Review

Workplace-Based Interventions for Neck Pain in Office Workers: Systematic Review and Meta-Analysis

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Background. At present, there is no consolidated evidence for workplace-based interventions for the prevention and reduction of neck pain in office workers.

Purpose. The purpose of this review was to investigate the effectiveness of workplace-based interventions for neck pain in office workers.

Data Sources. MEDLINE, PEDro, CINAHL, and CENTRAL were searched for trials published since inception and before May 31, 2016.

Study Selection. Randomized controlled trials (RCTs) were considered when they met the following criteria: population consisted of office workers, intervention(s) was performed at the workplace, outcome measures included neck and/or neck/shoulder pain intensity and incidence/prevalence, and comparator groups included no/other intervention.

Data Extraction. Data were extracted by 1 reviewer using predefined data fields and checked by a second reviewer. Risk of bias was assessed by 2 independent reviewers using the 2015 Cochrane Back and Neck Group guidelines. Evidence quality was evaluated using the Grading of Recommendations Assessment, Development, and Evaluation system.

Data Synthesis. Twenty-seven RCTs were included. There was moderate-quality evidence that neck/shoulder strengthening exercises and general fitness training were effective in reducing neck pain in office workers who were symptomatic, although the effect size was larger for strengthening exercises. Greater effects were observed with greater participation in exercise. Ergonomic interventions were supported by low-quality evidence.

Limitations. Data could not be obtained from some studies for meta-analysis and assessment of risk of bias. Reporting bias might have been present because only studies in the English language were included.

Conclusions. Workplace-based strengthening exercises were effective in reducing neck pain in office workers who were symptomatic, and the effect size was larger when the exercises were targeted to the neck/shoulder. Future RCTs of ergonomic interventions targeted at office workers who are symptomatic are required. More research on neck pain prevention is warranted.

Neck pain is a prevalent and burdensome condition particularly in office workers compared to other occupations.[1–3] The annual prevalence of neck pain in office workers varies from 42% to 63%,[1,4,5] and office workers have the highest incidence of neck disorders among all other occupations, at 17% to 21%.[6,7] Approximately 34% to 49% of workers report a new onset of neck pain during a 1-year follow-up.[1,2,5,8] The impact of neck pain is significant not just for the individual, but also for industry and society.[3] Workers who do not return to work within 1 to 2 months are at high risk of developing disability and may cease work altogether.[3] Costs associated with neck pain place a burden on employers, society, and the individual through care-seeking behavior, reduced productivity, and workers' compensation claims.[3,9,10]

Workplace-based interventions are becoming important to reduce the burden of neck pain. This is due to the increasing responsibility of companies toward employee health, and the potential cost-savings and productivity gains associated with a healthy workforce.[3] Workplace-based interventions are broadly grouped into those that target the workers' health and/or knowledge (eg, exercise, education), or those that target the job task and environment (eg, ergonomics). Recent reviews conducted on workplace-based interventions found very low to low quality, or mixed evidence for the beneficial effects of exercise and ergonomic interventions on neck pain severity. However, these reviews examined all occupational categories, including office workers.[3,11,12] In contrast, other reviews have studied solely office workers, but not performed meta-analysis, nor considered the potential influence of individual factors, such as neck pain presence at baseline, or intervention characteristics, including participation in an intervention.[13–15] Current reviews have also not distinguished between studies investigating workers with and without neck symptoms (general population of office workers), and those with symptoms (office workers who are symptomatic). It is relevant to also investigate the effectiveness of workplace interventions in the general population of office workers given the lack of evidence for the prevention of neck pain.[1]

The aim of this systematic review was to investigate the effectiveness of workplace-based interventions on the prevention and reduction of neck pain in office workers in comparison to other or to no interventions. This review extends previous reviews by doing subgroup analysis of 2 study populations—office workers who were symptomatic (ie, with neck pain) and a general population of office workers (ie, with or without neck pain)—and by exploring potential sources of heterogeneity, including the influence of participation rates.

Methods

This review followed the PRISMA guidelines for reporting systematic reviews and meta-analyses.[16] The Prospero registration number of this review is 42014006905. Although the original intent of the review (as stated in Prospero) was to include an additional primary outcome (ie, neck disability), and possibly secondary outcome(s), the preliminary literature search revealed inconsistency, and a lack of such studies that met the inclusion criteria of the review. In addition, a large amount of research on pain was encountered during the preliminary literature search, warranting the review to focus on the neck pain outcome only.

Data Sources and Searches

The electronic databases including MEDLINE (via PubMed), PEDro, CINHAL, and CENTRAL (via Cochrane Central Register of Controlled Trials) were used to search for literature from their inception to May 31, 2016. Studies were restricted to those written in English, and in peer-reviewed literature. The search strategy was reviewed by a university librarian (J.H.), and examples of the search terms used included "neck pain AND workplace AND office work" (Appendix). Additional sources were obtained from manual searching of relevant systematic reviews. Two reviewers (X.C., D.J.) independently performed the identification and screening (of titles and abstracts), and the eligibility assessment (of full texts). Discrepancies were resolved by a third reviewer (B.K.C.).

Study Selection

Randomized controlled trials (RCTs) were included if the following criteria were present: the population consisted of office workers performing computer work for most of their work time; the intervention was performed onsite at the workplace only, and outcome measures included pain intensity or incidence/prevalence of neck pain. Prevalence was considered as the number/proportion of cases of neck pain, while incidence was considered as the number/proportion of new cases identified at a given time. Studies were excluded if participants had neck pain due to complex or severe pathological conditions such as radiculopathy, whiplash-associated disorders, headache/dizziness related to neck pain, fracture, tumor, infections, and systemic diseases. Interventions performed partially at the worksite (eg, outpatient clinic combined with workplace interventions), or those performed in combination with manual therapy and physical therapy adjuncts, such as traction, acupuncture, neck collars, or nonportable electrotherapy, were excluded. Studies reporting only a combined assessment of neck, shoulder, and arm/hand pain were also excluded.

Data Extraction and Quality Assessment

One author (X.C.) independently extracted data using predefined data fields, and another author (B.K.C.) checked the accuracy of extracted data.[17] The predefined data fields were customized on the basis of the PICO (Population, Intervention, Control, and Outcomes) process and a modified Template for Intervention Description and Replication (TIDieR) checklist.[18] Data were subgrouped based on the type of intervention (eg, exercise, ergonomic intervention) and study population (eg, general population of office workers who were symptomatic). In addition to the a priori defined groups of "general population of office workers" and "office workers who were symptomatic," we defined a third subgroup, "at risk office workers," who are at risk of neck pain, which was relevant for only 1 trial.[5]

Risk of bias was assessed by 2 independent reviewers (X.C., D.J.) using the updated 2015 guidelines for systematic reviews from the Cochrane Back and Neck Group (12 questions).[19] The tool assessed selection, performance, attrition, detection, and reporting biases. The possible results of the assessment include "high," "low," or "unclear" risk of bias. In the event where authors could not be contacted for information or where information is unavailable, the criterion was scored as "unclear."[19] In the category of participation in an intervention, the percentage of participation was calculated for each study intervention group where available. For the ergonomic interventions, the percentage of participation in all preset ergonomic modifications was calculated. As there are no current recommendations for distinguishing between high and low risk of bias for participation, we judged studies with participation rates of greater than or equal to 50% as having a low risk of bias and those with participation rates of less than 50% as having a high risk of bias.

