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# Impact of Stretching Exercises on Work-Related Musculoskeletal Disorders: A Systematic Review

Qais Gasibat[1], Babina Rani[2]*, Denis Causevic[3], Seth Spicer[4], Reniery Pereira da Silva[5], Yu Xiao[1], Xiang Changqing[1], Nabilah Binti Ahmad[1], Agiela E Rafieda[6]

[1]*Department of Sport Studies, University Putra Malaysia UPM 43400, Selangor, Malaysia*

[2]*Department of Physical & Rehabilitation Medicine (Physiotherapy), Post Graduate Institute of Medical Education & Research, Chandigarh 160012, India*

[3]*Faculty of Sport and Physical Education, University of Sarajevo, 71000 Sarajevo, Bosnia and Herzegovina*

[4]*Department of Medicine, Rowan University School of Osteopathic Medicine, 1 Medical Center Drive, Stratford, NJ, 08084, USA*

[5]*Physical Activity Sciences Laboratory, University of São Paulo USP. 03828-000, São Paulo, Brazil*

[6]*Physiotherapy Department, College of Medical Technology, Misrata, Libya*

***Corresponding Author:** Babina Rani, E-mail: says2babina@gmail.com

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## ABSTRACT

**Objective:** This study aims to compile the latest information concerning workplace stretching regimens and to give a panoramic view of their effectiveness in reducing work-related Musculoskeletal disorders (MSDs). **Methods:** Searching MEDLINE, Embase, CINAHL, PEDro, Web of Science, Scopus, Google Scholar, SPORTDiscus and PubMed databases from 2010 to 2022 found 723 eligible studies, based on predefined inclusion criteria. **Results:** In the review, 14 included studies recruited subjects aged >18 years, with males (n=813), females (n=5141), and some research did not identify gender (n=3). The included studies were of both high (n=6) and low quality (n=8). Seven studies revealed stretching exercises to be an effective and safe non-pharmacological intervention for MSDs, and one study included an active control group observed better improvement in the treatment group. Four trials showed a significant effect from stretching exercises as a stand-alone treatment. Three studies revealed that stretching exercises had a meaningful and major effect on MSDs complaints, while two studies reported no significant results when utilizing Anti-fatigue mats in addition to stretching. **Conclusion:** The current study indicated that stretching exercises are a crucial and useful technique for preventing and treating pain and function in Work-related MSDs affecting the neck, shoulder, back, etc. Workplace/ergonomic changes can enhance the results of stretching exercises.

**Key words:** Muscle Stretching Exercises Musculoskeletal Diseases, Occupational Groups, Ergonomics, Workplace

## INTRODUCTION

Musculoskeletal Disorders (MSDs) are frequently related to occupational risk factors (Padula et al., 2016), and there is a correlation between the socioeconomic status of employees and musculoskeletal pain at different anatomical locations (Laclerc et al., 2016). There is an expanding body of evidence to prove that poor ergonomics can lead to various MSDs due to risk factors such as contact stress, uncomfortable posture (bodily postures that vary considerably from the neutral position while executing occupational tasks), and repetition (Adam et al., 2016). According to studies, ergonomic MSDs can cause physical injuries or pain resulting in medical leave, disability, and absence from work (Cho et al., 2012). The bottom line of an employer may suffer as a result. The individual's quality of life (QoL) and the productivity of their company, both are negatively impacted by MSDs.

About 70-80% of persons in developed nations will experience MSDs at some time in their life (Steenstra et al., 2003; Shariat et al., 2016a,b). Neck, shoulders, and lower back are the sites prone to MSDs. Work-related MSDs can be affected by the physical and mental health of a person, as well as other sociological and psychological concerns, according to World Health Organization (WHO) (Piranveyseh et al., 2016). This provides support for the idea that employees are more vulnerable to MSDs due to the nature of their jobs.

Interventions and therapies proposed by previous studies (Healy et al., 2013; Sihawong et al., 2011) are sometimes excessively generic and costly. There is a vacuum in the research that has been identified, and that gap is the fact that

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many studies solely investigate the immediate advantages of therapies (Purepong et al., 2015; Maakip et al., 2016). In one example, a recent study demonstrated reduced discomfort in the neck and shoulders following a four-week intervention of regular stretching exercises. However, the study did not indicate whether the stretching activities advised would result in relief that would be long-lasting (Repo et al., 2019). To treat ergonomic-related MSDs, several therapies have been employed, such as ergonomic adjustment, rest periods, and workplace exercise (Mueller and Hassenzahl, 2010). The extent to which a particular sequence of stretching exercises can effectively reduce or prevent MSDs among employees remains largely uncertain. According to an earlier review, stretching exercises were beneficial in preventing work-related MSDs, but studies included had a relatively low methodological quality (Da Costa and Vieira, 2008).

Stretching exercises are becoming increasingly popular with the aim of decreasing the likelihood of MSDs at work. Even so, little is understood regarding how effective stretching regimens are at preventing MSDs. Stretching exercises have the potential to decrease muscular stiffness and promote flexibility (Owada et al., 2022). It has been documented in literature that workplace stretching exercises can reduce and prevent work-related MSDs resulting from awkward postures and static loading (Schaller and Froboese, 2014). With that said, there is paucity of a systematic elaboration of the effects of stretching interventions on the prevention of MSDs in workers of different occupations, and a specific programme to guide stretching activities in the working population is lacking (Mehrparvar et al., 2014). Furthermore, a clear indication as to what the specific effects of the stretching exercises will be, especially regarding the prevention of work-related MSDs, is not presented in the research. Therefore, this study aims to compile the most recent research on workplace stretching regimens and present a panoramic view of their effects on preventing and/or lowering work-related MSDs in various occupational groups.

## METHODS

This systematic review was registered on PROSPERO (CRD42022367900) and conducted according to PRISMA guidelines.

