passive pause,  
16 showed a reduction of the perception of pain. In Andersen,<sup>[42]</sup> with a 10-week  
17 intervention, the use of scapular function training with exercise reduced pain  
18 intensity in the neck and shoulder region. A former systematic review<sup>[29]</sup> reported  
19 a disparity of results associated with the differences between interventions aimed  
20 at treating neck disorders, concluding with strong evidence that interventions with  
21 strength and endurance programs were more effective at reducing neck pain.  
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33 When focusing on treating lower back pain among office workers, both studies  
34 analysed concluded there were positive effects on reducing musculoskeletal  
35 pain. There was a disparity between the workplace exercise interventions  
36 performed. The del Pozo-Cruz study<sup>[40]</sup> consisted of a 9-minute daily routine with  
37 strength, stretching and mobility exercises in a 9-month intervention, while  
38 Kaeding<sup>[43]</sup> performed 2.5 sessions a week of whole-body vibration training with  
39 10-15-minute sessions during a 3-month intervention. These studies agree with  
40 the results indicated by the Sipaviciene study<sup>[53]</sup> that showed positive effects of  
41 performing stabilization exercises for the trunk and of muscle strength exercise  
42 program to reduce lower back pain. Additionally, the systematic review by  
43 Gordon<sup>[54]</sup> concluded that a general exercise programme with strength, flexibility  
44 and aerobic training would be beneficial for treating nonspecific, chronic lower  
45 back pain in the adult population.  
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55 Adherence to the exercise prescribed using compliance terminology was  
56 reported in more than 80% of the total interventions performed in three of the  
57 seven studies analysed.<sup>[40,42,43]</sup> There is no standardised definition of adherence  
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3 to the therapeutic exercise for musculoskeletal pain due to lack of consistency in  
4 the literature, finding other synonyms such as compliance or concordance.<sup>[55]</sup>  
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7 A standard definition of therapeutic adherence reported in the studies reviewed  
8 by Bissonete, notes that: "Adherence can be defined as the extent to which  
9 patients follow the instructions they are given for prescribed treatments".<sup>[56]</sup> It is  
10 essential to consider the therapeutic adherence levels for participants with  
11 musculoskeletal pain when reporting the results of clinical trials.<sup>[55]</sup> Considering  
12 that adherence to exercise by the general population is ordinarily low,<sup>[57,58]</sup>  
13 strategies to enhance a higher rate of treatment adherence must be considered  
14 when designing the intervention procedure. The del Pozo-Cruz web-based  
15 intervention used a system in which the participants logged on to the sessions,  
16 with high compliance reported. The implementation of web-based interventions  
17 using customized push reminders via e-mail or cellular phone and regularly  
18 updating the content, such as Edney's Randomised Control Trial,<sup>[59]</sup> is also  
19 effective. Additionally, in Gram and collaborators,<sup>[60]</sup> no differences were found,  
20 where both intervention groups improved in terms of decreasing neck pain and  
21 headache with or without instructor supervision; being a web-based program with  
22 push reminders is probably being a feasible option for future interventions.  
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35 Ambrose's study<sup>[61]</sup> concludes that any exercise regimen is better than a  
36 sedentary lifestyle as long as there is sustainable progression. Additionally,  
37 exercise induces analgesia in healthy people due to the pain inhibition  
38 mechanism by the reaction of endogenous opioids and nociception inhibitory  
39 mechanisms. However, in people with chronic pain, these reactions seem to not  
40 occur in the same way, and pain relief requires time after the initial increase in  
41 pain has been overcome.<sup>[62]</sup> In Bravo's randomised control trial,<sup>[63]</sup> where  
42 therapeutic exercises were performed in fibromyalgia participants, a significant  
43 reduction in pain did not appear until 2 weeks after the intervention.  
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51 Hence, it is essential to consider specific items at the methodological level and a  
52 multidimensional approach<sup>[64,65]</sup> to carry out interventions with appropriate  
53 exercise regimens to achieve a low drop-out rate with high compliance with  
54 exercise interventions preferences, self-management and pain neuroscience  
55 education for the treatment of musculoskeletal disorders.<sup>[66,67]</sup>  
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## 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<sup>[39–43]</sup> together with the use of nonvalidated scales,<sup>[38,39,41,42]</sup> 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



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3 significant differences between the workplace programs, such as the exercises  
4 performed, the session length, and the weekly frequency. A consensus is needed  
5 to find structured therapeutic exercise programs following a proper  
6 methodological assessment that can be optimal for office workers and other  
7 similar sedentary professions.  
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25 CB in the extraction data and the redaction of the results, ER has been involved  
26 in the supervision and quality assurance of the Systematic Review. All authors  
27 read and approved the final manuscript.  
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#### **ORCID iDs**

Carlos Tersa-Miralles <https://orcid.org/0000-0001-7037-5033>

Cristina Bravo <http://orcid.org/0000-0002-2962-8198>

Filip Bellon <https://orcid.org/0000-0003-4880-9207>

Roland Pastells-Peiró <https://orcid.org/0000-0002-9561-9038>

1  
2  
3 Esther Rubinat <https://orcid.org/0000-0003-0232-9777>  
4

5 Francesc Rubí-Carnacea <https://orcid.org/0000-0002-0162-3950>  
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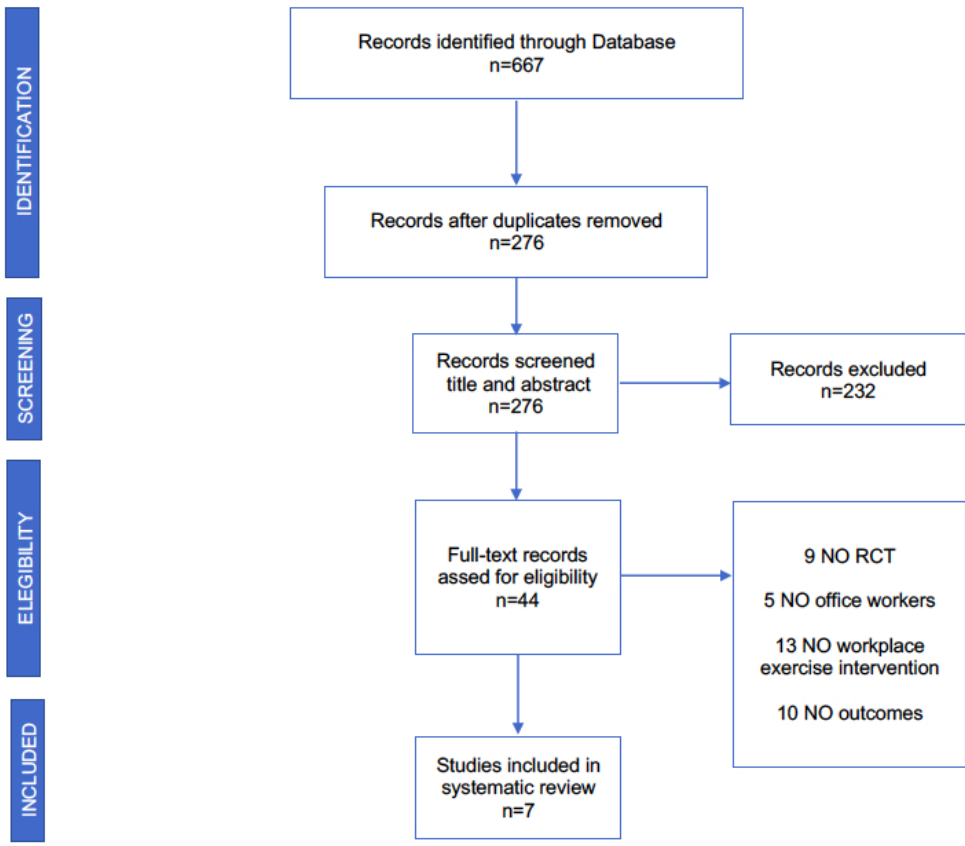


Figure 1. Flow diagram of trial selection, adapted from PRISMA

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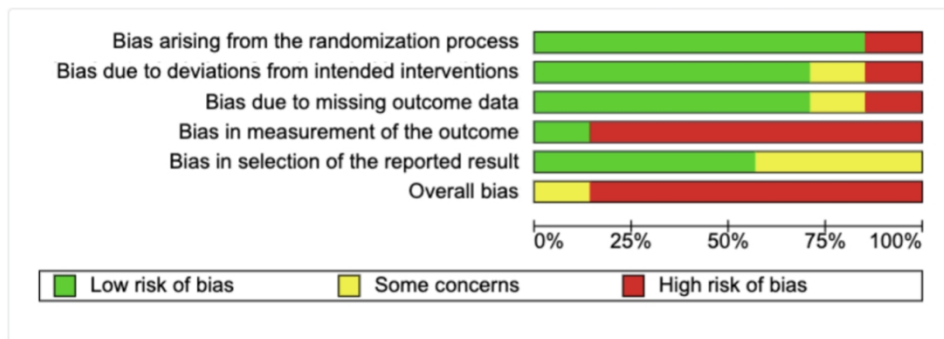


Figure 2. Risk of bias graph: review authors' judgements about risk of bias items presented as percentages across the included RCTs.