Data Synthesis and Analysis

When studies demonstrated clinical homogeneity (ie, similar study intervention, comparator intervention, postintervention time frames, and pain outcome),[20] data were pooled using a weighted mean difference. Statistical heterogeneity was examined using the I^2 statistics, with values of 25%, 50%, and 75% indicating low, moderate, and high heterogeneity, respectively.[20]

For continuous data, standardized mean differences (SMD) with 95% CI in pain intensity were calculated with a random-effects model.[21] The SMD (95% CI) for pain intensity was calculated by having the mean differences between the intervention and comparator groups divided by the pooled SD. The SMD was used, as it standardizes the results of studies to a uniform scale before they are combined.[21] A positive SMD (>0) indicated an effect in favor of the intervention, and a negative SMD (<0) favored the comparator.[22] When the CI did not cross 0, effects were deemed statistically significant.[22] An SMD of less than 0.5 indicated a small effect, SMDs of 0.5 to 0.8 indicated a medium effect, and an SMD of greater than 0.8 indicated a large effect.[22,23]

For dichotomous data, relative risk (RR) with corresponding 95% CI were calculated using postintervention neck pain incidence/prevalence values with a random-effects model.[21] The intervention was favored when RR was greater than 1, and the comparator was favored when RR was less than 1. Point estimates of effect were deemed statistically significant if the 95% CI for RR did not cross 1.[22] An RR of 1 to 1.25 or 0.8 to 1 indicated a small effect, an RR of 1.25 to 2 or 0.5 to 0.8 indicated a medium effect, and an RR of greater than 2 or less than 0.5 indicated a large effect.[22,23]

Data to calculate effect statistics were obtained from postintervention (final values) or, where possible, change from baseline values. If available, intention-to-treat data were used in favor of per-protocol data. Authors were contacted for additional data when not available in the published manuscript. All statistics were calculated using RevMan5 (version 5.3).[21]

Qualitative analyses to evaluate the quality of evidence for single trials and the overall quality of evidence for pooled analyses were done using Grading of Recommendations Assessment, Development, and Evaluation criteria.[21] In these criteria, 5 main domains (risk of bias, imprecision, inconsistency, indirectness, and publication bias) are used to categorize evidence quality. The quality of evidence for all individual or pools of RCTs begin as high quality, and quality could be downgraded by 1 or 3 levels to very low, low, or moderate evidence.[19,24] Downgrading for risk of bias was applied when the included studies (eg, Chiarotto et al[25]) did not meet at least 50% of the 12-item checklist by Furlan et al.[19] For a set of trials, risk of bias was applied when more than 25% of total participants were from studies that did not meet the 50% cutoff of the same checklist.[19,26] Downgrading for inconsistency was applied when there was high statistical heterogeneity ($I^2 \geq 75\%$), or when the direction of the study results was different in the majority (≥75%) of studies.[19] Evidence was downgraded for indirectness when there was uncertainty about the generalizability of the results based on the inclusion criteria defined in this review.[19] Imprecision was downgraded when a large CI was observed, when CIs were not reported in 1 or more studies, or when only 1 small study reported the outcome (total number of participants: <300).[19,26] Publication bias was downgraded when the study results provided differed from the original protocol or study objectives.[19] The criterion was scored as "unclear" if the authors could not be contacted or if the information is no longer available.[19]

The following definitions of quality of evidence were applied in this review: high-quality evidence means further research is very unlikely to change confidence in the estimate of effect; moderate-quality evidence means further research is likely to have an important impact on confidence in the estimate of effect and may change the estimate; low-quality evidence means further research is very likely to have an important impact on confidence in estimate of effect and is likely to change the estimate; and very low-quality evidence means very little confidence in the effect estimate.[19]

Results

Figure 1 shows the process of study selection, leading to 35 papers meeting the inclusion criteria. Several papers reported data from the same RCT (ie, same study population and trial registration numbers). To avoid double-counting, the results of studies from the same RCT were combined, analyzed, and referenced as a single RCT as follows: Andersen et al,[27–29] Blangsted et al,[30–33] Martin et al,[34,35] Bernaards et al,[36,37] and Voerman et al.[38,39] (These groups of RCTs were written by different authors but represent the same study population and share the same RCT trial registration numbers; the earliest publications of the groups of RCTs are cited here to represent each group.) Hence, a total of 27 RCTs were interpreted from the 35 papers, as reflected in the rest of this review. Four trials were identified

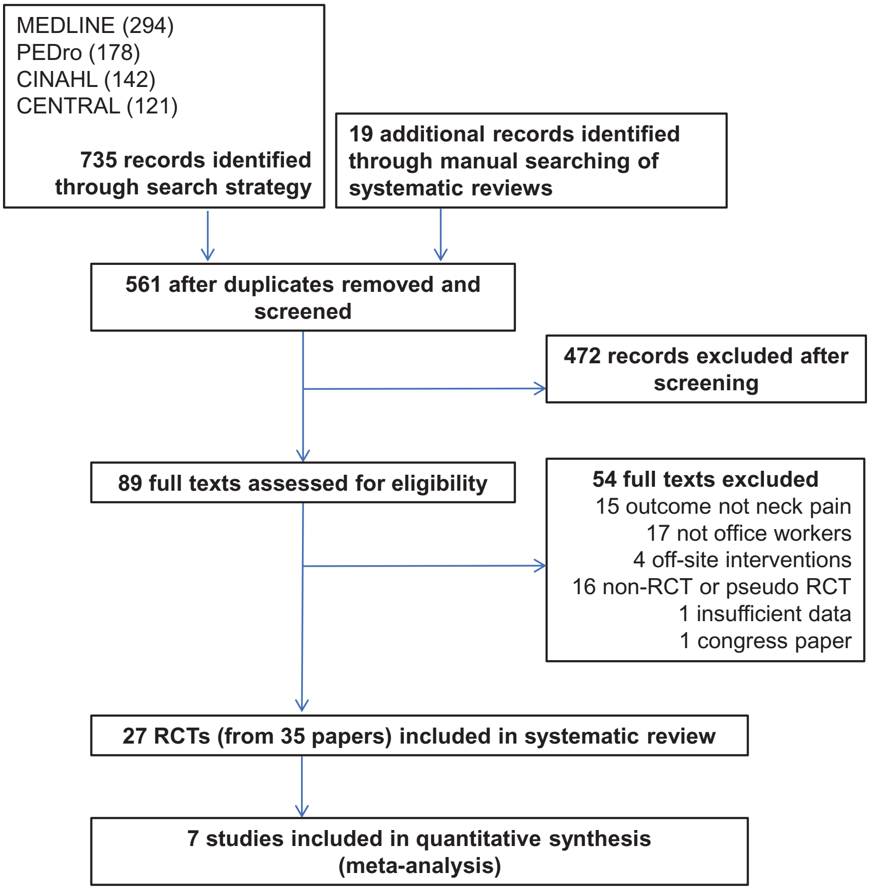

Figure 1.
Study selection. RCT = randomized controlled trial.

for their clustered RCT design.[5,27,32,40] In this review, clustering did not have an impact on the pooled effect sizes, as the studies that were being pooled were adjusted for clustering in their original analyses.[27,32] Table 1 displays the characteristics of the included trials, and a summary of the review results is presented in Table 2.