### Identification and Selection of Studies

Eligible studies were identified by searching MEDLINE, Embase, CINAHL, PEDro, Web of Science, Scopus, Google Scholar, SPORTDiscus and PubMed from 2010 until 2022, using key words (including MeSH) such as Stretching; Exercises; Workplace; Injury; Occupation; Work prevention; Safety and Ergonomics. We excluded studies that did not focus on the benefits of stretching exercises in work-related MSDs. The language of the studies was restricted to English. Hand searching was performed through the reference lists of the original studies/systematic reviews identified, for potentially relevant articles. Included studies were of the experimental design that studied the effect of stretching exercises as a stand-alone intervention, compared to no treatment or other interventions. The search strategy used is summarized in Supplementary Table 1.

Four review authors (BR, SS, DC, RPS) independently performed the selection. At first, the titles and abstracts were screened for possible eligibility. All the retrieved articles were imported into the Rayyan software and checked for duplicates. Next, the full-text articles were independently screened for definite inclusion. Any discrepancies were resolved by mutual consensus or discussion with the two other authors (QG, AER).

### Participants

Subjects older than 18 years old, with work-related MSDs, without restrictions on race, gender, country, or economic status, were involved in the study, and the effects of stretching exercises on various parameters were evaluated.

#### *Eligibility criteria*

The studies were assessed for eligibility using the following PICOS criteria:

P: Participants: Adult subjects (over 18 years of age) with work-related MSDs, with no restriction on gender, race, country, economic status or nature of work
I: Intervention: A stretching programme designed to alleviate work-related MSDs and administered
C: Comparator: Studies comparing stretching regimen to other forms of exercise or active/passive control group
O: Outcome: At least one measure to evaluate pain/disability/workstation
S: Study design: Experimental study designs, including randomised or non-randomized controlled trials

### Intervention

#### *a) Experimental intervention*

Stretching exercises of any form, administered singly, constituted the entirety of the treatments for the experimental group. Research examining the effectiveness of stretching in combination with another intervention method was not considered. No constraints were placed on the types, numbers, or durations of stretches, or the types or numbers of measuring devices used.

#### *b) Control intervention*

The treatments of the control group included any therapy other than stretching exercises, including active and inactive control, and any other kind of control (e.g., medication, placebo, routine care, exercises, etc.).

### Data Extraction

Relevant data from all the studies were included, in the form of Sample characteristics; Occupation; Interventions in different groups; Technique, dose, duration, and effects of stretching were discussed, along with outcome metrics and

**Table 1.** Summary of methodological quality assessment scores

| Author and year | Eligibility criteria | Random allocation | Concealed allocation | Group similar at baseline | Blind subject | Blind therapist | Blind assessor | Follow -up | Intention to treat analysis | Between-group comparisons | Point measure + variability | PEDro score |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Marangoni, (2010) | Yes | Yes | No | No | No | No | No | Yes | Yes | Yes | No | 4/10 |
| Chen et al., (2014) | Yes | Yes | No | Yes | No | No | No | Yes | Yes | Yes | Yes | 6/10 |
| Lee and Gak, (2014) | Yes | No | No | Yes | No | No | No | Yes | Yes | No | No | 3/10 |
| Mehrparvar et al., (2014) | Yes | No | No | Yes | No | No | No | Yes | No | No | No | 2/10 |
| Nakphet et al., (2014) | Yes | Yes | No | Yes | No | No | No | Yes | No | Yes | No | 4/10 |
| Tunwattanapong et al., (2016) | Yes | Yes | No | Yes | No | No | Yes | Yes | Yes | Yes | Yes | 7/10 |
| Aje et al., (2018) | Yes | No | No | No | No | No | No | Yes | No | No | No | 1/10 |
| Shariat et al., (2018) | Yes | Yes | Yes | Yes | No | Yes | No | Yes | Yes | Yes | Yes | 8/10 |
| Oka et al., (2019) | Yes | Yes | No | Yes | No | No | No | Yes | Yes | Yes | No | 5/10 |
| King et al., (2020) | Yes | No | No | No | No | No | No | Yes | No | No | No | 1/10 |
| Holzgreve et al., (2020) | Yes | No | Yes | Yes | No | No | No | Yes | Yes | Yes | Yes | 6/10 |
| Silva Filho et al., (2020) | Yes | Yes | No | Yes | No | No | No | Yes | Yes | Yes | Yes | 6/10 |
| Fraeulin et al., (2021) | Yes | No | No | No | No | No | No | Yes | No | No | Yes | 2/10 |
| Prima et al., (2022) | Yes | No | No | No | No | No | No | Yes | No | No | Yes | 2/10 |

effects. When further information was requested, emails were sent to the corresponding authors of the included research.

### Quality Assessment

The methodological quality of the trials and selected articles was assessed using the PEDro scale (De Morton, 2009). Eleven questions make up the PEDro scale, which assesses four core methodological aspects of a study: randomization, blinding techniques, group comparison, and data processing procedures. The PEDro scale was used to evaluate trial quality independently by two raters, with disagreements resolved by a third rater (Lucas et al., 2019). As it had no influence on the reliability of the data collected, the item 1 (eligibility criteria) was left out of the final tally. The range of the PEDro scores was 0 to 10, with 10 being the highest. The higher the PEDro score of a procedure, the better it was. The efficacy of a method was measured against these standards: Low quality was indicated by PEDro scores under 5, whereas scores over 5 indicated high quality (De Morton, 2009). (Table 1).

### Data Syntheses and Analysis

This study is a combination of quantitative and qualitative data synthesis. For the purpose of determining the relative importance of various pieces of scientific data, researchers turned to best evidence synthesis (Moseley et al., 2002; Cruz-Ferreira et al., 2011). Depending on the number of studies, technical robustness and reproducibility of the results, the evidence of an observation could be classified into four major categories: 1) Strong evidence when the same result was reported in at least two high-quality studies; 2) Moderate evidence, when the same finding was reported in at least one high-quality study and at least one in a low-quality study or in multiple low-quality studies; 3) Limited evidence, when a finding was reported by at least one low-quality study or was inconsistent across at least two other studies; and 4) conflicting evidence, when a result reported by one journal contradicted results published in at least two other studies (Burns et al., 2011).