157x88mm (220 x 220 DPI)

	Bias arising from the randomization process	Bias due to deviations from intended interventions	Bias due to missing outcome data	Bias in measurement of the outcome	Bias in selection of the reported result	Overall bias
Andersen 2010	+	+	?	+	+	?
Andersen 2014	+	+	+	-	+	-
del Pozo-Cruz 2013	+	+	+	-	+	-
Kaeding 2017	+	+	+	-	+	-
Marangoni 2010	+	-	-	-	?	-
Nakphet 2014	-	+	+	-	?	-
Shariat 2018	+	?	+	-	?	-

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] OR "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

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

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## PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
<b>TITLE</b>			
Title	1	Identify the report as a systematic review.	1
<b>ABSTRACT</b>			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2
<b>INTRODUCTION</b>			
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
<b>METHODS</b>			
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.	
<b>RESULTS</b>			
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.	
<b>DISCUSSION</b>			
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
<b>OTHER INFORMATION</b>			
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

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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/>

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# BMJ Open

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

Journal:	<i>BMJ Open</i>
Manuscript ID	bmjopen-2021-054288.R1
Article Type:	Original research
Date Submitted by the Author:	02-Nov-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
<b>Primary Subject Heading</b>:	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

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3 **The effectiveness of workplace exercise interventions in the treatment of**  
4 **musculoskeletal disorders in office workers: A systematic review.**  
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8 Carlos Tersa-Miralles<sup>1</sup>, Cristina Bravo<sup>1,2,4</sup>, Filip Bellon<sup>1,2</sup>, Roland Pastells-  
9 Peiró<sup>1,2</sup>, Esther Rubinat Arnaldo<sup>1,2,3,4</sup>, Francesc Rubí-Carnacea<sup>1,2,4</sup>.  
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11  
12

13 **E-mail Addresses** Carlos Tersa-Miralles; [carles.tersa@udl.cat](mailto:carles.tersa@udl.cat) Cristina Bravo;  
14 [cristina.bravo@udl.cat](mailto:cristina.bravo@udl.cat) Filip Bellon; [filip.bellon@udl.cat](mailto:filip.bellon@udl.cat) Roland Pastells-Peiró;  
15 [roland.pastells@udl.cat](mailto:roland.pastells@udl.cat) Esther Rubinat-Arnaldo; [esther.rubinat@udl.cat](mailto:esther.rubinat@udl.cat)  
16  
17 Francesc Rubí-Carnacea; [francesc.rubi@udl.cat](mailto:francesc.rubi@udl.cat).  
18  
19  
20  
21

22 **Affiliations**  
23  
24

- 25 1- Department of Nursing and Physiotherapy, University of Lleida, Lleida, Spain.  
26  
27 2- Health Care Research Group, GRECS, Biomedical Research Institute of Lleida,  
28 Lleida, Spain.  
29  
30 3- Center for Biomedical Research on Diabetes and Associated Metabolic  
31 Diseases, Health institute Carlos III, Barcelona, Spain.  
32  
33 4- Group on Society Studies, Health, Education and Culture, University of Lleida,  
34 Lleida, Spain.  
35  
36  
37  
38  
39

40 **Correspondence to** Esther Rubinat Arnaldo; Carrer de Montserrat Roig, 2,  
41 25198 Lleida, Espanya; [esther.rubinat@udl.cat](mailto:esther.rubinat@udl.cat); +34 973 70 24 43.  
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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

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3 included studies, no firm conclusions could be drawn, and more high-quality  
4 studies are needed.  
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7 **Keywords** Musculoskeletal disorders, Pain, Office Worker, Exercise, Workplace.  
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10 **PROSPERO registration number** CRD42020177462.  
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## 14 **Article Summary**

### 15 **Strengths and limitations of this study**

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

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46 The exponential growth of a sedentary lifestyle in society is due to the great  
47 technological advances in recent years increasing the time spent sitting  
48 throughout the day.<sup>[1,2]</sup> Maintaining sitting, reclining and lying postures are  
49 sedentary behaviours with low energy expenditure (<1.5 METs).<sup>[3]</sup> It is important  
50 to remark that sedentary behaviour is not the same as physical inactivity,<sup>[4]</sup>  
51 describing people who are performing insufficient amounts of moderate (3-6  
52 METs) and vigorous(>6 METS) intensity activity.<sup>[3]</sup> So strategies to improve both  
53 terms are necessary to have good health. Performing exercise 3 to 5 times a  
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3 week, such as running or practising sports, does not guarantee an active lifestyle  
4 if the rest of the day is based on sedentary behaviour.  
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8 The average daily time spent in a seated position by the adult population is 346  
9 minutes per day.<sup>[5]</sup> American and eastern Mediterranean countries have higher  
10 proportions of physical inactivity (43% of adult population); the worldwide  
11 average is lower but still surpasses 30%.<sup>[6]</sup> Moreover, these numbers may be  
12 worse due to COVID-19, where home confinement and mobility restrictions are  
13 necessary to reduce the spread of the virus, increasing sedentary behaviour.<sup>[7]</sup>  
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19 Even the association seems more than obvious; there is limited research relating  
20 sedentary behaviour and physical inactivity to suffering musculoskeletal  
21 disorders,<sup>[8]</sup> being one of the leading causes of health problems for the global  
22 population causing work disability, absenteeism, and work presentism.<sup>[9]</sup> The  
23 prevalence of disability due to musculoskeletal pain is predicted to increase  
24 exponentially over the next twenty years.<sup>[10]</sup>  
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30 Because the office workplace is an unfavourable environment in terms of high  
31 sedentary behaviour,<sup>[11]</sup> daily exercise is crucial to prevent pathologies caused  
32 by the lack of movement and poor posture while spending most of the workday  
33 in front of the computer.<sup>[12,13]</sup> In Kaliniene study<sup>[14]</sup> with 513 public service sector  
34 computer workers in Lithuania, the participants without rest breaks in their  
35 schedules had a higher prevalence (8,1-13%) of suffering musculoskeletal  
36 disorders in the elbow, wrist/hand, upper and lower back than participants with  
37 rest breaks every 2 hours. This higher prevalence of suffering pain is also due  
38 to working overtime, high quantitative and cognitive demands and not  
39 performing breaks during work hours, increasing the total time spent in a seated  
40 position<sup>[14,15]</sup>  
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50 Since productivity seems to be maintained by different standing breaks (5  
51 minutes every 30 minutes of work to bouts of 50 seconds in 5 minutes of work)  
52 compared to not taking breaks in one hour of work,<sup>[16]</sup> performing exercise  
53 interventions may help reduce the effect of sickness presenteeism on  
54 musculoskeletal complaints and the ability to work.<sup>[17]</sup>  
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3 Having a daily schedule for exercise interventions at work might help reduce the  
4 time sitting and increase the daily physical activity of employees.<sup>[18]</sup> Helping them  
5 reach the recommendations from the physical activity guidelines suggested by  
6 the WHO's (at least 150' moderate- or 75' vigorous- physical activity) in the adult  
7 population,<sup>[19]</sup> preventing cardiovascular and metabolic illnesses and reducing  
8 musculoskeletal dysfunction of the back.<sup>[20]</sup>  
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14 Strength and aerobic exercises focusing on the reduction of the intensity,  
15 disability, and duration of neck and shoulder pain can be easily performed in work  
16 environments because they do not require equipment and can be performed with  
17 office worker's own bodyweight.<sup>[21]</sup> Regarding the type of exercises, the most  
18 common interventions use stretching and strength training exercises.<sup>[22,23]</sup>  
19 Additionally, the practice of disciplines such as yoga<sup>[24]</sup> or qigong<sup>[25]</sup>, was  
20 implemented in the workplace together with home-based sessions that could be  
21 considered a feasible option in the treatment of musculoskeletal disorders related  
22 to their job demands.  
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31 Additionally, sedentary behaviour and its consequences for office workers  
32 concern multinational corporations regarding the levels of presentism due to the  
33 health issues of their employees, which is an occupational issue resulting in  
34 economic costs due to a reduction in productivity levels.<sup>[26]</sup>  
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39 However, to our knowledge, this is the first systematic review focusing exclusively  
40 on workplace exercise interventions in the treatment of musculoskeletal disorders  
41 in symptomatic office workers of any sector who spend most of their time in a  
42 seated position.  
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46 This review's practical implications aim to:

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48 - Determine the effect of workplace exercise interventions in the treatment  
49 of musculoskeletal disorders.  
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52 - Describe the characteristics of workplace interventions to improve  
53 therapeutic exercise programs for office workers.  
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57 - Recommend future lines of research enhancing interventions for a more  
58 active lifestyle of sedentary workers.  
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## 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.<sup>[27]</sup> The study protocol provides more specific details.<sup>[28]</sup>

### 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.<sup>[29]</sup> 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.<sup>[30]</sup>

### 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.



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3 (5) Studies in which the intervention is by means of "Sit-Stand Workstations"  
4 or Guidelines of ergonomics and health education without a physical  
5 exercise program have been excluded.  
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### 10 11 **Data extraction**

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13 Data extraction was performed by two reviewers (CT and CB), based on the  
14 recommendations of the Cochrane Handbook for Systematic Reviews of  
15 Interventions.<sup>[31]</sup> Data extraction was carried out in a standardised way, following  
16 the characteristics of the studies' methodology taking into account participants,  
17 interventions, outcome measures and the results section. The consensus method  
18 was used to resolve differences between reviewers where it did not take a third  
19 reviewer (FR) to reach the full consensus.  
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### 28 **Risk of bias assessment**

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30 The risk of bias of each article was independently assessed by two reviewers  
31 (FB, CT) using the Cochrane Risk of Bias 2 tool.<sup>[32]</sup> The sections where there was  
32 no coincidence were combined with a third reviewer (FR) to reach a consensus.  
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### 38 **Data synthesis**

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

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### 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<sup>[35,36]</sup>, del Pozo-Cruz in 2013<sup>[37]</sup>, Nakphet and Andersen in 2014<sup>[38,39]</sup>, Kaeding in 2017<sup>[40]</sup>, and Shariat in 2018.<sup>[41]</sup> A total of 967 participants were included in the seven studies, from the smallest sample of 30 participants<sup>[38]</sup> to the largest with 549.<sup>[35]</sup> 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 <i>et al</i> (2010) <sup>[35]</sup>	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 ( $-0.73\pm0.36$ , $P<0.05$ ) and APE ( $-0.91\pm0.31$ , $P<0.01$ ).	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 <i>et al</i> (2014) <sup>[39]</sup>	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
Marango <i>et al</i> (2010) <sup>[36]</sup>	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 <i>et al</i> (2017) <sup>[40]</sup>	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 <i>et al</i> (2013) <sup>[37]</sup>	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 Euroqol-5D (EQ-5D), ODI, STarT Back Screening Tool (SBST).	No
Shariat <i>et al</i> (2018) <sup>[41]</sup>	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
Nakphet <i>et al</i> (2014) <sup>[38]</sup>	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: Euroqol-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.