All included RCTs recruited office workers performing mostly computer work, with some studies targeted at specific occupational groups such as call center workers[41] and medical secretaries.[42] Some studies recruited a general population of office workers (with or without neck pain),[27,32,43,44] while others solely targeted office workers who were symptomatic (with neck pain).[36,42,45,46] The criteria for office workers who were symptomatic varied between studies, with some using a self-reported pain rating scale (eg, pain intensity, ≥3/10),[27,28,30–33] and others combining both pain intensity and duration (eg, pain intensity of at least 2 of 10 during the previous 3 months).[47,48] Other studies specified additional clinical criteria, such as trapezius myalgia[49] and tension neck syndrome.[44]

Twelve RCTs studied the effectiveness of exercise interventions, 8 studied ergonomic interventions, and 7 studied other interventions (ie, breaks, cognitive behavioral therapy [CBT], education, and myofeedback). Most RCTs addressing exercise interventions (67%), education, breaks, and myofeedback interventions (71%) focused on office workers who were symptomatic; whereas only 13% of trials of ergonomic interventions were undertaken in the symptomatic population. Of the exercise trials, 2 presented data for office workers who were symptomatic separately as a subgroup,[27,28,30–33] and 1 trial studied the "at risk office workers," defined as workers without neck pain (at baseline), but lower than normal neck flexion range and neck flexor muscle endurance.[5]

Four exercise RCTs reported the presence of musculoskeletal symptoms following strength training, but there were no lasting effects or major complications.[27,32,47,49]

Assessment of Risk of Bias

Risk of bias of the included trials is presented in Figure 2. All RCTs did not meet the patient and care provider blinding criteria, as it is not possible for the type of interventions performed in this review. Also, all RCTs did not meet the outcome assessor blinding criteria, as the primary outcome (pain) was self-reported.[19] Overall, 11 RCTs (41%) were rated "unclear" for participation, and 5 trials (19%) were rated high risk of bias. Ninety-two percent of the exercise RCTs reported participation; in comparison, the rates were 43% for the other interventions (ie, breaks, CBT, education, and myofeedback) and 25% for the ergonomic interventions. Of the exercise trials that reported participation, 73% scored low risk of bias. Sixty-seven percent of the other intervention trials, and only 50% of the ergonomic trials that reported participation scored low risk of bias. Seven RCTs (26%) were rated "unclear" for their randomization methodologies. Concealed allocation was performed in a minority of the trials (26%).

Effects of Neck/Shoulder-Specific Strengthening and Endurance Exercises

Nine trials[5,27,32,45,47–51] investigated the effectiveness of workplace-based strengthening exercises consisting of resistance exercises targeted to the neck/shoulder region using dumbbells or resistance band/tubing compared to no training. Most interventions were for 20 minutes per session, 3 sessions per week, and the intervention periods were at least 10 weeks.

Table 1.
Characteristics of Included Trials[a]

Intervention Category	Main Population Analyzed	Study (Country)	Participants' Job Description and Condition	Intervention Type/ Dosage, Description, Provider, Mode of Delivery, and Duration	Comparator Intervention	Outcome	Findings for Intervention vs Control, Reported as *P* Value or Effect Size, When Possible (95% CI)	Participation of Intervention Group
Neck/shoulder strengthening exercise vs no training	Office workers in general	Andersen et al, 2012[27] (Denmark)[b,c]	Job: 449 office workers from a national public admin authority	Type: 3 strengthening intervention arms: 1 × 60 (1 h/wk), 3 × 20 (20 min, 3 times/wk), 9 × 7 (7 min, 9 times/wk) Description: Specific strength training using 5 dumbbell exercises: front raises, lateral raises, reverse flies, shrugs, and wrist extensions Providers: Experienced exercise instructors Mode: Face-to-face in a group Duration: 20 wk	No training (no intervention)	Average pain for last 3 mo on 0–9 scale	3 intervention groups combined: SMD = 0.14 (–0.08 to 0.37)[d,e]	56% of participants participated at least 20 min/wk
		Blangsted et al, 2008[32] (Denmark)[b,c]	Job: 549 office workers from a public admin authority	Type: Dynamic and specific strength training, 20 min, 3 times/wk Description: Dynamic resistance training included seated static exercises for the neck and explosive rowing and kayaking ergometer exercises for the shoulders; specific resistance training with dumbbells included shoulder extension, abduction, and lift Providers: Experienced exercise instructors Mode: Face-to-face in a group Duration: 52 wk	No training (general health counseling)	Average pain for last 3 mo on 0–9 scale	SMD = –0.22 (–0.49 to 0.04)[d]	45% of participants participated at least 20 min/wk (mean of 54% the first half and 35% the second half of the intervention)
		Kietrys et al, 2007[50] (US)	Job: 72 office workers from a university and from insurance, physical therapy, and software companies	Type: Strength training twice daily Description: Resistance training included isometric neck rotation with manual resistance (5-s hold, 5 repetitions), shoulder shrugs, and scapular retraction with elastic band resistance (12 repetitions each) Provider: Not reported Mode: Face-to-face in a group Duration: 4 wk	No training (deep breathing and ankle pumps)	Current pain on 0–10 scale	SMD = 0.19 (–0.38 to 0.75)[d,f]	74% of planned training attended (average daily frequency of exercise = 1.47 times/d)

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Table 1.
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Intervention Category	Main Population Analyzed	Study (Country)	Participants' Job Description and Condition	Intervention Type/ Dosage, Description, Provider, Mode of Delivery, and Duration	Comparator Intervention	Outcome	Findings for Intervention vs Control, Reported as *P* Value or Effect Size, When Possible (95% CI)	Participation of Intervention Group
	Office workers who were symptomatic	Andersen et al, 2012[27] (Denmark)[b,c]	Job: 256/449 office workers (subset of general population from Andersen et al, 2012[27]) from a public admin authority Condition: Neck/shoulder pain with intensity of ≥3 (of 9)	Type: 3 strengthening intervention arms: 1 × 60 (1 h/wk), 3 × 20 (20 min, 3 times/wk), 9 × 7 (7 min, 9 times/wk) Description: Specific strength training using 5 dumbbell exercises: front raises, lateral raises, reverse flies, shrugs, and wrist extensions Providers: Experienced exercise instructors Mode: Face-to-face in a group Duration: 20 wk	No intervention	Average pain for last 3 mo on 0–9 scale	3 intervention groups combined: SMD = 0.23 (−0.07 to 0.52)[d,e]	56% of participants participated at least 20 min/wk[g]
		Blangsted et al, 2008[32] (Denmark)[b,c]	Job: 100/549 office workers (subset of general population from Blangsted et al, 2008[32]) from a public admin authority Condition: Neck pain with intensity of ≥3 (of 9)	Type: Dynamic and specific strength training, 20 min, 3 times/wk Description: Dynamic resistance training included seated static exercises for the neck and explosive rowing and kayaking ergometer exercises for the shoulders; specific resistance training with dumbbells included shoulder extension, abduction, and lift Providers: Experienced exercise instructors Mode: Face-to-face in a group Duration: 52 wk	No training (general health counseling)	Average pain for last 3 mo on 0–9 scale	SMD = 0.46 (0.07 to 0.86)[d]	45% of participants participated at least 20 min/wk (mean of 54% the first half and 35% the second half of the intervention)[g]
		Andersen et al, 2008[b49] (Denmark)[b]	Job: 48 female participants from banks, post offices, national admin offices, and an industrial production unit Condition: Trapezius myalgia	Type: Strength training, 20 min, 3 times/wk Description: Specific strength training using 5 dumbbell exercises: 1-arm row, shoulder abduction, elevation, reverse flies, and upright row Provider: Exercises were supervised Mode: Face-to-face in a group Duration: 10 wk	No training (general health counseling)	General pain for last 3 d on 0–100 VAS	SMD = 1.29 (0.20 to 2.38)[d]	87% of planned sessions attended