## RESULTS

### Flow of Studies Through The Review

The preliminary search yielded a range of 1033 results. Following the removal of duplicates using the screening system Rayyan, overall, only 310 unique hits were saved for further analysis. The titles and abstracts of 723 records were used to exclude them, and 43 papers were evaluated to determine eligibility. Finally, 14 papers were acceptable for inclusion in the current study (Marangoni, 2010; Chen et al., 2014; Lee and Gak, 2014; Mehrparvar et al., 2014; Nakphet et al., 2014; Tunwattanapong et al., 2016; Aje et al., 2018; Shariat et al., 2018; Oka et al., 2019; King et al., 2020; Holzgreve et al., 2020; Silva Filho et al., 2020; Fraeulin et al., 2021; Prima et al., 2022), while 29 were eliminated (Figure 1).

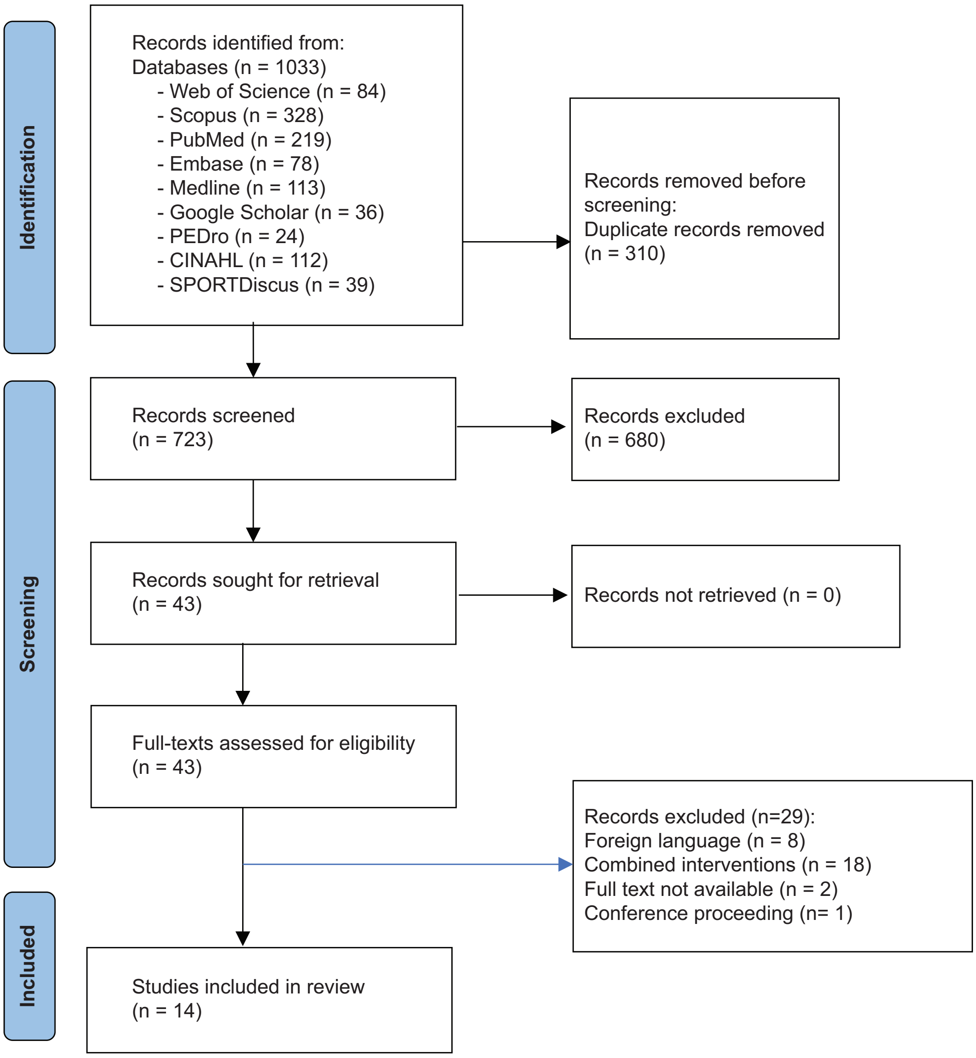


**Figure 1.** Prisma flow chart for systematic review of studies

### Description of Studies

All selected studies were published in the English language. The design of the studies was systematically reviewed: Randomised controlled trial (n=14). The distribution of countries where study was conducted was as follows: United States (n=2), Taiwan (n=1), Germany (n=2), Japan (n=1), Iran (n=1), Australia (n=1), Brazil (n=1), Korea (n=1), Indonesia (n=1), Thailand (n=2), Malaysia (n=1). The most important output of the studies is demonstrated in Table 2.

### Participants

The sample size among the studies consisted of 6277 participants, males (n=813) females (n=5141) aged >18 years, and some studies did not specify gender (n=3). Overall, the participants from different occupations included Office workers (n=3), Sewing operators (n=1), Nurses (n=3), Computer workers (n=1), Bus drivers (n=1) Workers in the central office of the University (n=1), Workers in automotive industry (n=1), Video Display Unit (VDU) operators (n=1), Food Factory Production workers (n=1), Perioperative staff (n=1). Moreover, the effects of stretching exercises on parameters for those subjects were investigated before and after receiving stretching exercises sessions.

### Interventions

Several stretching methods of wide varieties, frequencies and duration were adopted by the current study. The stretching methods included: Computer Assisted Stretching Programme (CASP), Facsimile Lesson with Instructional Pictures (FLIP), Stretching with video, Basic Stretching Protocol (BSP), Muscle Stretching Exercises (MSE), Static stretch training (Five-Business), Stretching plus anti-fatigue mats, trunk stretching exercises on a specially developed device, Workplace stretching programme, One stretch, 2 ways of Self-stretching. Intervention dosage varied among the included studies, which ranged from 10-30 s holds/for 3-15 m/1-30reps/0-3 sets/2-3 times a week/for 15 days to 3 months. The follow-up was variable from immediately after each break to 6 months of receiving the program.