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

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

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

### 3.3. Risk of bias

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32 All of the studies, except for Andersen's,<sup>[35]</sup> had a "high risk" in the "measurement  
33 of the outcome" section because the participants and/or instructors were not  
34 blinded. The main difference in Andersen's<sup>[35]</sup> was that participants were blinded  
35 due to the cluster randomisation and the internet-based questionnaires.  
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3 In Marangoni, Nakphet and Shariat<sup>[36,38,41]</sup> we found "some concerns" in the  
4 section "selection of the reported results" due to the lack of a "prespecified  
5 analysis plan". Although all the studies were randomised, in the study of  
6 Nakphet,<sup>[38]</sup> the type of randomization was not specified and was considered  
7 "high risk" in the "randomization process". Another section to highlight is that in  
8 charge of evaluating "missing the outcome data", where, despite finding five  
9 articles with low adherence, Andersen and Shariat documented the cause of the  
10 dropout.<sup>[39,41]</sup> In Andersen<sup>[35]</sup> there is no information about why the participants  
11 dropped out of the study, and Marangoni<sup>[36]</sup> did not specify the number of  
12 participants or the reason for the drop out having a "high risk" of bias in this  
13 section. A summary of the risk of bias is shown in Figure 2 and Figure 3.  
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24 Figure 2. Risk of bias graph: review authors' judgements about risk of bias items  
25 presented as percentages across the included RCTs  
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30 Figure 3: Risk of bias summary: review authors' judgements about each risk of  
31 bias item for each included study. In green (Low risk), yellow (Some concerns)  
32 and red (High risk).  
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### 38 **3.4. Effects of workplace exercise interventions in reducing** 39 **musculoskeletal disorders and pain** 40 41

42 In Andersen, Marangoni and Shariat,<sup>[35,36,41]</sup> the reduction of musculoskeletal  
43 pain in office workers was assessed in multiple body parts. Nakphet and  
44 Andersen<sup>[38,39]</sup> focused on the neck and shoulder area, while del Pozo-Cruz and  
45 Kaeding<sup>[37,40]</sup> assessed workplace interventions concerning disability caused by  
46 lower back pain.  
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#### 52 **3.4.1. Effects of workplace exercise interventions in reducing** 53 **musculoskeletal disorders in multiple body regions** 54 55

56 As mentioned above, Andersen, Marangoni and Shariat<sup>[35,36,41]</sup> evaluated  
57 workplace exercise interventions' effectiveness in reducing musculoskeletal pain  
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3 in more than one specific region. In Andersen's<sup>[35]</sup> Nordic Questionnaire was used  
4 to measure musculoskeletal symptoms, and the VAS scale was used to measure  
5 the participants' pain perception. The intensity of pain had a significant reduction  
6 in the neck, lower back, right elbow and right hand, in the two interventions, with  
7 exercise and physical activity compared to the reference group ( $P < 0.0001-0.05$ )  
8 main effects for region ( $F=3.04$ ,  $P < 0.0005$ ), group ( $F=2.93$ ,  $P=0.05$ ) and status  
9 ( $F=905$ ,  $P < 0.0001$ ). In the feet region, the group where participants were  
10 encouraged to perform physical activity on their own, had a greater decrease in  
11 pain perception than the workplace exercise intervention ( $P < 0.001$ ) and the  
12 reference group ( $P < 0.05$ ).

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

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36 The Shariat study<sup>[41]</sup> found significant differences in pain reduction after 6 months  
37 of intervention using the Cornell Musculoskeletal Disorders Questionnaire in the  
38 groups with exercise sessions, compared to the control group without intervention  
39 in the neck [MD-10.55(-14.36 to -6.74)], right shoulder [MD-12.17(-16.87 to -  
40 7.47)], left shoulder [MD-11.1(-15.1 to -7.09)] and lower back [MD-7.8(-11.08 to -  
41 4.53)]. Additionally, significant differences were found with the combined group  
42 with exercises and ergonomic guidelines compared to the control group in the  
43 same regions, neck (-13.63 to -6.36)], right shoulder [MD-11.12 (-15.59 to -6.65)],  
44 left shoulder [MD-10.67 (-14.49 to -6.85)] and lower back [MD-6.87 (-10 to -3.74)].  
45 Measures were taken every 2 months, and the most significant improvement in  
46 pain reduction was experienced from months 4 to 6 in the exercise group ( $p <$   
47 0.05).

#### 58 **3.4.2. Effects of workplace exercise interventions in reducing** 59 **musculoskeletal disorders and pain in the neck and shoulder region** 60

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3 Nakphet and Andersen<sup>[38,39]</sup> carried out interventions where neck and shoulder  
4 pain were assessed. In Andersen's study,<sup>[42]</sup> there was a significant reduction in  
5 pain in the neck and shoulder region 2.0 (95% CI 0.4–3.6) ( $p < 0.01$ ) and an  
6 increase in the lower trapezius pressure pain threshold 129 kPa (95% CI 31–227  
7 kPa) ( $p < 0.01$ ) in the active pause group compared to the control group that did  
8 not perform any intervention in the neck/shoulder region. No significant  
9 differences in the pressure pain threshold in the other body regions were  
10 measured.  
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20 Otherwise, in Nakphet,<sup>[38]</sup> for the assessment of pain, the Borg Scale for pain  
21 perception was used, and there was a reduction in neck discomfort in the three  
22 groups after each pause without significant differences between the active  
23 pauses and the passive pauses intervention group: neck:  $F(6.16, 83.16) = 1.41$ ,  
24  $p = .221$ ; right shoulder:  $F(4.97, 67.11) = 1.30$ ,  $p = .273$ ; left shoulder:  $F(6.56,$   
25  $88.54) = 1.15$ ,  $p = .342$ ; right elbow:  $F(6.78, 91.76) = 0.91$ ,  $p = .500$ ; left elbow:  
26  $F(5.29, 71.36) = 0.73$ ,  $p = .613$ ; right wrist and hand:  $F(5.45, 73.55) = 1.14$ ,  $p =$   
27  $.347$ ; and left wrist and hand:  $F(4.86, 65.59) = 1.39$ ,  $p = .242$ .  
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### 36 **3.4.3. Effects of workplace exercise interventions in reducing** 37 **musculoskeletal disorders and pain in disability caused by low back pain**

38 The del Pozo-Cruz and Kaeding studies involved reducing disability and the  
39 intensity of lower back pain<sup>[37,40]</sup>. In Kaeding,<sup>[40]</sup> where the intervention was made  
40 through the use of a whole-body vibration machine, improvements were reported  
41 in reducing lower back disability compared to the control group in which there  
42 was no intervention. There was a mean difference between the two groups in  
43 the Roland Morris Questionnaire of 1.8 RMQ points (95% CI: [0.2, 3.4]) ( $P = .027$ ),  
44 with an improvement in the training group of 1.5 ( $\pm 2.6$ ) RMQ points, while the  
45 control group worsened by an average of 0.3 ( $\pm 2.6$ ) RMQ points. Additionally,  
46 measures for the Oswestry Disability Index and changes at the end of the  
47 intervention were significantly higher in the training group, with a 4.5 ( $\pm 6.6$ )  
48 improvement in relation to a  $-1.2 \pm (3.2)$  worsening for the control group ( $P =$   
49  $.002$ ).  
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3 There was also a reduction in disability caused by lower back pain in the del  
4 Pozo-Cruz study<sup>[37]</sup> among participants who performed a physical exercise  
5 intervention measured by the Oswestry Disability Index questionnaire, with a  
6 clinical change of 5.420 (1.707 to 17.216) 85%,  $P = 0.001$ ) compared to the  
7 control group. Additionally, there was a reduction in the risk of chronicity (SBST  
8 clinical change, 75%,  $P < 0.001$ ) and the EQ-5D-3 L pain- and disability-related  
9 components (visual analogue scale (VAS) 73%,  $P < 0.001$ ; mobility, 77%,  $P <$   
10 0.001; self-care, 79%,  $P = 0.003$ ; pain/discomfort, 88%,  $P < 0.001$ ). However, the  
11 participants in the intervention group did not perceive an improvement in the  
12 performance of their daily tasks ( $P = 0.103$ ). Additionally, in the nonphysical  
13 exercise group, an increase in disability and low back pain episodes was reported  
14 at the end of the intervention.  
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#### 26 **4. DISCUSSION**

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28 Based on the results of seven RCTsr, exercise has significant benefits in treating  
29 musculoskeletal disorders of the lower back, neck and general regions of the  
30 body. There was a wide variety of exercise routines performed in the different  
31 interventions, with supervised or unsupervised programs, different outcome  
32 measures, and the number of participants with musculoskeletal disorders who  
33 participated in each study. Diversity has also been found in comparative groups  
34 with other exercise interventions and ergonomic advice or control groups without  
35 intervention.  
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43 There is a lack of consistency in the outcomes, not allowing us to draw firm  
44 conclusions regarding the effectiveness of workplace exercise interventions in  
45 treating musculoskeletal disorders.  
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48 The trials' overall risk of bias was considered high, except for Andersen's,<sup>[35]</sup>  
49 which was the only study that blinded the instructor and the participants. The rest  
50 of the RCTs did not provide blinding of their participants or the exercise program's  
51 instructors, both being the most important aspects for quality assessment that  
52 can affect the internal validity of the results, despite being very complicated to  
53 implement in exercise interventions.<sup>[42]</sup> Regarding external validity, it should be  
54 noted that interventions were carried out in the workplace, except for the Nakphet  
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3 study,<sup>[38]</sup> where the office was simulated in a laboratory to carry out a one-day  
4 intervention to gather surface myoelectric activity of the targeted muscles. This  
5 might be a limitation, as it is essential to carry out interventions on employees'  
6 workspaces so that the results can be easily extrapolated to the population that  
7 works in an office setting.<sup>[43]</sup>  
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12 More significant efforts should be made when carrying out participant recruitment  
13 and designing the intervention procedure, considering essential aspects to  
14 reduce biases such as blinding and losses in the follow-up.<sup>[44]</sup>  
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18 As previously mentioned, one remarkable point of the review is the significant  
19 difference in the interventions that workers carried out in the different studies.  
20 The duration of the studies with physical exercise in clinical and nonclinical  
21 populations is commonly between one and three months so that the performance  
22 of the intervention and the economic costs would be viable.<sup>[42]</sup>  
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26 The studies reviewed showed no difference between longer or shorter sessions  
27 with greater frequency in exercise physiological adaptations regarding exercise  
28 volume and weekly frequency. Mainenti<sup>[12]</sup> showed that physical activity in a more  
29 extended session is not associated with decreased sedentarism levels.  
30 Therefore, using brief sessions with a high weekly frequency could provide office  
31 workers with significant improvements without a prolonged stoppage of their work  
32 activity.<sup>[45]</sup>  
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## 42 **Evidence of workplace exercise interventions in the treatment of** 43 **musculoskeletal disorders** 44