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Table 1.
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Intervention Category	Main Population Analyzed	Study (Country)	Participants' Job Description and Condition	Intervention Type/ Dosage, Description, Provider, Mode of Delivery, and Duration	Comparator Intervention	Outcome	Findings for Intervention vs Control, Reported as *P* Value or Effect Size, When Possible (95% CI)	Participation of Intervention Group
		Andersen et al, 2011[47] (Denmark)[b]	Job: 198 office workers Condition: Neck/shoulder pain with intensity of ≥2 (out of 10) during the past 3 mo, at least 30 d during the past year	Type: 2 strengthening intervention arms: 2 min/d, 12 min/d, 5 times/wk Description: Both intervention groups did resistance training with elastic tubing, performing shoulder abductions (lateral raises) Providers: Physical therapists Mode: Face-to-face initially and then individually thereafter Duration: 10 wk	No training (general health counseling)	Worst pain in last week on 0–10 NRS	2 min/d: SMD = 0.60 (0.32 to 1.03) 12 min/d: SMD = 0.90 (0.54 to 1.26) 2 min+12 min/d: SMD = 0.74 (0.43 to 1.05)	2 min/d: 65% of planned training sessions attended 12 min/d: 66% of planned training sessions attended
		Andersen et al, 2014[48] (Denmark)[b]	Job: 47 office workers from a university Condition: Neck/shoulder pain with intensity of ≥3 (out of 9) in the previous month	Type: Scapular functional training, 20 min, 3 times/wk Description: Scapular exercises targeting serratus anterior and lower trapezius muscles to a high extent and upper trapezius muscle to a lower extent; elastic bands were provided for extra resistance if required Provider: Experienced exercise instructor Mode: Face-to-face in a group Duration: 10 wk	No intervention	Pain in last month on 0–9 scale	SMD = 0.93 (0.26 to 1.59)[d]	70% of planned training sessions attended
		Viljanen et al, 2003[51] (Finland)	Job: 393 female office workers from a health care center Condition: Nonspecific neck pain of ≥12 wk	Type: Dynamic muscle training, 30 min, 3 times/wk Description: Dynamic muscle training using dumbbells to activate large muscle groups in the neck/shoulder region, followed by stretching Provider: Physical therapist Mode: Face-to-face in a group Duration: 12 wk	No intervention	Average pain in last week on 0–10 scale	SMD = −0.08 (−0.33 to 0.17)[f]	39% of planned training sessions attended
Neck/shoulder strengthening exercise vs physical therapy	Office workers who were symptomatic	Vasseljen et al, 1995[46] (Norway)	Job: 33 female office workers Condition: Neck/shoulder pain with intensity of ≥3 (out of 6) for last 6 mo and 2 wk, and pain for ≥3 d continuously for last 2 wk	Type: Group strengthening at workplace, 30 min, 3 times/wk Description: Strengthening exercises consisted of 4 arm exercises (shoulder abduction, flexion, and extension and modified push-ups),[69] each performed for 10 repetitions, 3 sets, using dumbbells or body weight Provider: Physical therapist Mode: Face-to-face in a group Duration: 5–6 wk	Individual physical therapy (1 h, twice/wk)	Average pain in last week on 0–10 VAS	SMD = 0.04 (−0.76 to 0.84)[d,f]	86% of planned training sessions attended

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Table 1.
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Intervention Category	Main Population Analyzed	Study (Country)	Participants' Job Description and Condition	Intervention Type/ Dosage, Description, Provider, Mode of Delivery, and Duration	Comparator Intervention	Outcome	Findings for Intervention vs Control, Reported as *P* Value or Effect Size, When Possible (95% CI)	Participation of Intervention Group
Combined neck/shoulder endurance training and stretching vs no intervention	"At risk office workers"	Sihawong et al, 2014[5] (Thailand)	Job: 567 office workers Condition: "Lower than normal" neck flexion range (<54.1°) or neck flexor endurance (<39 s)	Type: Stretching twice/ workday and neck muscle endurance training twice/ wk at home Description: Stretching exercises for upper trapezius, levator scapulae, pectoralis, and rectus capitis posterior muscles were performed for 30 s each; endurance training for long muscles (ie, longus capitis, longus colli, and rectus capitis anterior and lateralis) was performed 10 times; exercises were prompted by a text message Provider: Not reported Mode: Individually at work (endurance training) and at home (stretching) Duration: 52 wk	No intervention	Pain incidence: pain for >24 h in last month; pain intensity: >30 mm on 0- to 100-mm VAS	RR = 2.20 (1.50 to 3.22)[d]	Stretching: 30% of planned training sessions attended Endurance training: 57% of planned training sessions attended
Neck/shoulder stretching exercise vs no stretching	Office workers in general	Galinsky et al, 2007[53] (US)	Job: 90 data entry operators	Type: Stretching during work breaks Description: Stretches were targeted at the neck, shoulders, back, and upper body and required no more than 2 min to perform Provider: Principal investigator Mode: Individually Duration: 8 wk	No stretching during work break times	"Feeling State Questionnaire" on 1–5 scale	Stretching not more effective than no stretching ($P > .05$)	Breaks in which participants stretched/total no. of breaks: 25%–39%
Whole-body light resistance exercise vs no intervention	Office workers who were symptomatic	Sjögren et al, 2005[54] (Finland)	Job: 126 office workers from admin companies Condition: Neck/shoulder pain or headache restricting normal daily activities for last 12 mo	Type: Whole-body light resistance exercise once/d for first 5 wk and then 1 or 2 times/d for next 10 wk Description: Whole-body progressive light resistance exercise consisted of dynamic symmetrical movements: upper body extension/flexion, trunk rotation to right/left, knee extension/flexion, 20 repetitions Provider: Physical therapist Mode: Individually except for 3 group sessions that were supervised face-to-face at 5-wk intervals Duration: 15 wk	No intervention	Pain in last week on 0–10 Borg CR10 Scale	Whole-body light resistance exercise more effective than no intervention ($P = .002$)	75% of planned training sessions attended