Seven of the studies assigned respondents to a control group with no treatment (Marangoni, 2010; Chen et al.,

**Table 2:** Overview of the included studies (n = 14)

| Author and Year | Country | Population (N/M/F) | Age | Occupation | Intervention/ Control | Stretching technique | Muscle group | Dosage/ Duration/ Follow up | Outcomes measures | Effects of stretching |
|---|---|---|---|---|---|---|---|---|---|---|
| Marangoni, (2010) | USA | N=68<br>M=8/F=60 | 43 | Computer workers | G1: Stretching Programme (CASP) (N=22)<br>G2: Facsimile Lesson with Instructional Pictures (FLIP) (N=23)<br>G3: CG with no treatment (N=15) | CASP<br>FLIP | Neck, upper extremities, trunk, lower extremities, eyes and breathing | 36 stretches lasting 10-15 sec. X 15 workdays<br>CASP: One stretch every 6 min, with 6 min break in-between. 10 minibreaks/ hour.<br>FLIP: Pre-set to alarm every 6 min once activated.<br>Follow up at 15$^{th}$ day. | Assessment of individual workstation risk factors<br>Total pain Index Score<br>PSA<br>VAS | Pain ↓: 72% in CASP, 64 % in FLIP,<br>CG: 1 % increase in pain |
| Chen et al., (2014) | Taiwan | N=127 | G1: 30.67±4.45<br>G2: CG 37.70±8.88 | Nurses | G1: SEP (N=64)<br>G2: CG with no treatment (N=63) | SEP | Neck, shoulders, upper and lower back, quadriceps, hamstrings, arms, & ankles. | SEP for 50 min/ time, 3 times a week after work X 6 months.<br>Follow-up at 2,4,6 months | VAS<br>Exercise Self-efficacy Scale | SEP is an effective and safe non -pharmacological intervention for management of LBP<br>81% EG: moderate -high level of LBP relief |
| Lee and Gak, (2014) | Korea | N=81 | 49.39±8.19 | Bus drivers | G1: Stretching exercises for 30 symptomatic subjects | 2 ways of Self-stretching- 7 movements | Elevator scapulae, upper trapezius and sternocleid-mastoid | 3 times/set, 3 times/week X 4 weeks<br>Hold maximum stretch for>25 sec<br>Follow-up at week 4 | NRS<br>RULA | Pain & MSD symptoms in neck and ↓ shoulders |
| Mehrparvar et al., (2014) | Iran | N=164<br>M=81/F=83 | 38.7±7.7 | Workers in central office of the University | G1: Ergonomic modification group (N=83)<br>G2: Stretching exercise (N=81) | Stretching exercise | Neck, shoulder, wrist, back and low back. | Two 1-quarter periods of office exercises including stretching at 10 AM and 12.<br>Follow up: 30 days | Nordic Questionnaire | Frequency of MSD in low back area ↓ |

(*Contd...*)

**Table 2:** *(Continued)*

| Author and Year | Country | Population (N/M/F) | Age | Occupation | Intervention/ Control | Stretching technique | Muscle group | Dosage/ Duration/ Follow up | Outcomes measures | Effects of stretching |
|---|---|---|---|---|---|---|---|---|---|---|
| Nakphet et al. (2014) | Thailand | N=30<br>M=0/F=30 | G1:31.4±5.9<br>G2:29.6±5.9<br>G3:27.6±3.0 | VDU operators | G1: Rest-break intervention with stretching (N=10)<br>G2: Rest-break intervention with dynamic contractions (N=10)<br>G3: Reference: hands off the computer and relax sitting back on their chairs (N=10) | Stretching with video | Bilateral upper & lower trapezius, anterior deltoid, cervical erector spinae | G1: Stretching each muscle twice during 3-min breaks after each 20 min of work during a 60-min typing task- 15 sec hold.<br>G2: 3 sets of shoulder elevation, flexion & neck extension during any 3 minutes break<br>G3: Resting<br>Follow up at end of each 20-min session and immediately after each break | Borg's CR-10 scale for muscle discomfort<br>EMG activity of neck & shoulders during work<br>Work productivity | Effect of types of activities during breaks on neck and shoulder muscle activity, muscle discomfort or productivity ↔<br>Significant difference in the level of muscle discomfort over time |
| Tunwattanapong et al., (2016) | Thailand | N=96<br>M=9/F=87 | G1: 34.2±9.0<br>G2: CG 36.5±8.7 | Office workers | G1: Stretching+ Brochure (N=44)<br>G2: CG: Ergonomics Brochure (N=43) | Stretching exercise programme as instructed by rehabilitation doctor | Neck & shoulder, trunk, back | 20–30 reps/ session; 10–15 min/session<br>2 sessions/day; 5 days a week X 4 weeks<br>Follow up at week 4 | VAS<br>NPQ<br>QOL (SF-36) | Greater improvement in treatment group for VAS; NPQ; and physical dimension of SF-36 |
| Aje et al., (2018) | USA | N=146<br>M=98/F=48 | 18-64 | Food Factory Production workers | G1: BSC (N=146) | BSP | Neck, shoulders, upper and lower back, quadriceps, hamstrings, arms, and ankles. | Ten stretches lasting 10 to 15 seconds in a standing position 3-4 times for a total of 8 minutes.<br>Follow up: 60 days. | MSD Questionnaire | ↓ Requested days off from 84.8 to 62.3 days/100 workers in the first 60 days of the programme period |
| Shariat et al., (2018) | Malaysia | N=142<br>M=47/F=95 | G1: 29.41±1.16 | Office workers | G1: Exercise training | Constant, controlled, | Back, shoulders and neck joints | Office-based stretching | CMDQ | Pain ↓<br>Significant |