45 Three studies that evaluated musculoskeletal pain in multiple body regions<sup>[35,36,41]</sup>  
46 concluded that workplace exercise interventions reduced pain compared with the  
47 control groups. Rodrigues' systematic review,<sup>[46]</sup> which also included Marangoni's  
48 study,<sup>[36]</sup> found that regarding the duration of the exercise program, performing  
49 strength exercises in the workplace three times a week for 20 minutes could  
50 reduce musculoskeletal pain in the different regions of the spine and the upper  
51 limbs. Another systematic review<sup>[47]</sup> focused on video display terminal workers  
52 with musculoskeletal pain, using a rehabilitation program with exercises, pain  
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3 education, and ergonomic adjustments found a significant reduction in pain in  
4 different body areas, such as the wrist, shoulder and lower back regions.  
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7 Despite the anterior systematic review when analysing the best treatment for  
8 specific interventions in the neck and shoulder region, Bertozzi's systematic  
9 review<sup>[48]</sup> found a significant overall effect supporting exercise therapies alone on  
10 the reduction of pain in the short and intermediate term despite the results of the  
11 aforementioned systematic review in which different therapeutic strategies were  
12 combined.<sup>[47]</sup> The two studies analysed in this review that focused on the neck  
13 and shoulder region showed benefits in terms of decreasing intensity of pain and  
14 associated disability. Nakphet's study<sup>[38]</sup> concluded that performing a pause in  
15 the working hours, either with an exercise intervention or a passive pause,  
16 showed a reduction of the perception of pain. In Andersen,<sup>[39]</sup> with a 10-week  
17 intervention, the use of scapular function training with exercise reduced pain  
18 intensity in the neck and shoulder region. A former systematic review<sup>[21]</sup> reported  
19 a disparity of results associated with the differences between interventions aimed  
20 at treating neck disorders, concluding with strong evidence that interventions with  
21 strength and endurance programs were more effective at reducing neck pain.  
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33 When focusing on treating lower back pain among office workers, both studies  
34 analysed concluded there were positive effects on reducing musculoskeletal  
35 pain. There was a disparity between the workplace exercise interventions  
36 performed. The del Pozo-Cruz study<sup>[37]</sup> consisted of a 9-minute daily routine with  
37 strength, stretching and mobility exercises in a 9-month intervention, while  
38 Kaeding<sup>[40]</sup> performed 2.5 sessions a week of whole-body vibration training with  
39 10-15-minute sessions during a 3-month intervention. These studies agree with  
40 the results indicated by the Sipaviciene study<sup>[49]</sup> that showed positive effects of  
41 performing stabilization exercises for the trunk and of muscle strength exercise  
42 program to reduce lower back pain. Additionally, the systematic review by  
43 Gordon<sup>[50]</sup> concluded that a general exercise programme with strength, flexibility  
44 and aerobic training would be beneficial for treating nonspecific, chronic lower  
45 back pain in the adult population.  
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55 Adherence to the exercise prescribed using compliance terminology was  
56 reported in more than 80% of the total interventions performed in three of the  
57 seven studies analysed.<sup>[37,39,40]</sup> There is no standardised definition of adherence  
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3 to the therapeutic exercise for musculoskeletal pain due to lack of consistency in  
4 the literature, finding other synonyms such as compliance or concordance.<sup>[51]</sup>  
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7 A standard definition of therapeutic adherence reported in the studies reviewed  
8 by Bissonete, notes that: "Adherence can be defined as the extent to which  
9 patients follow the instructions they are given for prescribed treatments".<sup>[52]</sup> It is  
10 essential to consider the therapeutic adherence levels for participants with  
11 musculoskeletal pain when reporting the results of clinical trials.<sup>[51]</sup> Considering  
12 that adherence to exercise is ordinarily low,<sup>[53,54]</sup> strategies to enhance a higher  
13 rate of treatment adherence must be considered when designing the intervention  
14 procedure. The del Pozo-Cruz web-based intervention used a log-in system with  
15 high compliance reported. The implementation of web-based interventions using  
16 customized push reminders via e-mail or phone and regularly updating the  
17 content, such as Edney's study,<sup>[55]</sup> is also effective. Additionally, in Gram and  
18 collaborators,<sup>[56]</sup> no differences were found, where both intervention groups  
19 improved in terms of decreasing neck pain and headache with or without  
20 instructor supervision; being a web-based program with push reminders is  
21 probably being a feasible option for future interventions.  
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33 Ambrose's study<sup>[57]</sup> concludes that any exercise regimen is better than a  
34 sedentary lifestyle as long as there is sustainable progression. Additionally,  
35 exercise induces analgesia in healthy people due to the pain inhibition  
36 mechanism by the reaction of endogenous opioids and nociception inhibitory  
37 mechanisms. However, in people with chronic pain, these reactions seem to not  
38 occur in the same way, and pain relief requires time after the initial increase in  
39 pain has been overcome.<sup>[58]</sup> In Bravo's study,<sup>[59]</sup> where therapeutic exercises  
40 were performed in fibromyalgia participants, a significant reduction in pain did not  
41 appear until 2 weeks after the intervention.  
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49 Hence, it is essential to consider specific items at the methodological level and a  
50 multidimensional approach<sup>[60,61]</sup> to carry out interventions with appropriate  
51 exercise regimens to achieve a low drop-out rate with high compliance with  
52 exercise interventions preferences, self-management and pain neuroscience  
53 education for the treatment of musculoskeletal disorders.<sup>[62,63]</sup>  
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## 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.<sup>[10]</sup> More studies are needed to draw firm conclusions related to developed and developing countries where different factors can predict Musculoskeletal disorders in office workers.<sup>[64]</sup> The studies included in the review are conducted in developed with high income<sup>[35–37,39,40]</sup> and developing countries with middle-upper income<sup>[38,41]</sup>. Differences could be found when extrapolating results to low and middle-income countries because the prevalence of musculoskeletal disorders is rising exponentially.<sup>[10]</sup>

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<sup>[36–40]</sup> together with the use of nonvalidated scales,<sup>[35,36,38,39]</sup> 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

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3 regions, such as the neck and shoulder, lower back and upper limbs, compared  
4 to other groups of ergonomic guidelines or control groups without interventions.  
5 However, heterogeneity in the intervention characteristics, the number of  
6 participants, outcome measures, and the low methodological quality of the  
7 included studies restricted our ability to draw firm conclusions.  
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12 Improvement in the quality of studies is required to strengthen the current  
13 evidence of workplace exercise interventions in office workers. There were  
14 significant differences between the workplace programs, such as the exercises  
15 performed, the session length, and the weekly frequency. A consensus is needed  
16 to find structured therapeutic exercise programs following a proper  
17 methodological assessment that can be optimal for office workers and other  
18 similar sedentary professions.  
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35 CT involved in the entire process of writing this manuscript. RP was involved in  
36 the review of manuscript contributing to the methodological aspects and the  
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38 CB in the extraction data and the redaction of the results, ER has been involved  
39 in the supervision and quality assurance of the Systematic Review. All authors  
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3 **Data availability statement** No additional data available  
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8 **Ethical Approval Statement** Not applicable  
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## 12 **ORCID iDs**

13  
14  
15 Carlos Tersa-Miralles <https://orcid.org/0000-0001-7037-5033>  
16

17  
18 Cristina Bravo <http://orcid.org/0000-0002-2962-8198>  
19

20  
21 Filip Bellon <https://orcid.org/0000-0003-4880-9207>  
22

23  
24 Roland Pastells-Peiró <https://orcid.org/0000-0002-9561-9038>  
25

26  
27 Esther Rubinat <https://orcid.org/0000-0003-0232-9777>  
28

29  
30 Francesc Rubí-Carnacea <https://orcid.org/0000-0002-0162-3950>  
31

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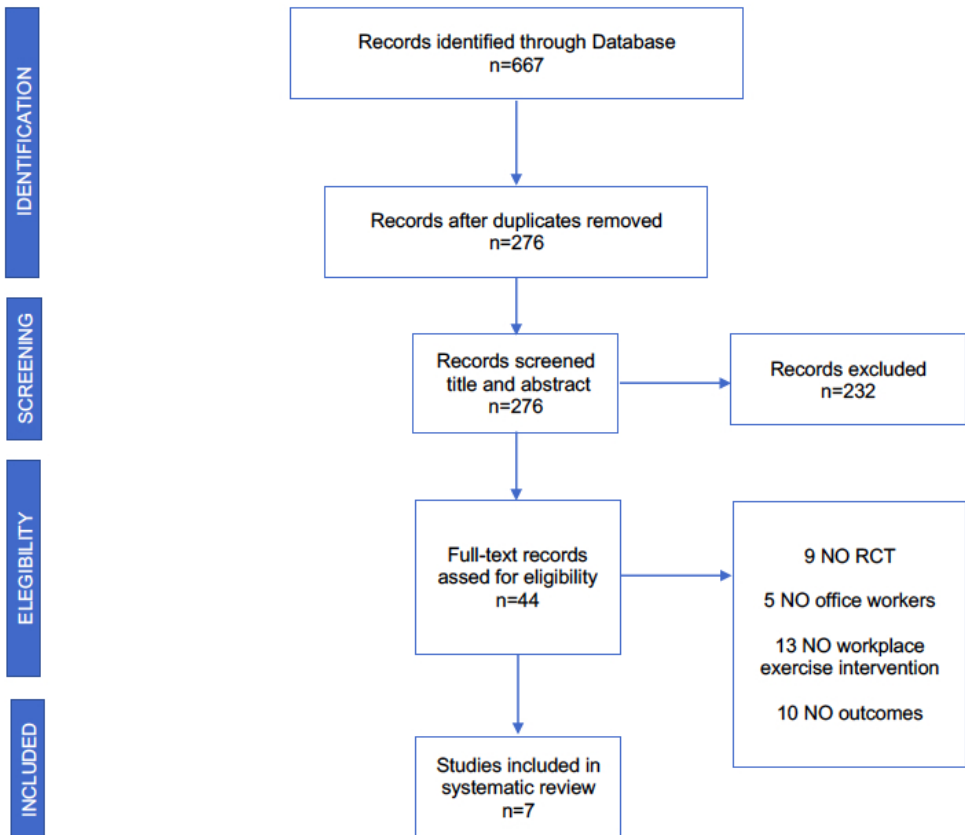