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Table 1.
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Intervention Category	Main Population Analyzed	Study (Country)	Participants' Job Description and Condition	Intervention Type/ Dosage, Description, Provider, Mode of Delivery, and Duration	Comparator Intervention	Outcome	Findings for Intervention vs Control, Reported as *P* Value or Effect Size, When Possible (95% CI)	Participation of Intervention Group
General fitness exercise vs no training	Office workers in general	Blangsted et al, 2008[32] (Denmark)[c]	Job: 549 office workers from a public admin authority	Type: All-around physical activity, 1 h/wk Description: Participants were motivated to increase their daily physical activities at their worksite and during leisure time via pep talks and "contract" setting; activities such as Nordic walking and running were started, and exercise instruments such as steppers were placed next to copy machines to encourage activity Providers: Experienced exercise instructors Mode: Face-to-face in a group Duration: 52 wk	No training (general health counseling)	Average pain for last 3 mo on 0–9 scale	SMD = −0.20 (−0.44 to 0.05)[d]	30% of participants participated at least 20 min/ wk (mean of 31% the first half and 28% the second half of the intervention)
		Grønningaeter et al, 1992[44] (Norway)	Job: 79 office workers from an insurance company	Type: Aerobic exercise, 55 min, 3 d/wk Description: Aerobic exercises were dynamic and rhythmical, at moderate intensity, and aimed at improving physical capacity, muscle strength, flexibility, and relaxation of neck, back, and shoulder muscles Providers: Instructors with university-level sport education and aerobic dance certification Mode: Face-to-face in a group Duration: 10 wk	No intervention	Pain in last month on 4-point scale using Health Questionnaire Pain Index	Aerobic physical exercise more effective than no intervention ($P < .05$)	Not reported
	Office workers who were symptomatic	Blangsted et al, 2008[32] (Denmark)[b,c]	Job: 113/549 office workers (subset from Blangsted et al, 2008[32]) from a national public admin authority Condition: Neck pain with intensity of ≥3 (out of 9)	Type: All-around physical activity, 1 h/wk Description: Participants were motivated to increase their daily physical activities at their worksite and during leisure time via pep talks and "contract" setting; activities such as Nordic walking and running were started, and exercise instruments such as steppers were placed next to copy machines to encourage activity Providers: Experienced exercise instructors Mode: Face-to-face in a group Duration: 52 wk	No training (general health counseling)	Average pain for last 3 mo on 0–9 scale	SMD = 0.43 (0.06 to 0.81)[d]	30% of participants participated at least 20 min/ wk (mean of 31% the first half and 28% the second half of the intervention)[g]

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Table 1.
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Intervention Category	Main Population Analyzed	Study (Country)	Participants' Job Description and Condition	Intervention Type/ Dosage, Description, Provider, Mode of Delivery, and Duration	Comparator Intervention	Outcome	Findings for Intervention vs Control, Reported as *P* Value or Effect Size, When Possible (95% CI)	Participation of Intervention Group
		Andersen et al, 2008b[49] (Denmark)[b]	Job: 48 female participants from banks, post offices, national admin offices, and an industrial production unit Condition: Trapezius myalgia	Type: General fitness training, 20 min, 3 times/wk Description: Participants performed high-intensity general fitness training with legs only (without holding onto handlebars) on a Monark bicycle ergometer (Monark Exercise AB, Vansbro, Sweden) Provider: Exercises were supervised Mode: Face-to-face in a group Duration: 10 wk	No training (general health counseling)	General pain for last 3 d on 0–100 VAS	SMD = 0.40 (−0.67 to 1.47)[d]	83% of planned training sessions attended
Qigong vs no intervention	Office workers in general	Skoglund et al, 2011[54] (Sweden)	Job: 37 office workers from the electronic and electrotechnical sectors	Type: Qigong (Chinese martial arts) Description: Participants performed Qigong as a group activity while watching a video daily for 17–25 min; the training involved movements, breathing, and verbal instructions Provider: Video of Qigong program Mode: Video activity in a group Duration: 6 wk	No intervention	Current/ average/ worst pain in last week on 0–10 scale[70]	Qigong not more effective than no intervention ($P > .05$)	83% of planned training sessions attended
Multiple ergonomic adjustments (eg, keyboard, monitor, mouse) vs no intervention	Office workers in general	Gerr et al, 2005[55] (US)	Job: 376 office workers from insurance, financial, and food product companies and universities	Type: 2 intervention arms, consisting of alternative ergonomics (from protective factors identified for neck and upper body in a pilot study) and conventional ergonomics (from industry recommendations) Description: Both alternative and conventional ergonomics involved ergonomic adjustments, such as keyboard, monitor, and mouse angles at various degrees Provider: Study staff member Mode: Face-to-face individually Duration: 26 wk	No intervention	Pain incidence: pain severity of ≥6 on any day of the week using 0–10 VAS	Alternate ergonomics: RR = 0.93 (0.63 to 1.37) Conventional ergonomics: RR = 0.99 (0.67 to 1.47)	Alternate ergonomics: 25% fully compliant to all preset ergonomic adjustments Conventional ergonomics: 38% fully compliant to all preset ergonomic adjustments

(Continued)

Table 1.
Continued

Intervention Category	Main Population Analyzed	Study (Country)	Participants' Job Description and Condition	Intervention Type/ Dosage, Description, Provider, Mode of Delivery, and Duration	Comparator Intervention	Outcome	Findings for Intervention vs Control, Reported as *P* Value or Effect Size, When Possible (95% CI)	Participation of Intervention Group
		Martin et al, 2003[35] (US)[c]	Job: 16 female clerical and office workers from a college	Type/Description: Work injury prevention program consisting of education (on posture, stretching, and proper use and positioning of office supplies), workstation redesign (chairs, monitors, and keyboards were readjusted on the basis of a worksite analysis and worker input), and individually tailored task modifications (eg, stretching and changing positions throughout the day) Provider: Master of Occupational Therapy students and principal investigator Mode: Face-to-face individually Duration: 4 wk	No intervention	Pain on 1–4 Likert severity scale	RR = −0.46 (−1.52 to 0.61)	Not reported
		Mahmud et al, 2015[40] (Malaysia)	Job: 179 office workers	Type/Description: Lecture on office ergonomics followed by a practical one-on-one session with a trainer who provided assistance on adjustment of workstation Providers: Trainers from the National Institute of Safety and Health Mode: Face-to-face in a group and individually Duration: 26 wk	No intervention	Pain in the last 6 mo (yes or no)	Workstation adjustments more effective than no intervention ($P < .0001$)	Not reported
	Office workers who were symptomatic	Mekhora et al, 2000[45] (Thailand)	Job: 80 office workers Condition: Tension neck syndrome	Type/Description: Workstation adjustments were performed on the basis of recommendations from computer software (IntelAd version 1.2; for individual participants; examples of recommendations included changes to height of seat base, keyboard home row, center of monitor, and footrest height Provider: Not reported Mode: Face-to-face individually Duration: 26 wk	No intervention	Pain in the morning and afternoon on 0–10 VAS	Workstation adjustments more effective than no intervention ($P < .0001$)	Not reported
Ergonomic interventions (alternative mouse vs conventional mouse)	Office workers in general	Conlon et al, 2008[43] (US)[b]	Job: 206 office workers from an aerospace engineering firm	Type/Description: Alternative mouse (vertical handle, flat base for ulnar support, and roller ball for tracking) Provider: Not reported Mode: Face-to-face individually Duration: 52 wk	Conventional mouse (LED for mouse tracking, hand pronated)	Pain incidence: worst pain in last week of >5 on 0–10 scale	RR = 1.57 (0.63 to 3.89)	Not reported

(Continued)