*(Contd...)*

**Table 2:** *(Continued)*

| Author and Year | Country | Population (N/M/F) | Age | Occupation | Intervention/ Control | Stretching technique | Muscle group | Dosage/ Duration/ Follow up | Outcomes measures | Effects of stretching |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | G2: 28.31±0.92<br>G3: 29.64±0.90<br>G4: CG 28.74±0.82 | | (N=43)<br>G2: Ergonomic modification (N=37)<br>G3: Exercise training+ Ergonomic modification (N=34)<br>G4: CG with no treatment (N=28) | and slow stretching. | | (10-15 sec hold: 10 reps)- 3 sets -1/a day; 3/week<br>Follow-up at 6 months | | improvement from month 4 to 6 only in exercise group |
| Oka et al., (2019) | Japan | N=4767<br>M=260/<br>F=4507 | G1: 35.5<br>G2: 35.1<br>G3: 35.5 | Nurses | G1: CG: with no treatment (N=1799)<br>G2: One stretch exercise (N=1420)<br>G3: G2+physical and psychological approaches to LBP treatment (N=1548) | One stretch | Back | "One Stretch" standing back extension: 1-2 reps<br>Follow-up: 6 months | Fear-Avoidance Beliefs Questionnaire | Improvement rates in G1, G2, and G3 were 13.3%, 23.5%, and 22.6%, respectively. The worsened pain rates were 13.0 %, 9.6 %, and 8.1 %, which decreased as the intervention degree increased |
| King et al., (2020) | Australia | N=42<br>M=14/F=28 | 43+10 | Perioperative staff | G1: Stretching programme | Workplace stretching programme: Stretching instructions on posters located on the walls of the stretching station | Not specified | 10 min of stretching/2-3 times/week during breaks, or immediately before or after work<br>Follow up at post-programme immediately after stretching exercises | CMDQ | MSDs scores pre- and post-programme ↔<br>MSD-related incident, Compensation claim, and MSDs or sick leave: 60%,<br>40% and 20% reduction respectively |

*(Contd...)*

**Table 2:** *(Continued)*

| Author and Year | Country | Population (N/M/F) | Age | Occupation | Intervention/ Control | Stretching technique | Muscle group | Dosage/ Duration/ Follow up | Outcomes measures | Effects of stretching |
|---|---|---|---|---|---|---|---|---|---|---|
| Holzgreve et al., (2020) | Germany | N=313 M=173/ F=137 | 43.37±11.24 | Office workers | G1: Five-Business -programme (N=158) G2: CG with no Treatment (N=95) | Five stretch exercises of the trunk in two degrees of freedom on a specially developed device. | Whole body – focus on the trunk. | Twice a week for 10 minutes Each exercise held twice for 20 second X 12 weeks: 22-24 training sessions. Follow up after 12 weeks | QOL - SF-36 Questionnaire | Improvements: mental sum score, physical functioning, bodily pain, vitality, physical problems, and mental health. |
| Silva Filho et al., (2020) | Brazil | N=28 M=7/F=21 | G1: 47.4±9.5 G2:CG 39.15±9.6 | Nursing professionals | G1: Static and active stretching exercises (N=15) G2: CG with no treatment (N=13) | MSE | Upper limbs, trunk, hips and lower limbs. | Stretching exercises sessions for 40 min. Classes were 3 days/week, with 48-hours rest between sessions X 8 weeks Each exercise: 4sets of 30 s, with 30s interval between sets. Follow up after 1st session, 8 weeks | Visual Numeric Scale | Pain in G1 post MSE ↓ |
| Fraeulin et al. (2021) | Germany | N=161 M=116/F=45 | 44.81±10.55 | Office workers in automotive industry | Stretching programme | Static stretch training (five-Business) | Trunk | 5 exercises, each for 20s hold, supervised 2/ week for 10 minutes X 22-24 sessions in 3 months Follow up at 3months | ROM: a digital inclinometer (shoulder, hip and trunk extension) and a tape measure (fingertip-to-floor and lateral inclination) | ROM gains in all except hip extension Subjects with limited flexibility reached the largest gains (1.41–25.33%). |

(*Contd...*)

**Table 2:** *(Continued)*

| Author and Year | Country | Population (N/M/F) | Age | Occupation | Intervention/ Control | Stretching technique | Muscle group | Dosage/ Duration/ Follow up | Outcomes measures | Effects of stretching |
|---|---|---|---|---|---|---|---|---|---|---|
| Prima et al. (2022) | Indonesia | N=112 | >18 years | Active workers, sewing operators | G1: No AFM, no stretching G2: Stretching; no AFM G3: AFM; no stretching G4: AFM+ stretching. | Stretching mats | Head and neck, shoulders, arms, back body, legs covering the legs, ankles and soles of the feet | 3 minutes 30 seconds X 5 days Follow-up on day 5 | MSDs Questionnaire | Stretching and AFM alone ↔ AFM + stretching mats: MSDs complaints ↓ |

M/F - Male/Female; G- Group; CG - Control Group; EG- Experimental Group; CASP - Computer Assisted Stretching Programme; FLIP - Facsimile Lesson with Instructional Pictures; PSA – Pain Spot Assessment; VAS– Visual Analogue Scale; SEP - Stretching Exercise Programme; LBP - Low Back Pain; NRS - Numeric Rating Scale; RULA - Rapid Upper Limb Assessment; MSDs - Musculoskeletal Disorders; VDU - Video Display Unit; NPQ - Northwick Park Neck Pain Questionnaire; QOL - Quality of Life; SF-36 – Short Form-36; ROM - Range of Motion; CMDQ - Cornell Musculoskeletal Discomfort Questionnaire; MSE –Muscle Stretching Exercises; AFM - Anti-Fatigue Mats; BSP- Basic Stretching Protocol; ↔ - No significant effect; ↓ - Significant decrease; ↑ - Significant increase

2014; Shariat et al., 2018; Oka et al., 2019; Holzgreve et al., 2020; Silva Filho et al., 2020; Prima et al., 2022), and one study assigned respondents to an active control group (Tunwattanapong et al., 2016). Five studies compared stretching exercise with other interventions such as Ergonomic modification, Rest-break intervention with dynamic contractions, sit back and relax without using the computer, Ergonomic modification, Exercise training + Ergonomic modification, Physical and psychological approaches to Low Back Pain (LBP) treatment, and Anti-Fatigue Mats (AFM) (Mehrparvar et al., 2014; Nakphet et al., 2014; Shariat et al., 2018; Oka et al., 2019; Prima et al., 2022). Four studies included stretching exercises as a stand-alone treatment (Lee and Gak, 2014; Aje et al., 2018; King et al., 2020; Fraeulin et al., 2021).