Figure 1. Flow diagram of trial selection, adapted from PRISMA

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

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	Bias arising from the randomization process	Bias due to deviations from intended interventions	Bias due to missing outcome data	Bias in measurement of the outcome	Bias in selection of the reported result	Overall bias
Andersen 2010	+	+	?	+	+	?
Andersen 2014	+	+	+	-	+	-
del Pozo-Cruz 2013	+	+	+	-	+	-
Kaeding 2017	+	+	+	-	+	-
Marangoni 2010	+	-	-	-	?	-
Nakphet 2014	-	+	+	-	?	-
Shariat 2018	+	?	+	-	?	-

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	<p>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])</p> <p>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])</p> <p>3. ("Exercise movement Therapy"[MeSH] OR "Exercise movement Therapy"[tiab] OR "Exercise Therapy"[MeSH] OR "Exercise Therapy"[tiab] OR "Circuit Based Exercise"[MeSH] OR "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])</p> <p>4. 1 AND 2 AND 3</p> <p>- Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only</p>
CINHAL	<p>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</p>

	<p>Cervical Pains" OR "Posterior Neck Pain" OR "Posterior Neck Pains" OR "Shoulder pain" OR "Shoulder pain" OR "Shoulder pains"))</p> <p>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"))</p> <p>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"))</p> <p>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"))</p> <p>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"))</p> <p>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"))</p> <p>7. 1 OR 2 AND 3 OR 4 AND 5 OR 6</p> <p>- Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only</p>
Cochrane	<p>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</p>

	<p>Cervical Pains” OR “Posterior Neck Pain” OR “Posterior Neck Pains” OR “Shoulder pain” OR “Shoulder pain” OR “Shoulder pains”)):ti,ab,kw</p> <p>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</p> <p>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</p> <p>4. 1 AND 2 AND 3</p> <p>- Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only</p>
Scopus	<p>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”)</p> <p>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”)</p> <p>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”)</p> <p>4. 1 AND 2 AND 3</p> <p>- Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only</p>
ISI WoS	<p>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</p>

	<p>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)</p> <p>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)</p> <p>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)</p> <p>4. 1 AND 2 AND 3 AND</p> <p>- Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only</p>
PeDRO	<p>A simple search of the different terms and their synonyms:</p> <ol style="list-style-type: none"> <li>1. Musculoskeletal Disorders</li> <li>2. Office workers</li> <li>3. Exercise Therapy</li> </ol>



## PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
<b>TITLE</b>			
Title	1	Identify the report as a systematic review.	1
<b>ABSTRACT</b>			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2
<b>INTRODUCTION</b>			
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
<b>METHODS</b>			
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.	
<b>RESULTS</b>			
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.	
<b>DISCUSSION</b>			
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
<b>OTHER INFORMATION</b>			
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

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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/>

For peer review only

## 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>

<b>SWiM is intended to complement and be used as an extension to PRISMA</b>			
<b>SWiM reporting item</b>	<b>Item description</b>	<b>Page in manuscript where item is reported</b>	<b>Other*</b>
<i>Methods</i>			
<b>1</b> 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		
<b>2</b> 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	
<b>3</b> 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	
<b>4</b> 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*
<b>5</b> 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	
<b>6</b> Certainty of evidence	Describe the methods used to assess certainty of the synthesis findings	7	
<b>7</b> 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	
<i>Results</i>			
<b>8</b> 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	
<i>Discussion</i>			
<b>9</b> 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:	<i>BMJ Open</i>
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
<b>Primary Subject Heading</b>:	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

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Manuscripts



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3 **The effectiveness of workplace exercise interventions in the treatment of**  
4 **musculoskeletal disorders in office workers: a systematic review**  
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8 Carlos Tersa-Miralles<sup>1</sup>, Cristina Bravo<sup>1,2,4</sup>, Filip Bellon<sup>1,2</sup>, Roland Pastells-  
9 Peiró<sup>1,2</sup>, Esther Rubinat Arnaldo<sup>1,2,3,4</sup>, Francesc Rubí-Carnacea<sup>1,2,4</sup>.  
10  
11

12  
13 **E-mail Addresses** Carlos Tersa-Miralles; [carles.tersa@udl.cat](mailto:carles.tersa@udl.cat) Cristina Bravo;  
14 [cristina.bravo@udl.cat](mailto:cristina.bravo@udl.cat) Filip Bellon; [filip.bellon@udl.cat](mailto:filip.bellon@udl.cat) Roland Pastells-Peiró;  
15 [roland.pastells@udl.cat](mailto:roland.pastells@udl.cat) Esther Rubinat-Arnaldo; [esther.rubinat@udl.cat](mailto:esther.rubinat@udl.cat)  
16  
17 Francesc Rubí-Carnacea; [francesc.rubi@udl.cat](mailto:francesc.rubi@udl.cat).  
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20  
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22 **Affiliations**  
23  
24

- 25 1- Department of Nursing and Physiotherapy, University of Lleida, Lleida, Spain.  
26  
27 2- Health Care Research Group, GRECS, Biomedical Research Institute of Lleida,  
28 Lleida, Spain.  
29  
30 3- Center for Biomedical Research on Diabetes and Associated Metabolic  
31 Diseases, Health institute Carlos III, Barcelona, Spain.  
32  
33 4- Group on Society Studies, Health, Education and Culture, University of Lleida,  
34 Lleida, Spain.  
35  
36  
37  
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39

40 **Correspondence to** Esther Rubinat Arnaldo; Carrer de Montserrat Roig, 2,  
41 25198 Lleida, Espanya; [esther.rubinat@udl.cat](mailto:esther.rubinat@udl.cat); +34 973 70 24 43.  
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45 **Word count** 4371  
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## 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.<sup>[1,2]</sup> Maintaining sitting, reclining and lying postures are sedentary behaviours with low energy expenditure (<1.5 METs).<sup>[3]</sup> It is important to remark that sedentary behaviour and physical inactivity have different meanings,<sup>[4]</sup> being the latter the result of performing insufficient amounts of moderate (3-6 METs) and vigorous(>6 METS) intensity activity.<sup>[3]</sup> 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

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3 (at least 150' moderate- or 75' vigorous- physical activity, per week);<sup>[5]</sup> the  
4 worldwide average is lower but still surpasses 30%.<sup>[6]</sup> Moreover, these numbers  
5 may be worse due to COVID-19, where home confinement and mobility  
6 restrictions are necessary to reduce the spread of the virus, increasing  
7 sedentary behaviour.<sup>[7]</sup>  
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12 Even though the association seems obvious, there is limited evidence that  
13 physically active individuals have less prevalence of suffering from chronic  
14 musculoskeletal complaints.<sup>[8]</sup> More high-quality studies are required to  
15 determine the cause/effect of sedentary behaviour and its association with  
16 musculoskeletal pain.<sup>[9]</sup> This condition is one of the leading causes of health  
17 problems for the global population, causing work disability, absenteeism, and  
18 work presentism.<sup>[10]</sup>  
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25 Because the office workplace is an unfavourable environment in terms of high  
26 sedentary behaviour,<sup>[11]</sup> daily exercise is crucial to prevent pathologies caused  
27 by the lack of movement and poor posture while spending most of the workday  
28 in front of the computer.<sup>[12,13]</sup> In a study by Kaliniene<sup>[14]</sup> with 513 public service  
29 sector computer workers in Lithuania, the participants without rest breaks in their  
30 schedules had a higher prevalence (8,1-13%) of suffering from musculoskeletal  
31 disorders in the elbow, wrist/hand, upper and lower back than participants with  
32 rest breaks every 2 hours. This higher prevalence of suffering pain is also due  
33 to working overtime, high quantitative and cognitive demands and not  
34 performing breaks during work hours, increasing the total time spent in a seated  
35 position.<sup>[14,15]</sup>  
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45 Since productivity seems to be maintained by different standing breaks (5  
46 minutes every 30 minutes of work to bouts of 50 seconds in 5 minutes of work)  
47 compared to not taking breaks in one hour of work,<sup>[16]</sup> performing exercise  
48 interventions may help reduce the effect of sickness presenteeism on  
49 musculoskeletal complaints and the ability to work.<sup>[17]</sup>  
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54 Having a daily schedule for exercise interventions at work might help reduce the  
55 time spent sitting and increase the daily physical activity of employees,<sup>[18]</sup>  
56 preventing cardiovascular and metabolic illnesses and reducing musculoskeletal  
57 dysfunction of the back.<sup>[19]</sup>  
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3 Strength and aerobic exercises focusing on the reduction of the intensity,  
4 disability, and duration of neck and shoulder pain can be easily performed in work  
5 environments because they do not require equipment and can be performed with  
6 office worker's own bodyweight.<sup>[20]</sup> Regarding the type of exercises, the most  
7 common interventions use stretching and strength training exercises.<sup>[21,22]</sup>  
8 Additionally, the practice of disciplines such as yoga<sup>[23]</sup> or qigong,<sup>[24]</sup> was  
9 implemented in the workplace together with home-based sessions that could be  
10 considered a feasible option in the treatment of musculoskeletal disorders related  
11 to their job demands.  
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19 However, to our knowledge, this is the first systematic review focusing exclusively  
20 on workplace exercise interventions in the treatment of musculoskeletal disorders  
21 in symptomatic office workers of any sector who spend most of their time in a  
22 seated position.  
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27 This review's practical implications aim to:

- 28 - Determine the effect of workplace exercise interventions in the treatment  
29 of musculoskeletal disorders.
- 30 - Describe the characteristics of workplace interventions to improve  
31 therapeutic exercise programs for office workers.
- 32 - Recommend future lines of research enhancing interventions for a more  
33 active lifestyle of sedentary workers.  
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## 42 2. METHODS

43 A systematic review of RCTs published in English and Spanish between Jan 1,  
44 2010 and Dec 31, 2020 was conducted according to the PRISMA standards.<sup>[25]</sup>  
45 The study protocol provides more specific details.<sup>[26]</sup>  
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### 52 Data sources and search strategy

53 The search was generated using PubMed MeSH terms and keywords related to  
54 office workers, musculoskeletal pain and exercise interventions. Subsequently,  
55 the search was adapted in the following databases: CINAHL Plus, Cochrane,  
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3 Scopus, ISI WoS and PeDRO. The full search strategy for all databases is  
4 available in supplementary file 1.  
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7 The strategy was reviewed in pairs and followed the criteria of the PRESS tool.<sup>[27]</sup>  
8 Two reviewers (RP and CT) performed a peer review of all the retrieved records  
9 by titles and abstracts and then by full text using the Covidence tool.<sup>[28]</sup>  
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### 15 **Inclusion criteria and study selection**