Table 1.
Continued

Intervention Category	Main Population Analyzed	Study (Country)	Participants' Job Description and Condition	Intervention Type/ Dosage, Description, Provider, Mode of Delivery, and Duration	Comparator Intervention	Outcome	Findings for Intervention vs Control, Reported as *P* Value or Effect Size, When Possible (95% CI)	Participation of Intervention Group
		Rempel et al, 2006[56] (US)[b]	Job: 182 customer service employees from a large health care company	Type/Description: Trackball (Marble Mouse; Logitech, Fremont, California) Provider: Trained research associate Mode: Face-to-face individually Duration: 52 wk	Conventional mouse	Pain incidence: worst pain in last week of >5 on 0–10 scale	RR = 1.61 (0.91 to 2.87)	Not reported
Ergonomic interventions (arm support vs no support)	Office workers in general	Conlon et al, 2008[43] (US)	Job: 206 office workers from an aerospace engineering firm	Type/Description: Forearm board (butterfly shaped) attached to desk at inclination upwards at 5° and padded forearm support Provider: Not reported Mode: Face-to-face individually Duration: 52 wk	No forearm board	Pain incidence: worst pain in last week of >5 on 0–10 scale	RR = 0.62 (0.25 to 1.55)	Not reported
		Cook and Burgess-Limerick, 2004[41] (Australia)	Job: 59 newspaper call center workers	Type/Description: Forearm support (using desk surface) and maintenance of neutral shoulder elevation Provider: Not reported Mode: Face-to-face individually Duration: 6 wk	No forearm support	Pain in last week or within last 12 mo	RR = 1.62 (0.54 to 4.83)	64% (used forearm support all the time)
		Rempel et al, 2006[56] (US)	Job: 182 customer service employees from a health care company	Type/Description: Arm board (wraparound padded arm support on edge of desk) Provider: Trained research associate Mode: Face-to-face individually Duration: 52 wk	No arm board	Pain incidence: Worst pain in last week of >5 on 0–10 scale	RR = 1.83 (1.03 to 3.26)	Not reported
Ergonomic interventions (low vs high monitor angle)	Office workers in general	Fostervold et al, 2006[48] (Norway)	Job: 150 employees from an insurance company	Type/Description: Low monitor line of sight (at −30° to horizontal line) Provider: Not reported Mode: Face-to-face individually Duration: 52 wk	High monitor line of sight (at −15°)	Pain symptom questionnaire developed in-house	Low more effective than high monitor line of sight ($P = .039$)	Not reported
Group education vs no intervention	Office workers who were symptomatic	Bernaards et al, 2007[36,] (the Netherlands)[c]	Job: 466 employees from insurance, science, energy, transportation, and tax offices Condition: Neck stiffness/ tingling ≥1 time/wk for last 6 mo and/ or 2 wk	Type/Description: Work style behavior education (behavioral change for posture, workplace adjustments, breaks, and coping with job demands) Provider: Specially trained counselor Mode: Face-to-face in a group Duration: 26 wk	No intervention	Current, average, and worst pain in last 4 wk on 0–10 NRS	Work style education not more effective than no intervention ($P > .05$)	82% of participants who attended ≥3 of total of 6 group meetings

(Continued)

Table 1.
Continued

Intervention Category	Main Population Analyzed	Study (Country)	Participants' Job Description and Condition	Intervention Type/ Dosage, Description, Provider, Mode of Delivery, and Duration	Comparator Intervention	Outcome	Findings for Intervention vs Control, Reported as *P* Value or Effect Size, When Possible (95% CI)	Participation of Intervention Group
		Kamwendo and Linton, 1991[42] (Sweden)	Job: 79 medical secretaries Condition: Neck/shoulder pain in previous year	Type/Description: 2 intervention arms: Traditional neck school (lectures twice weekly on prevention of work-related neck/shoulder pain [eg, anatomy, etiology, and self-care measures]); reinforced neck school (traditional neck school plus individualized workstation and psychological intervention) Provider: Physical therapist Mode: Face-to-face in a group (traditional neck school) and individually (reinforced neck school) Duration: 4 wk	No intervention	Morning, noon, and afternoon pain intensity on 0–100 VAS	Traditional and reinforced neck school not more effective than no intervention ($P > .05$)	Traditional neck school: 100% of planned sessions attended Reinforced neck school: 98% of planned sessions attended
Cognitive behavioral stress management vs no intervention	Office workers in general	Grønningaeter et al, 1992[44] (Norway)	Job: 79 office workers from an insurance company	Type/Description: Cognitive behavioral stress management of lifestyle and health issues (diet, smoking, common health problems) for 55 min, 3 d/wk Providers: Principal investigator, psychiatrist, medical officer, and scientist specializing in stress research Mode: Face-to-face in a group Duration: 10 wk	No intervention	Pain in last month on 4-point scale using Health Questionnaire Pain Index	Cognitive behavioral stress management not more effective than no intervention ($P > .05$)	Not reported
Supplementary vs conventional work breaks	Office workers in general	Galinsky et al, 2000[58] (US)	Job: 101 data entry operators	Type/Description: Supplementary work breaks (extra 5-min break/h of work shift) Provider: Not applicable Mode: Individual Duration: 8 wk	Conventional work breaks (15-min breaks during first and second halves of shift)	Current discomfort: "Feeling State Questionnaire" on 1–5 scale	Supplementary more effective than conventional work breaks ($P = .0002$)	Not reported
		Galinsky et al, 2007[52] (US)	Job: 90 data entry operators processing income tax forms	Type/Description: Supplementary work breaks (extra 5-min break/h of work shift) Provider: Not applicable Mode: Individual Duration: 8 wk	Conventional work breaks (15-min breaks during first and second halves of shift)	Current discomfort: "Feeling State Questionnaire" on 1–5 scale	Supplementary more effective than conventional work breaks ($P = .03$)	Supplementary: Mean of 6 breaks/d Conventional: Mean of 3 breaks/d
	Office workers who were symptomatic	van den Heuvel et al, 2003[59] (the Netherlands)	Job: 268 office workers from a social security allowance company Condition: Current neck/shoulder complaints for ≥2 wk	Type/Description: Extra breaks (5-min break after computer use of 35 min and microbreak of 7 s after each continuous use of 5 min) Provider: Not applicable Mode: Individual Duration: 8 wk	No intervention/conventional breaks	Pain in last week on 1–10 scale	SMD = –0.13 (–0.46 to 0.20)	Not reported

(Continued)

Table 1.
Continued

Intervention Category	Main Population Analyzed	Study (Country)	Participants' Job Description and Condition	Intervention Type/ Dosage, Description, Provider, Mode of Delivery, and Duration	Comparator Intervention	Outcome	Findings for Intervention vs Control, Reported as *P* Value or Effect Size, When Possible (95% CI)	Participation of Intervention Group
Myofeedback vs no myofeedback	Office workers who were symptomatic	Sandsjö et al, 2010[60] (the Netherlands and Sweden)	Job: 65 female office workers from rehabilitation centers and patient websites and medical secretaries Condition: Average neck/ shoulder pain in the past month of ≥3 (of 10) on VAS	Type/Description: Myofeedback-based teletreatment (muscle biofeedback for relaxation of the trapezius muscle plus teleconsultations) Provider: "Therapist" Mode: Individual Duration: 4 wk	No intervention	Average pain in last month on 0–10 VAS	Myofeedback-based teletreatment not more effective than no intervention ($P > .05$)	Not reported
		Voerman et al, 2007a[38] (the Netherlands and Sweden)[c]	Job: 79 female job counselors and medical secretaries Condition: Neck/shoulder symptoms for ≥30 d during the last year	Type/Description: Myofeedback training (upper trapezius muscle biofeedback) and individualized ergonomic counseling Provider: "Therapist" Mode: Face-to-face individually (ergonomic counseling) Duration: 4 wk	Ergonomic counseling	Current pain on 0–10 VAS	Myofeedback training and ergonomic counseling not more effective than ergonomic counseling alone ($P > .05$)	Not reported

[a]Bold type indicates statistically significant results ($P < .05$). NRS = numerical rating scale, RR = relative risk, SMD = standardized mean difference, VAS = visual analog scale.
[b]Study selected for meta-analysis.
[c]Single study representing duplicate articles (with same randomized controlled trial numbers).
[d]Data not reported in published study and provided by author(s) on request.
[e]Reported results (insignificance) differed from original published results (significance) because of unadjusted estimates. In original published study, estimates were adjusted on the basis of sex and baseline neck pain.
[f]Final values rather than changes from baseline scores were used for SMD calculations.
[g]Participation rates were based on total office worker population.