### Effect of the Stretching Interventions on WMSDs

Compared to the control group with no treatment received, seven studies found that stretching exercises to be an effective and safe non-pharmacological intervention for MSDs, and one study that assigned respondents to an active control group found greater improvement in the treatment group. Some four trials revealed a significant and substantial benefit from stretching exercises as an exclusive treatment with no comparison to other treatments. For stretching exercises in comparison to other therapies, three studies reported stretching exercises to have a measurable and considerable effect, while two studies reported no significant effects on MSDs complaints, the effect found when stretching exercises using AFM + stretching on MSDs complaints.

As a nonpharmacological treatment for LBP, SEP has been demonstrated to be safe and effective by Chen et al., (2014). This study suggests a straightforward SEP that may be implemented as a home exercise programme. The strength of the study was the provision of an atmosphere that was conducive for exercise self-efficacy, including a selection of exercise periods and indoor exercise with air conditioning and music. However, as the authors suggested, further research would be required to assess the effectiveness of SEP among nurses from numerous institutions to acquire a more representative outcome. There was a statistically significant decline in pain (on both VAS and PSA) for both the intervention groups (CASP and FLIP), and the hypothesis was validated by Marangoni (2010). Following the self-stretching intervention, Lee and Gak (2014) reported a reduction in pain. Following the self-stretching exercise, a significant reduction was seen in neck and shoulder MSDs. In the case of office employees, Mehrparvar et al. (2014) showed a positive short-term effect of ergonomic modifications and workplace stretching exercises on the reduction of MSDs. Nakphet et al. (2014) found that stretching and dynamic movement during breaks had a favourable impact on neck and shoulder muscle activity and productivity, as well as on muscle pain in symptomatic VDU operators. Research by Tunwattanapong et al. (2016) found that office workers experiencing moderate-to-severe neck-shoulder pain benefitted greatly from a 4-week programme of stretching exercise focusing on the neck and shoulder regions, which included two sessions per day, five days per week. Researchers Aje et al. (2018) discovered that a daily 8-minute stretching routine reduced MSDs and lost workdays. Despite a very limited sample size, the new stretching programme showed statistically significant improvements in worker health. To verify the results of this programme assessment study, it is suggested that future research employ larger samples/number of workers and longitudinal designs. Shariat et al. (2018) claimed considerable reductions in the discomfort scores as early as two-month post-intervention; however, the effectiveness of the treatment decreased over time. After two months of intervention, the ergonomic modification group viewed no significant improvement, and after four months, neither of the experimental groups showed any significant change. Oka et al. (2019) found that "One Stretch" improved and avoided LBP in a wide sample of healthcare workers. King et al. (2020) observed that workplace stretching reduced MSDs, sick absence, occurrences, and claims. According to participants, the curriculum was deemed suitable, practical, and well-aligned with the department's needs. Holzgreve et al. (2020) found that a 12-week stretching programme improved the health-related QoL of office workers. Silva Filho et al. (2020) established that both acute and chronic effects of exercise reduced pain. Chronically, MSE reduced muscular activation and fatigue. Fraeulin et al. (2021) reported that twice-weekly "five-Business" stretch training enhances trunk Rang of Motion (ROM). Participants with restricted or moderate ROM gained the most, whereas advanced baseline flexibility decreased. In the study by Prima et al. (2022), stretching and anti-fatigue mats in isolation had no effect on MSDs complaints, whereas combined intervention of stretching with anti-fatigue mats influence MSDs complaints.

### Methodical Quality

The scores on the PEDro scale for quality assessment of included studies ranging from 1 to 8. There appeared to be a blend of high- and low-quality studies, with 8 studies scoring below 5, and the remaining 6 studies scoring 5 or higher. Research of lowest quality were published in 2010, while the best quality studies were released between 2011 and 2022, demonstrating that the year of publication had no bearing on the quality of the research (Table 1). For the studies included in this review, the following criteria were met: all studies met the eligibility requirements representing external validity; nine studies depicted group similarity at baseline level; seven studies had described point measure and variability; seven studies did random allocation; between-group comparisons were made by 8 studies; and follow-up comparisons were made by all 14 studies. None of the analysed trials met the crucial requirement of a blind subject; however, the criteria for a blind assessor or therapist were fulfilled in one research each. The allocation was done in a concealed way by two trials and eight studies described the intention-to-treat analysis.

## DISCUSSION

This systematic review found that stretching exercises are an effective intervention for managing musculoskeletal disorders when used in conjunction with other treatments and as a standalone treatment. When compared to other therapies, such as pharmacological treatment, stretching was not found to be different in efficacy and thus is a suitable and accessible alternative. Significant factors leading to the development of MSD's include improper working posture, excessive workload, jobs requiring repetitive motions, inadequate work to rest intervals, lack of knowledge regarding proper working posture, and workplace stress. Outcomes observed as a result of stretching interventions include increased flexibility, decreased muscular tension and hypertonicity, and reduced discomfort associated with MSD's. The main MSD findings regarding stretching interventions are discussed by prevalence and work absence, dose-response effect, pain or discomfort levels, and preventative factors.