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17 The selection criteria for conducting the review were as follows:  
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- 19 (1) RCT articles with at least one intervention through exercise at work.
- 20 (2) Studies with an entire sample carried out on office workers spending the  
21 majority of their working hours sitting.
- 22 (3) Evaluation of musculoskeletal disorders or pain in the intervention in all  
23 body regions or specific areas of the body.
- 24 (4) Exercise interventions in the workplace, excluding those with exercises  
25 prescribed at home or outside the office setting.
- 26 (5) Studies in which the intervention is by means of "Sit-Stand Workstations"  
27 or Guidelines of ergonomics and health education without a physical  
28 exercise program have been excluded.  
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### 42 **Data extraction**

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44 Data extraction was performed by two reviewers (CT and CB), based on the  
45 recommendations of the Cochrane Handbook for Systematic Reviews of  
46 Interventions.<sup>[29]</sup> Data extraction was carried out in a standardised way, following  
47 the characteristics of the studies' methodology taking into account participants,  
48 interventions, outcome measures and the results section. The consensus method  
49 was used to resolve differences between reviewers where it did not take a third  
50 reviewer (FR) to reach the full consensus.  
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### **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.<sup>[30]</sup> 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<sup>[31]</sup> and the SWiM Checklist items.<sup>[32]</sup> 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<sup>[33,34]</sup>, del Pozo-Cruz in 2013<sup>[35]</sup>, Nakphet and Andersen in 2014<sup>[36,37]</sup>, Kaeding in 2017<sup>[38]</sup>, and Shariat in 2018.<sup>[39]</sup> A total of 967 participants were included in the seven studies, from the smallest sample of 30 participants<sup>[36]</sup> to the largest with 549.<sup>[33]</sup> A summary of the different interventions, statistical analysis of the relevant outcomes and the results of the different studies are shown in Table 1.

For peer review only

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 <i>et al</i> (2010) <sup>[33]</sup>	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 <i>et al</i> (2014) <sup>[37]</sup>	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 <i>et al</i> (2010) <sup>[34]</sup>	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 Assessment (PSA) created by the author.	No
Kaeding <i>et al</i> (2017) <sup>[38]</sup>	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.		
1 2 3 4 5 6 7 8 9 10 11	Del Pozo-Cruz <i>et al</i> (2013) <sup>[35]</sup>	Spain	<b>n=90 (24 ♂, 66 ♀)</b> 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
12 13 14 15 16 17 18 19 20 21 22	Shariat <i>et al</i> (2018) <sup>[39]</sup>	Malaysia	<b>n=142 (47 ♂, 95 ♀)</b> 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
23 24 25 26 27 28 29 30 31 32 33 34	Nakphet <i>et al</i> (2014) <sup>[36]</sup>	Thailand	<b>n=30 ♀ (18-40 years)</b> 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
35 36 37 38 39	<b>Abbreviations:</b> 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.							

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4 Interventions varied in each study, from 10- to 15-second stretch exercises every  
5 six minutes while working<sup>[34]</sup> to up to one-hour strengthening exercises for 2–3  
6 sets of 10–15 repetitions, combined with 5-second static neck exercises once a  
7 week.<sup>[33]</sup> A three-minute breaks intervention in Nakphet<sup>[36]</sup> with a dynamic  
8 contraction group and a stretching group focused on the neck/shoulder region;  
9 Andersen and Shariat<sup>[37,39]</sup> with a three-days-a-week intervention, Andersen with  
10 10- to 15-minutes stretching routine<sup>[39]</sup> and Shariat<sup>[37]</sup> with a 20-minutes strength  
11 routine with scapular training function. Kaeding's study<sup>[38]</sup> with whole-body  
12 interventions performed 2.5 sessions a week with 15 minutes of vibration training  
13 and del Pozo-Cruz<sup>[35]</sup> with a five-day-a-week exercise intervention of seven  
14 minutes of physical exercise combining postural stability strengthening, flexibility,  
15 mobility, and stretching.  
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25 Regarding the length of the interventions, prevail studies with medium- and long-  
26 term interventions, except for Nakphet,<sup>[36]</sup> were performed with a one-day  
27 intervention to observe the acute effects of two workplace exercise interventions  
28 compared with a passive pause and Marangoni<sup>[34]</sup> with a three-week intervention.  
29 The rest of the studies lasted from a 10-week intervention in the case of  
30 Andersen<sup>[37]</sup>, three months in the Kaeding<sup>[38]</sup> intervention, Shariat<sup>[39]</sup> with a six-  
31 month intervention, a nine-month intervention in the del Pozo-Cruz study<sup>[35]</sup> and  
32 a one-year intervention in Andersen's<sup>[33]</sup>.  
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39 There is great variety in the comparison groups that sort from control groups  
40 without intervention, the ergonomic guidelines in Marangoni, Andersen, Kaeding  
41 and Shariat,<sup>[34,37–39]</sup> ergonomic and health guidelines in Andersen and del Pozo-  
42 Cruz,<sup>[33,35]</sup> and a passive pause intervention group taking hands off of the  
43 computer for a three-minutes rest period in Kaeding's.<sup>[36]</sup>  
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### 50 **3.3. Risk of bias**

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52 All of the studies, except for Andersen's,<sup>[33]</sup> had a "high risk" in the "measurement  
53 of the outcome" section because the participants and/or instructors were not  
54 blinded. The main difference in Andersen's<sup>[33]</sup> was that participants were blinded  
55 due to the cluster randomisation and the internet-based questionnaires.  
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3 In Marangoni, Nakphet and Shariat<sup>[34,36,39]</sup> we found "some concerns" in the  
4 section "selection of the reported results" due to the lack of a "prespecified  
5 analysis plan". Although all the studies were randomised, in the study of  
6 Nakphet,<sup>[36]</sup> the type of randomisation was not specified and was considered  
7 "high risk" in the "randomisation process". Another section to highlight is that in  
8 charge of evaluating "missing the outcome data", where, despite finding five  
9 articles with low adherence, Andersen and Shariat documented the cause of the  
10 dropout.<sup>[37,39]</sup> In Andersen<sup>[33]</sup> there is no information about why the participants  
11 dropped out of the study, and Marangoni<sup>[34]</sup> did not specify the number of  
12 participants or the reason for the drop out having a "high risk" of bias in this  
13 section. A summary of the risk of bias is shown in Figure 2 and Figure 3.  
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24 Figure 2. Risk of bias graph: review authors' judgements about risk of bias items  
25 presented as percentages across the included RCTs.  
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30 Figure 3: Risk of bias summary: review authors' judgements about each risk of  
31 bias item for each included study. In green (Low risk), yellow (Some concerns)  
32 and red (High risk).  
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### 38 **3.4. Effects of workplace exercise interventions in reducing** 39 **musculoskeletal disorders and pain** 40

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42 In Andersen, Marangoni and Shariat,<sup>[33,34,39]</sup> the reduction of musculoskeletal  
43 pain in office workers was assessed in multiple body parts. Nakphet and  
44 Andersen<sup>[36,37]</sup> focused on the neck and shoulder area, while del Pozo-Cruz and  
45 Kaeding<sup>[35,38]</sup> assessed workplace interventions concerning disability caused by  
46 lower back pain.  
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#### 52 **3.4.1. Effects of workplace exercise interventions in reducing** 53 **musculoskeletal disorders in multiple body regions** 54

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56 As mentioned above, Andersen, Marangoni and Shariat<sup>[33,34,39]</sup> evaluated  
57 workplace exercise interventions' effectiveness in reducing musculoskeletal pain  
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3 in more than one specific region. In Andersen's<sup>[33]</sup> Nordic Questionnaire was used  
4 to measure musculoskeletal symptoms, and the VAS scale was used to measure  
5 the participants' pain perception. The intensity of pain had a significant reduction  
6 in the neck, lower back, right elbow and right hand, in the two interventions, with  
7 exercise and physical activity compared to the reference group ( $P < 0.0001-0.05$ )  
8 main effects for region ( $F=3.04$ ,  $P < 0.0005$ ), group ( $F=2.93$ ,  $P=0.05$ ) and status  
9 ( $F=905$ ,  $P < 0.0001$ ). In the feet region, the group where participants were  
10 encouraged to perform physical activity on their own, had a greater decrease in  
11 pain perception than the workplace exercise intervention ( $P < 0.001$ ) and the  
12 reference group ( $P < 0.05$ ).

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

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36 The Shariat study<sup>[39]</sup> found significant differences in pain reduction after 6 months  
37 of intervention using the Cornell Musculoskeletal Disorders Questionnaire in the  
38 groups with exercise sessions, compared to the control group without intervention  
39 in the neck [MD-10.55(-14.36 to -6.74)], right shoulder [MD-12.17(-16.87 to -  
40 7.47)], left shoulder [MD-11.1(-15.1 to -7.09)] and lower back [MD-7.8(-11.08 to -  
41 4.53)]. Additionally, significant differences were found with the combined group  
42 with exercises and ergonomic guidelines compared to the control group in the  
43 same regions, neck (-13.63 to -6.36)], right shoulder [MD-11.12 (-15.59 to -6.65)],  
44 left shoulder [MD-10.67 (-14.49 to -6.85)] and lower back [MD-6.87 (-10 to -3.74)].  
45 Measures were taken every 2 months, and the most significant improvement in  
46 pain reduction was experienced from months 4 to 6 in the exercise group ( $p <$   
47 0.05).