Three of these RCTs studied a general population of office workers, each finding no significant effect on neck pain intensity.[27,32,50] The intervention length for these studies was 4,[50] 20,[27] and 52[32] weeks, with participation rates of 74%, 56%, and 45%, respectively. Data from the 4-week intervention could not be subjected to a meta-analysis due to lack of data for change from baseline and the short intervention period.[50] Meta-analysis of the other 2 trials[24,28] (n = 674) found moderate quality evidence (downgraded for inconsistency) for the ineffectiveness of neck/ shoulder strengthening in comparison to no training in a general population of office workers (SMD = −0.03; 95% CI = −0.39 to 0.33) (Fig. 3A). However, the high heterogeneity between the trials ($I^2 = 77\%$) possibly was related to differences in intervention lengths (given that similar exercises and total training durations [60 min/wk]) were reported).

Six trials studied the effects of neck/ shoulder strengthening exercises in office workers who were symptomatic in comparison to no training.[27,32,47–49,51] Although the intervention periods varied from 10 to 52 weeks, all trials showed a positive effect in favor of exercise intervention except for a single trial, which had the lowest participation at 39% (SMD = −0.08; 95% CI = 0.33 to 0.17).[51] Change from baseline data could not be obtained for this trial (with the lowest participation) and hence was excluded from meta-analysis.[51] Meta-analysis of the other 5 trials (n = 605) found moderate-quality evidence (downgraded for inconsistency), and a medium effect of neck/ shoulder strengthening exercises in office workers who were symptomatic (SMD = 0.59; 95% CI = 0.29 to 0.89) ($I^2 = 57\%$) (Fig. 3B). For the 5 trials subjected to a meta-analysis, there

Table 2.
Summary of Evidence for Effectiveness of Workplace-Based Interventions for Neck Pain Intensity, Incidence, or Prevalence in Office Workers[a]

Intervention vs Comparator Category	Population	Studies	Risk of Bias	Inconsistency	Indirectness	Imprecision	Quality[b]	Conclusion[c]
Exercise interventions								
Neck/shoulder strengthening vs no training	Office workers in general	Blangsted et al, 2008[32] Andersen et al, 2012[27] Kietrys et al, 2007[50,d]	Not serious	Serious (−1)[e]	Not serious	Not serious	⊕⊕⊕○	No difference (SMD = −0.03; 95% CI = −0.39 to 0.33)
	Office workers who were symptomatic	Blangsted et al, 2008[32] Andersen et al, 2008b[49] Andersen et al, 2011[47] Andersen et al, 2012[27] Andersen et al, 2014[48] Viljanen et al, 2003[51,d]	Not serious	Serious (−1)[e]	Not serious	Not serious	⊕⊕⊕○	**Medium effect in favor of strengthening (SMD = 0.59; 95% CI = 0.29 to 0.89);** the greatest effects were found for studies with the highest participation rates
Neck/shoulder strengthening vs physical therapy (individualized)	Office workers who were symptomatic	Vasseljen et al, 1995[46]	Not serious	Not applicable	Not serious	Serious (−1)[f]	⊕⊕⊕○	No difference (SMD = 0.04; 95% CI = −0.76 to 0.84)
Combined neck endurance and stretching vs no intervention	"At risk office workers"	Sihawong et al, 2014[5]	Not serious	Not applicable	Not serious	Not serious	⊕⊕⊕⊕	**Large effect in favor of combined endurance and stretching (RR = 2.20; 95% CI = 1.50 to 3.22)**
Neck/shoulder stretching exercise vs no stretching	Office workers in general	Galinsky et al, 2007[52]	Very serious (−2)[g]	Not applicable	Not serious	Serious (−1)[h]	⊕○○○	No difference ($P > .05$)[i]
Whole-body light resistance exercise vs no training	Office workers who were symptomatic	Sjögren et al, 2005[53]	Not serious	Not applicable	Not serious	Serious (−1)[f]	⊕⊕⊕○	**In favor of whole-body light resistance training ($P < .01$)[i]**
General fitness exercise vs no training	Office workers in general	Blangsted et al, 2008[32] Grønningaeter et al, 1992[44]	Not serious	Very serious (−2)[j]	Not serious	Serious (−1)[h]	⊕⊕○○	Conflicting evidence[i]
	Office workers who were symptomatic	Blangsted et al, 2008[32] Andersen et al, 2008b[49]	Not serious	Not serious	Not serious	Serious (−1)[k]	⊕⊕⊕○	Small effect in favor of general fitness exercise (SMD = 0.43; 95% CI = 0.08 to 0.78)
Qigong (Chinese marital arts) vs no intervention	Office workers in general	Skoglund et al, 2011[54]	Not serious	Not applicable	Not serious	Serious (−1)[f]	⊕⊕⊕○	No difference ($P > .05$)[i]
Ergonomic interventions								
Multiple ergonomic adjustments (eg, keyboard, monitor, mouse) vs no intervention	Office workers in general	Gerr et al, 2005[55] Martin et al, 2003[35] Mahmud et al, 2015[40]	Not serious	Serious (−1)[j]	Not serious	Serious (−1)[h]	⊕⊕○○	Conflicting evidence[i]

(Continued)

Table 2.
Continued

Intervention vs Comparator Category	Population	Studies	Risk of Bias	Inconsistency	Indirectness	Imprecision	Quality[b]	Conclusion[c]
	Office workers who were symptomatic	Mekhora et al, 2000[45]	Very serious (−2)[g]	Not applicable	Not serious	Serious (−1)[f]	⊕○○○	In favor of multicomponent ergonomic intervention ($P < .01$)[i]
Alternative mouse vs conventional mouse	Office workers in general	Conlon et al, 2008[43] Rempel et al, 2006[56]	Not serious	Not serious	Not serious	Serious (−1)[k]	⊕⊕⊕○	No difference (RR = 1.60; 95% CI = 0.99 to 2.60) ($P = .06$)
Arm support vs no arm support	Office workers in general	Cook and Burgess-Limerick, 2004[41] Conlon et al, 2008[43] Rempel et al, 2006[56]	Not serious	Very serious (−2)[j]	Not serious	Not serious	⊕⊕○○	Conflicting evidence[i]
Low vs high monitor angle	Office workers in general	Fostervold et al, 2006[57]	Not serious	Not applicable	Not serious	Very serious (−2)[f,h]	⊕⊕○○	**In favor of low monitor angle ($P < .05$)[i]**
Other interventions								
Group education vs no intervention	Office workers who were symptomatic	Bernaards et al, 2007[36] Kamwendo and Linton, 1991[42]	Not serious	Not serious	Not serious	Serious (−1)[h]	⊕⊕⊕○	No difference ($P >.05$)[i]
Cognitive behavioral stress management training vs no intervention	Office workers in general	Grønningaeter et al, 1992[44]	Serious (−1)[g]	Not applicable	Not serious	Serious (−1)[f]	⊕⊕○○	No difference ($P > .05$)[i]
Supplementary vs conventional work breaks	Office workers in general	Galinsky et al, 2000[58] Galinsky et al, 2007[52]	Very serious (−2)[g]	Not serious	Not serious	Very serious (−2)[h]	⊕○○○	**In favor of supplementary work breaks ($P < .05$)[i]**
	Office workers who were symptomatic	van den Heuvel et al, 2003[59]	Not serious	Not applicable	Not serious	Serious (−1)[f]	⊕⊕⊕○	No difference (SMD = −0.13; 95% CI = −0.46 to 0.20)
Myofeedback (muscle biofeedback intervention) vs no myofeedback	Office workers who were symptomatic	Sandsjö et al, 2010[60] Voerman et al, 2007a[37]	Serious (−1)[g]	Not serious	Not serious	Not serious	⊕⊕⊕○	No difference ($P > .05$)[i]