Stretching was shown to decrease the prevalence of MSD's and the days missed from work as a result. Aje et al (2018) demonstrated that an 8-minute stretching exercise regimen was associated with a decrease in prevalence of MSDs by 2.4% which was statistically significant. A second trial, by Prima et al. (2022), compared stretching for 3 minutes and 30 seconds to anti-fatigue mats. A 5% reduction in MSD's was found in the stretching group but not in the mat group, as was observed in other studies on the impact of stretching (Gasibat et al., 2017). This contrasts with the findings of Aghazadeh et al. (2015), who investigated the effects of standing on carpeted and tile floors for 2 hours and found that anti-fatigue mats were beneficial in reducing lower back pain (LBP). Complaints related to musculoskeletal disorders (MSDs) varied in the third group, which combined the use of anti-fatigue mats with stretching exercises.

Silva Filho et al. (2020) reported that both acute and chronic effects of musculoskeletal stretching exercise (MSE) led to a significant reduction in pain. In the MSE group, the percentage of volunteers experiencing back pain decreased from 93.3% to 73.3% and 80% acutely and chronically, respectively. This means that the number of patients with discomfort decreased by 20% in the MSE group compared to a 13% decrease in the control group. A reduction in prevalence of MSD's following stretching interventions is in agreement with previous literature as seen by Lowe et al., 2017; Gartley and Prosser, 2011; and Moreira-Silva et al., 2014.

Muscle discomfort decreases following stretching interventions. Lacaze et al. (2010) found that active breaks from work involving stretching and joint mobilization were more effective than passive breaks in reducing muscle discomfort (p=0.01). This is supported in the literature by Galinsky et al. (2000) who found that the stretching treatment group experienced significantly less increases in symptoms through their work period compared to the traditional-work control group. There are many explanations as to why stretching may reduce muscle discomfort. One hypothesis by Crenshaw et al. (2006) suggests that observed improvement in discomfort may be attributed to increased muscle oxygenation. Other fields suggest that the effect of reduced discomfort may be due to recruitment of peripheral muscle mechanoreceptors or neural modulation (Roberts et al. 2022).

Similar to discomfort but different in assessment method, stretching was found to decrease pain from MSD's as well. A study conducted by Marangoni (2010) yielded significant decreases in pain from two types of stretching interventions, CASP and FLIP, compared to the control group. Both stretching groups experienced notable reductions in pain as assessed through the VAS and PSA with no significant differences between stretching intervention types. Specifically, the VAS revealed a 74% reduction in symptoms for the CASP group while the FLIP group showed a 66% reduction in pain. The non-treatment control group experienced a 1% increase in pain after three weeks. Further, a study by Tunwattanapong et al. (2016) used 4 weeks of stretching 2x/day 5 days a week resulted in a reduction in neck pain and an improvement in functional ability. Additionally, the reduction of pain from MSD by stretching has been previously reported by Birch et al. (2001) and Irmak and Irmak (2012). The benefits of stretching on MSD is a very well supported thesis as Shariat et al. (2018), who compared stretching, ergonomics, and combination therapy, found that stretching alone was the most effective at reducing shoulder, neck, and low back pain at the 6 month follow up point. These findings are consistent with previous studies conducted by Nakphet et al. (2014), Amoudi and Ayed (2021), Ward et al. (2013), and Alnaser (2015), which reported similar improvements in pain. Significant reductions in Visual Analog Scale for Pain (VASP) scores were also reported by Chen et al. (2014) in the experimental group compared to the control group at the second, fourth, and sixth months. Thus, stretching exercise programs (SEP) were shown to effectively reduce LBP among nurses. These results are consistent with previous studies, including meta-analyses and systematic reviews, which have demonstrated the positive effects of stretching specifically in decreasing LBP (Buchner et al., 2006; del Pozo-Cruz et al., 2013; Richards et al., 2012). Chen et al. (2014) conducted observations at three different time points with a control group while some other less rigorous studies have conducted pre-posttest observation in non-randomized and non-controlled research with follow-up periods ranging from 6 to 9 months (Buchner et al., 2006; del Pozo-Cruz et al., 2013). Additionally, Chen et al. (2014) examined the efficacy of an MSE program for LBP. They compared an MSE group with a control group over a 24-week period and found that the MSE group had significantly lower pain scores. Similar results were observed in another study by Puppin et al. (2011), which evaluated the effects of an 8-week MSE intervention in 55 patients with back pain, demonstrating a significant reduction in pain compared to the control group. Similar positive outcomes have been reported in studies involving different population profiles, where patients with back pain experienced reduced pain sensations compared to the control group (Cunha et al., 2008). It is conclusive that stretching is capable of reducing pain from MSD.

The dose-response relationship of stretching on MSD symptoms was also noted in this review. Duration of stretches (10-30 seconds), total sets, reps, and time (0-3 sets, 1-30 repetitions, 3-15 minutes), and program duration (15 days to 3 months) were studied. Follow up assessments were conducted at different intervals, ranging from immediately after each exercise session to up to six months later. Greater stretching results in greater relief as supported by Tsauo et al. (2004). In this study, a greater frequency of stretching, described as the 2x per day program of greater intensity, resulted in significantly less pain symptoms than the once daily program.

Lastly, protective factors were found to be associated with MSD's primarily consisting of resistance training exercise or combination exercise and stretching. A longitudinal study conducted over one year among office employees revealed that individuals who engaged in exercise more than three times per week had a lower risk factor (Hazard Ratio: 0.64; 95% Confidence Interval: 0.25, 1.51) for developing neck pain (Hush et al., 2009). Another longitudinal investigation by Korhonen et al. (2003) found that office employees who exercised less than twice per week had a 1.4-fold increased incidence of neck discomfort (Odds Ratio: 1.4; 95% CI: 0.7, 2.7). This is further supported by Blangsted et al. (2008) who demonstrated that one year of resistance training specifically targeting the neck and shoulders was more effective than general physical exercise in reducing the severity and duration of neck and shoulder symptoms. The participants had a low sick leave rate to start but did not see any change in sick leave amount or job performance. Machado-Matos and Arezes (2016) demonstrated that exercise programs focusing on core stability were effective in reducing pain while Robertson et al. (2016) found that adjusting ergonomics significantly improved lower back pain. Lastly, pain reduction from exercise training in office employees was also seen by Silva Filho et al. (2020). It can be deduced that a sedentary lifestyle should be minimized to prevent MSD's similarly to occupational overuse and repetitive tasks.