#### 58 **3.4.2. Effects of workplace exercise interventions in reducing** 59 **musculoskeletal disorders and pain in the neck and shoulder region** 60



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3 Nakphet and Andersen<sup>[36,37]</sup> carried out interventions where neck and shoulder  
4 pain were assessed. In Andersen's study,<sup>[37]</sup> there was a significant reduction in  
5 pain in the neck and shoulder region 2.0 (95% CI 0.4–3.6) ( $p < 0.01$ ) and an  
6 increase in the lower trapezius pressure pain threshold 129 kPa (95% CI 31–227  
7 kPa) ( $p < 0.01$ ) in the active pause group compared to the control group that did  
8 not perform any intervention in the neck/shoulder region. No significant  
9 differences in the pressure pain threshold in the other body regions were  
10 measured.  
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20 Otherwise, in Nakphet,<sup>[36]</sup> for the assessment of pain, the Borg Scale for pain  
21 perception was used, and there was a reduction in neck discomfort in the three  
22 groups after each pause without significant differences between the active  
23 pauses and the passive pauses intervention group: neck:  $F(6.16, 83.16) = 1.41$ ,  
24  $p = .221$ ; right shoulder:  $F(4.97, 67.11) = 1.30$ ,  $p = .273$ ; left shoulder:  $F(6.56,$   
25  $88.54) = 1.15$ ,  $p = .342$ ; right elbow:  $F(6.78, 91.76) = 0.91$ ,  $p = .500$ ; left elbow:  
26  $F(5.29, 71.36) = 0.73$ ,  $p = .613$ ; right wrist and hand:  $F(5.45, 73.55) = 1.14$ ,  $p =$   
27  $.347$ ; and left wrist and hand:  $F(4.86, 65.59) = 1.39$ ,  $p = .242$ .  
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### 36 **3.4.3. Effects of workplace exercise interventions in reducing** 37 **musculoskeletal disorders and pain in disability caused by low back pain**

38 The del Pozo-Cruz and Kaeding studies involved reducing disability and the  
39 intensity of lower back pain<sup>[35,38]</sup>. In Kaeding,<sup>[38]</sup> where the intervention was made  
40 through the use of a whole-body vibration machine, improvements were reported  
41 in reducing lower back disability compared to the control group in which there  
42 was no intervention. There was a mean difference between the two groups in  
43 the Roland Morris Questionnaire of 1.8 RMQ points (95% CI: [0.2, 3.4]) ( $P = .027$ ),  
44 with an improvement in the training group of 1.5 ( $\pm 2.6$ ) RMQ points, while the  
45 control group worsened by an average of 0.3 ( $\pm 2.6$ ) RMQ points. Additionally,  
46 measures for the Oswestry Disability Index and changes at the end of the  
47 intervention were significantly higher in the training group, with a 4.5 ( $\pm 6.6$ )  
48 improvement in relation to a  $-1.2 \pm (3.2)$  worsening for the control group ( $P =$   
49  $.002$ ).  
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3 There was also a reduction in disability caused by lower back pain in the del  
4 Pozo-Cruz study<sup>[35]</sup> among participants who performed a physical exercise  
5 intervention measured by the Oswestry Disability Index questionnaire, with a  
6 clinical change of 5.420 (1.707 to 17.216) 85%,  $P = 0.001$ ) compared to the  
7 control group. Additionally, there was a reduction in the risk of chronicity (SBST  
8 clinical change, 75%,  $P < 0.001$ ) and the EQ-5D-3 L pain- and disability-related  
9 components (visual analogue scale (VAS) 73%,  $P < 0.001$ ; mobility, 77%,  $P <$   
10 0.001; self-care, 79%,  $P = 0.003$ ; pain/discomfort, 88%,  $P < 0.001$ ). However, the  
11 participants in the intervention group did not perceive an improvement in the  
12 performance of their daily tasks ( $P = 0.103$ ). Additionally, in the nonphysical  
13 exercise group, an increase in disability and low back pain episodes was reported  
14 at the end of the intervention.  
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#### 26 **4. DISCUSSION**

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28 Based on the results of seven RCTs, exercise has significant benefits in treating  
29 musculoskeletal disorders of the lower back, neck and general regions of the  
30 body. There was a wide variety of exercise routines performed in the different  
31 interventions, with supervised or unsupervised programs, different outcome  
32 measures, and the number of participants with musculoskeletal disorders who  
33 participated in each study. Diversity has also been found in comparative groups  
34 with other exercise interventions and ergonomic advice or control groups without  
35 intervention.  
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43 There is a lack of consistency in the outcomes, not allowing us to draw firm  
44 conclusions regarding the effectiveness of workplace exercise interventions in  
45 treating musculoskeletal disorders.  
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48 The trials' overall risk of bias was considered high, except for Andersen's,<sup>[33]</sup>  
49 which was the only study that blinded the instructor and the participants. The rest  
50 of the RCTs did not provide blinding of their participants or the exercise program's  
51 instructors, both being the most important aspects for quality assessment that  
52 can affect the internal validity of the results, despite being very complicated to  
53 implement in exercise interventions.<sup>[40]</sup> Regarding external validity, it should be  
54 noted that interventions were carried out in the workplace, except for the Nakphet  
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3 study,<sup>[36]</sup> where the office was simulated in a laboratory to carry out a one-day  
4 intervention to gather surface myoelectric activity of the targeted muscles. This  
5 might be a limitation, as it is essential to carry out interventions on employees'  
6 workspaces so that the results can be easily extrapolated to the population that  
7 works in an office setting.<sup>[41]</sup>  
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12 More significant efforts should be made when carrying out participant recruitment  
13 and designing the intervention procedure, considering essential aspects to  
14 reduce biases such as blinding and losses in the follow-up.<sup>[42]</sup>  
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18 As previously mentioned, one remarkable point of the review is the significant  
19 difference in the interventions that workers carried out in the different studies.  
20 The duration of the studies with physical exercise in clinical and nonclinical  
21 populations is commonly between one and three months so that the performance  
22 of the intervention and the economic costs would be viable.<sup>[40]</sup>  
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27 The studies reviewed showed no difference between longer or shorter sessions  
28 with greater frequency in exercise physiological adaptations regarding exercise  
29 volume and weekly frequency; however, further investigation is required to draw  
30 firm conclusions. Mainenti<sup>[12]</sup> showed that physical activity in a more extended  
31 session is not associated with decreased sedentarism levels. Therefore, using  
32 brief sessions with a high weekly frequency could provide office workers with  
33 significant improvements without a prolonged stoppage of their work activity.<sup>[43]</sup>  
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## 40 41 42 **Evidence of workplace exercise interventions in the treatment of** 43 **musculoskeletal disorders** 44

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46 As inclusion criteria of the search, one of the key points was that study  
47 interventions should be exclusively at the workplace. It is difficult to determine if  
48 the musculoskeletal disorders are work-related or there may be other leading  
49 causes. However, even in non-work-related musculoskeletal disorders, the  
50 implementation of workplace exercise interventions could help reduce the  
51 symptoms that might worsen by prolonged sitting and working without rest breaks  
52 in their schedule.  
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58 Three studies that evaluated musculoskeletal pain in multiple body regions<sup>[33,34,39]</sup>  
59 concluded that workplace exercise interventions reduced pain compared with the  
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3 control groups. Rodrigues' systematic review,<sup>[44]</sup> which also included Marangoni's  
4 study,<sup>[34]</sup> found that regarding the duration of the exercise program, performing  
5 strength exercises in the workplace three times a week for 20 minutes could  
6 reduce musculoskeletal pain in the different regions of the spine and the upper  
7 limbs. Another systematic review<sup>[45]</sup> focused on video display terminal workers  
8 with musculoskeletal pain, using a rehabilitation program with exercises, pain  
9 education, and ergonomic adjustments found a significant reduction in pain in  
10 different body areas, such as the wrist, shoulder and lower back regions.

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

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44 When focusing on treating lower back pain among office workers, both studies  
45 analysed concluded there were positive effects on reducing musculoskeletal  
46 pain. There was a disparity between the workplace exercise interventions  
47 performed. The del Pozo-Cruz study<sup>[35]</sup> consisted of a 9-minute daily routine with  
48 strength, stretching and mobility exercises in a 9-month intervention, while  
49 Kaeding<sup>[38]</sup> performed 2.5 sessions a week of whole-body vibration training with  
50 10-15-minute sessions during a 3-month intervention. These studies agree with  
51 the results indicated by the Sipaviciene study<sup>[47]</sup> that showed positive effects of  
52 performing stabilization exercises for the trunk and of muscle strength exercise  
53 program to reduce lower back pain. Additionally, the systematic review by  
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3 Gordon<sup>[48]</sup> concluded that a general exercise programme with strength, flexibility  
4 and aerobic training would be beneficial for treating nonspecific, chronic lower  
5 back pain in the adult population.  
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8  
9 Adherence to the exercise prescribed using compliance terminology was  
10 reported in more than 80% of the total interventions performed in three of the  
11 seven studies analysed.<sup>[35,37,38]</sup> There is no standardised definition of adherence  
12 to the therapeutic exercise for musculoskeletal pain due to lack of consistency in  
13 the literature, finding other synonyms such as compliance or concordance.<sup>[49]</sup>  
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16  
17 A standard definition of therapeutic adherence reported in the studies reviewed  
18 by Bissonete, notes that: "Adherence can be defined as the extent to which  
19 patients follow the instructions they are given for prescribed treatments".<sup>[50]</sup> It is  
20 essential to consider the therapeutic adherence levels for participants with  
21 musculoskeletal pain when reporting the results of clinical trials.<sup>[49]</sup> Considering  
22 that adherence to exercise is ordinarily low,<sup>[51,52]</sup> strategies to enhance a higher  
23 rate of treatment adherence must be considered when designing the intervention  
24 procedure. The del Pozo-Cruz web-based intervention used a log-in system with  
25 high compliance reported. The implementation of web-based interventions using  
26 customized push reminders via e-mail or phone and regularly updating the  
27 content, such as Edney's study,<sup>[53]</sup> is also effective. Additionally, in Gram and  
28 collaborators,<sup>[54]</sup> no differences were found, where both intervention groups  
29 improved in terms of decreasing neck pain and headache with or without  
30 instructor supervision; as a web-based program with push reminders, it is likely a  
31 feasible option for future interventions.  
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35 Ambrose's study<sup>[55]</sup> concludes that any exercise regimen is better than a  
36 sedentary lifestyle as long as there is sustainable progression. Additionally,  
37 exercise induces analgesia in healthy people due to the pain inhibition  
38 mechanism by the reaction of endogenous opioids and nociception inhibitory  
39 mechanisms. However, in people with chronic pain, these reactions seem to not  
40 occur in the same way, and pain relief requires time after the initial increase in  
41 pain has been overcome.<sup>[56]</sup> In Bravo's study,<sup>[57]</sup> where therapeutic exercises  
42 were performed in fibromyalgia participants, a significant reduction in pain did not  
43 appear until 2 weeks after the intervention.  
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3 Hence, it is essential to consider specific items at the methodological level and a  
4 multidimensional approach<sup>[58,59]</sup> to carry out interventions with appropriate  
5 exercise regimens to achieve a low drop-out rate with high compliance with  
6 exercise interventions preferences, self-management and pain neuroscience  
7 education for the treatment of musculoskeletal disorders.<sup>[60,61]</sup>  
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## 14 **Study limitations**