Collectively, this literature provides sufficient insight into the question regarding the efficacy of stretching interventions in reducing work related musculoskeletal disorders. This was completed by analyzing a number of studies and supporting literature discussing the prevalence of MSD's, work absence as a result, dose-response effect of stretching on symptoms, pain or discomfort levels, and preventative factors. The variables of interest compared in the results included the intensity, frequency, and duration of the interventions. The findings indicate that regular exercise, including occupational stretching programs and targeted resistance training, can effectively reduce or prevent pain from musculoskeletal disorder among office workers. WMSDs are a global concern for both employers and employees. Therefore, more studies are needed from various regions to investigate the different parameters and factors contributing to WMSDs. This includes conducting workplace evaluations using validated scales and implementing homogenous intervention protocols specific to different occupations. Simple reporting standards should be developed for the MSD literature such as universal reporting of MSD prevalence, VAS, work time missed, and the protocol used. It is evident that further research is needed to better understand the factors contributing to WMSDs and to develop specific intervention protocols based on occupation. The use of validated scales and comprehensive workplace evaluations should be employed to obtain more accurate and consistent data. By expanding the scope of studies across different regions, a more comprehensive understanding of WMSDs can be achieved, benefiting both employers and employees in effectively addressing and mitigating these occupational health concerns.

### Limitations of the Study

This review is limited by the heterogeneity of the work profiles of the participants, and the interventions and their associated variables. The included studies pose a risk of bias as the quality of included studies was low in 42% of the studies. Also, only few studies focused on ergonomic evaluation as an important assessment tool in the MSDs population. So, it poses a difficulty in drawing a high impact statement as to the best method of stretching exercise protocol that could potentially limit or prevent the work-related MSDs.

### The Strength and Practical Implication of the Study

The strength of this systematic review is the inclusion of a comprehensive search strategy, which involved screening a large number of records (n = 723) and assessing the eligibility of 14 reports. The review also assessed the methodological quality of the included studies using the PEDro scale, which is a validated measure of the quality of clinical trials. The review identified a mix of high and low-quality studies, providing a balanced assessment of the available evidence.

The practical implication of the study is that stretching exercises are an essential and efficient strategy for treating and preventing the main side effects of pain and function in work-related musculoskeletal disorders (MSDs) that affect different anatomical regions such as the neck, shoulder, and back. Along with stretching exercises, workplace/ergonomic adjustments might improve the effects even further. Future studies are advised to use a fixed-line strategy for stretching as an intervention to lower MSDs in a specific participant group and to improve study designs in terms of randomization, blinding, and the inclusion of control groups. The uniformity of workplace ergonomic assessments is also needed to analyze the effects of stretching and employ workplace modifications.

## CONCLUSION

According to the findings of this review, stretching exercises are an effective and accessible strategy for treating pain and preventing dysfunction in work-related MSDs that affect different anatomical regions such the neck, shoulder, and back. Along with stretching exercises, workplace/ergonomic adjustments might improve the effects even further. Future studies are strongly advised to use a fixed-line strategy for stretching as an intervention to lower MSDs in a specific participant group to properly assess the dose-response relationship. To enhance the internal validity of the research, study designs must also be improved in terms of randomization/concealment, blinding, and the inclusion of control groups. The uniformity of workplace ergonomic assessments is needed to be able to analyse the effects of stretching and to employ workplace modifications.

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### Conflict of Interest

The authors declare no conflict of interest.

### Authors' Contributions

QG, BR, DC and AER participated in the study design and drafted and critically revised the manuscript. SS, RS, DC and BR were responsible for selecting articles for inclusion and Quality assessment. RS, BR, QG, YX, XC and NA were responsible for data extraction and helped to revise the manuscript. All authors read and approved the final manuscript.

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**Supplementary Table 1.** The search strategy for each database

| Date of search | November, 2022 | November, 2022 | November, 2022 | December, 2022 | November, 2022 | November, 2022 | November, 2022 | November, 2022 |
|---|---|---|---|---|---|---|---|---|
| Database | WoS | Scopus | PubMed | Medline | Embase, Cinahl | PEDro | Google Scholar | SPORTDiscus |
| Keywords | „stretching“, „workplace“ | „stretching“, „exercises“, „workplace“, „injury“, „work prevention“, „occupation“ | „stretching“, „workplace“, „occupation“ | „stretching“, „exercises“, „workplace“, „injury“, „work prevention“, „occupation“, „safety“ | „stretching“, „exercises“, „workplace“, „injury“, „work prevention“, „occupation“, „safety“ | „stretching“, „exercises“, „workplace“, „injury“, „work prevention“, „occupation“, „safety“ | „stretching“, „exercises“, „workplace“, „occupation“ | „stretching“, „exercises“, „workplace“, „injury“, „work prevention“, „occupation“, „safety“ |
| Database field for the search | All | All | All | All | All | All | All | All |
| Examples of search strategy code line | | WoS | ALL=(stretching) AND ALL=(workplace) | | | | | |
| | | Pubmed | „stretching“ [All fields] AND „workplace“ OR „occupation“ | | | | | |
| | | Scopus | Title-Abs-Key („stretching“) OR Title-Abs-Key („exercises“) OR Title-Abs-Key ( „worklplace“ ) AND Title-Abs-Key („injury“) OR Title-Abs-Key („work prevention“) AND TitleAbs-Key („occupation“) | | | | | |
| | | Google Scholar | „stretching“ OR „exercises“ AND „occupation“ OR „workplace“ | | | | | |