15  
16 The present study was limited by the small number of RCTs available that  
17 perform workplace exercise interventions to treat musculoskeletal disorders. Only  
18 studies published in English and Spanish were analysed. Relevant articles  
19 published in other languages could be lost.  
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24 The great diversity in the methodological aspects of the different interventions  
25 performed in the trials could be a limitation. We found significant heterogeneity in  
26 the samples, in the type of interventions and in the period in which the studies'  
27 pre/post interventions were carried out. Additionally, heterogeneity was found in  
28 the outcomes, which did not allow us to perform a meta-analysis due to the  
29 different outcome measures for musculoskeletal disorders and pain used in the  
30 studies.  
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36 Musculoskeletal conditions are a global concern.<sup>[62]</sup> More studies are needed to  
37 draw firm conclusions related to developed and developing countries where  
38 different factors can predict Musculoskeletal disorders in office workers.<sup>[63]</sup> The  
39 studies included in the review are conducted in developed with high income<sup>[33–</sup>  
40 <sup>35,37,38]</sup> and developing countries with middle-upper income.<sup>[36,39]</sup> Differences  
41 could be found when extrapolating results to low and middle-income countries  
42 because the prevalence of musculoskeletal disorders is rising exponentially.<sup>[62]</sup>  
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49 The review only focused on RCTs, excluding studies with interventions without a  
50 control group. The control groups' interventions analysed were heterogeneous,  
51 with no interventions, while others had other exercise interventions, or ergonomic  
52 and health guidelines.  
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56 The sample size of participants was low in the majority of the studies<sup>[34–38]</sup>  
57 together with the use of nonvalidated scales,<sup>[33,34,36,37]</sup> which could be a limitation  
58 of the results obtained.  
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## 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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10 **Conflicts of Interest** None declared.  
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15 **Data availability statement** No additional data are available.  
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20 **Ethical Approval Statement** Not applicable.  
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## 25 **ORCID iDs**

26  
27  
28 Carlos Tersa-Miralles <https://orcid.org/0000-0001-7037-5033>  
29

30 Cristina Bravo <http://orcid.org/0000-0002-2962-8198>  
31

32 Filip Bellon <https://orcid.org/0000-0003-4880-9207>  
33

34  
35 Roland Pastells-Peiró <https://orcid.org/0000-0002-9561-9038>  
36

37  
38 Esther Rubinat <https://orcid.org/0000-0003-0232-9777>  
39

40 Francesc Rubí-Carnacea <https://orcid.org/0000-0002-0162-3950>  
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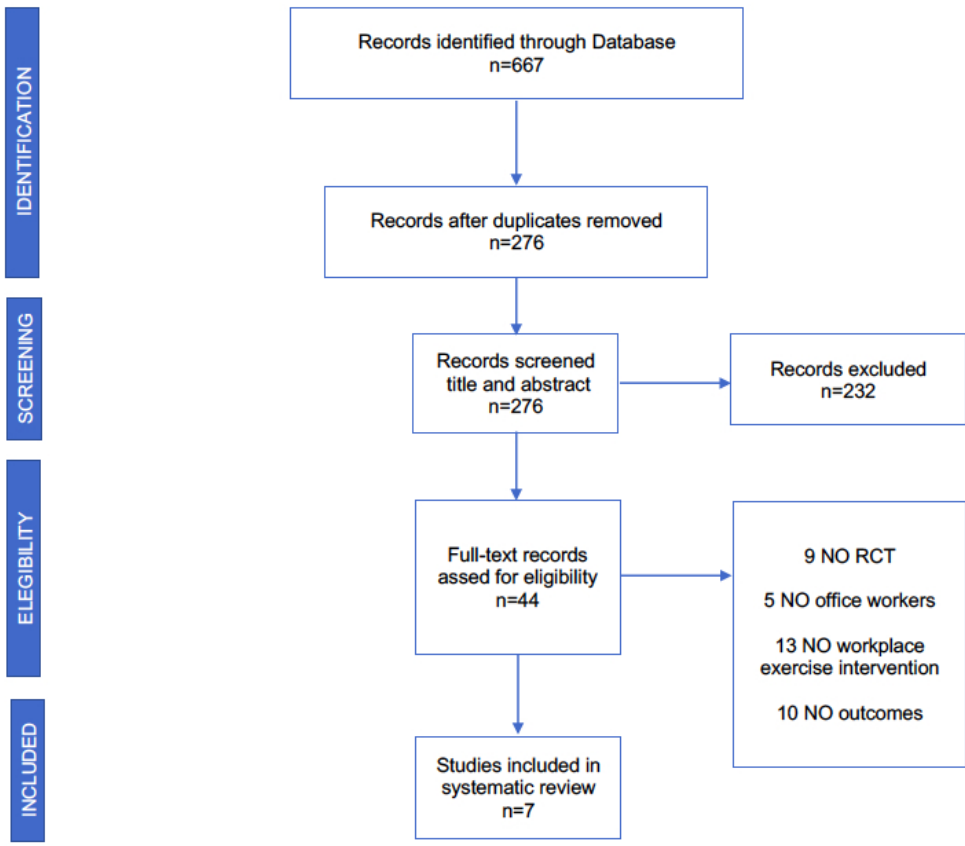


Figure 1. Flow diagram of trial selection, adapted from PRISMA

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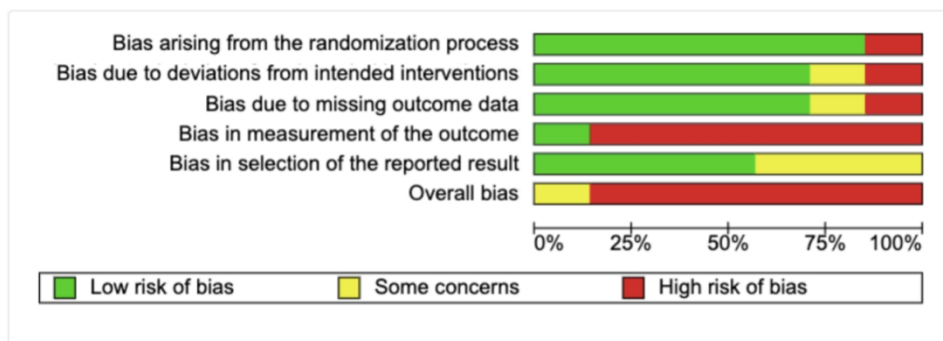


Figure 2. Risk of bias graph: review authors' judgements about risk of bias items presented as percentages across the included RCTs.

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	Bias arising from the randomization process	Bias due to deviations from intended interventions	Bias due to missing outcome data	Bias in measurement of the outcome	Bias in selection of the reported result	Overall bias
Andersen 2010	+	+	?	+	+	?
Andersen 2014	+	+	+	-	+	-
del Pozo-Cruz 2013	+	+	+	-	+	-
Kaeding 2017	+	+	+	-	+	-
Marangoni 2010	+	-	-	-	?	-
Nakphet 2014	-	+	+	-	?	-
Shariat 2018	+	?	+	-	?	-

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	<p>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])</p> <p>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])</p> <p>3. ("Exercise movement Therapy"[MeSH] OR "Exercise movement Therapy"[tiab] OR "Exercise Therapy"[MeSH] OR "Exercise Therapy"[tiab] OR "Circuit Based Exercise"[MeSH] OR "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])</p> <p>4. 1 AND 2 AND 3</p> <p>- Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only</p>
CINHAL	<p>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</p>

	<p>Cervical Pains" OR "Posterior Neck Pain" OR "Posterior Neck Pains" OR "Shoulder pain" OR "Shoulder pain" OR "Shoulder pains"))</p> <p>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"))</p> <p>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"))</p> <p>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"))</p> <p>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"))</p> <p>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"))</p> <p>7. 1 OR 2 AND 3 OR 4 AND 5 OR 6</p> <p>- Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only</p>
Cochrane	<p>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</p>

	<p>Cervical Pains” OR “Posterior Neck Pain” OR “Posterior Neck Pains” OR “Shoulder pain” OR “Shoulder pain” OR “Shoulder pains”)):ti,ab,kw</p> <p>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</p> <p>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</p> <p>4. 1 AND 2 AND 3</p> <p>- Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only</p>
Scopus	<p>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”)</p> <p>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”)</p> <p>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”)</p> <p>4. 1 AND 2 AND 3</p> <p>- Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only</p>
ISI WoS	<p>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</p>

	<p>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)</p> <p>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)</p> <p>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)</p> <p>4. 1 AND 2 AND 3 AND</p> <p>- Filters/Limits: Publication Date = 1 January 2020 to 31 December 2020; Language = English and Spanish only</p>
PeDRO	<p>A simple search of the different terms and their synonyms:</p> <ol style="list-style-type: none"> <li>1. Musculoskeletal Disorders</li> <li>2. Office workers</li> <li>3. Exercise Therapy</li> </ol>



## PRISMA 2020 Checklist

Section and Topic	Item #	Checklist item	Location where item is reported
<b>TITLE</b>			
Title	1	Identify the report as a systematic review.	1
<b>ABSTRACT</b>			
Abstract	2	See the PRISMA 2020 for Abstracts checklist.	2
<b>INTRODUCTION</b>			
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
<b>METHODS</b>			
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.	
<b>RESULTS</b>			
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.	
<b>DISCUSSION</b>			
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
<b>OTHER INFORMATION</b>			
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

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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/>

For peer review only



## 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>

<b>SWiM is intended to complement and be used as an extension to PRISMA</b>			
<b>SWiM reporting item</b>	<b>Item description</b>	<b>Page in manuscript where item is reported</b>	<b>Other*</b>
<i>Methods</i>			
<b>1</b> 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		
<b>2</b> 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	
<b>3</b> 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	
<b>4</b> 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*
<b>5</b> 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	
<b>6</b> Certainty of evidence	Describe the methods used to assess certainty of the synthesis findings	7	
<b>7</b> 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	
<i>Results</i>			
<b>8</b> 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	
<i>Discussion</i>			
<b>9</b> 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)).