[a]Bold type indicates significant differences between intervention and comparator groups. −1 = downgraded by 1 level, −2 = downgraded by 2 levels, RR = relative risk, SMD = standardized mean difference.
[b]⊕○○○ = very low, ⊕⊕○○ = low, ⊕⊕⊕○ = moderate, ⊕⊕⊕⊕ = high.
[c]Conclusions were based on reported results or effect statistics (SMD or RR) calculated using the random-effects model, when possible.
[d]Trial excluded from meta-analysis.
[e]High statistical heterogeneity.
[f]One small study reporting an outcome.
[g]High risk of bias.
[h]CIs not reported in 1 or more studies.
[i]No effect sizes displayed because of lack of change from baseline data.
[j]Inconsistency in intervention length, population size, and/or direction of results.
[k]Large CIs in 1 or more studies.

was an observed trend toward higher SMD effect size with higher participation (45%–87%). A participation rate of greater than or equal to 66% was associated with an SMD of medium to large effect sizes (0.74–1.29) (Fig. 3B).

A single trial (n = 33) of moderate-quality evidence (downgraded for imprecision) compared group-based neck/shoulder strengthening exercises with individualized physical therapy and found no differences between the interventions in the reduction of neck pain intensity in office workers who were symptomatic (SMD = 0.04; 95% CI = −0.76 to 0.84).[46] In this trial, the intervention period was short (5–6 weeks), but the strengthening group had high participation at 86%.[46]

Study	1) Method of randomization adequate?	2) Concealed allocation?	3) Patient blinded?	4) Care provider blinded?	5) Outcome assessor blinded?	6) Drop out rate acceptable?	7) All randomized participants analysed?	8) Selective outcome reporting?	9) Groups similar at baseline?	10) Cointerventions avoided or similar?	11) Compliance acceptable in all groups?	12) Timing of outcome assessment similar in groups?
Andersen 2008b	+	+	–	–	–	+	+	+	+	+	+	+
Andersen 2011	+	+	–	–	–	+	+	+	+	+	+	+
Andersen 2012	+	+	–	–	–	–	+	+	+	+	+	+
Andersen 2013	+	–	–	–	–	+	+	+	+	+	+	+
Bernaards 2007	+	–	–	–	–	+	+	+	+	+	+	+
Blangsted 2008	+	+	–	–	–	+	+	+	+	+	–	+
Conlon 2008	+	–	–	–	–	–	+	+	+	+	?	+
Cook 2004	+	–	–	–	–	+	+	+	+	+	+	+
Fostervold 2006	+	–	–	–	–	+	–	+	+	+	?	+
Galinsky 2000	+	–	–	–	–	–	–	+	–	+	?	+
Galinsky 2007	+	–	–	–	–	–	–	+	–	+	–	+
Gerr 2005	+	–	–	–	–	+	+	+	+	+	–	+
Grønningaeter 1992	?	–	–	–	–	+	–	+	+	+	?	+
Kamwendo 1991	?	–	–	–	–	–	+	+	–	+	+	+
Kietrys 2007	?	–	–	–	–	+	+	+	–	+	+	+
Mahmud 2015	+	–	–	–	–	–	+	+	+	+	?	+
Martin 2003	?	–	–	–	–	+	–	+	+	+	?	+
Mekhora 2000	?	–	–	–	–	–	–	+	–	+	?	+
Rempel 2006	+	–	–	–	–	–	+	+	+	+	?	+
Sandsjo 2010	+	–	–	–	–	–	–	+	+	+	?	+
Sihawong 2014	+	+	–	–	–	+	+	+	+	+	–	+
Sjögren 2005	?	+	–	–	–	–	+	+	+	+	+	+
Skoglund 2011	?	–	–	–	–	+	–	+	+	+	+	+
van den Heuvel 2003	+	–	–	–	–	+	–	+	+	+	?	+
Vasseljen 1995	+	–	–	–	–	+	+	+	+	+	+	+
Viljanen 2003	+	+	–	–	–	+	+	+	+	+	–	+
Voerman 2007a	+	–	–	–	–	+	–	+	+	+	?	+

Figure 2.
Summary of review authors' judgments about each risk-of-bias item for each included study.

One further large RCT (n = 567) of high-quality evidence recruited participants without neck pain but lower than normal neck flexion range and neck flexor muscle endurance ("at risk office workers").[5] A large effect was found in favor of 52 weeks of combined neck endurance and stretching exercises (RR = 2.20; 95% CI = 1.50 to 3.22) in reducing neck pain incidence in the "at risk office workers" compared to no intervention. However, the participation levels in the trial varied from 30% (stretching exercise) to 57% (neck endurance exercise). The low participation in stretching may be related to the higher frequency of exercises expected by the study protocol (daily during break times versus twice per week for endurance exercise).

Effect of General Fitness Training

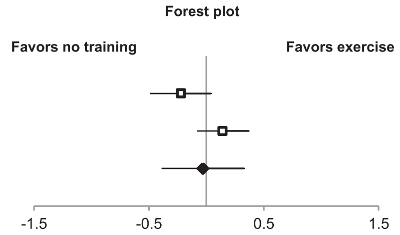
Two trials (n = 628) of low quality (downgraded for inconsistency and imprecision) found conflicting evidence for the effectiveness of general fitness exercises on reducing neck pain intensity in a general population of office workers.[32,43] Of the 2 trials, a large 52-week study (n = 549) found insignificant differences between 1 hour of general fitness training per week (consisting of activities such as Nordic walking and running) and no training (SMD = −0.20; 95% CI = −0.44 to 0.05).[32] The other, smaller trial (n = 79) of 10 weeks found significant effectiveness of aerobics exercise (55 minutes, 3 times per week) compared to no intervention ($P < .05$).[43]

Two RCTs (n = 127) studied the effect of 1 hour of general fitness training per week on office workers who were symptomatic in comparison to no training.[32,49] In the trial that found a significant effect, training consisted of 52 weeks of all-around fitness exercises involving the whole body,[32] while the other that trial that found no significant effect consisted of 10 weeks of purely leg cycling.[49] When the 2 studies were pooled, meta-analysis found moderate-quality evidence (downgraded for imprecision) of a small effect in favor of 1 hour of general fitness training per week on reducing pain intensity in office workers who were symptomatic

(A)

Study	Comparator Mean	Comparator SD	Comparator Total	Experimental Mean	Experimental SD	Experimental Total	Weight	SMD (95% CI)
Blangsted et al, 2008[32]	0.04	1.89	123	0.45	1.75	102	48.1%	-0.22 (-0.49 to 0.04)
Andersen et al, 2012[27]	-0.58	1.95	101	-0.85	1.86	348	51.9%	0.14 (-0.08 to 0.37)
Total			**224**			**450**	**100.0%**	**-0.03 (-0.39 to 0.33)**

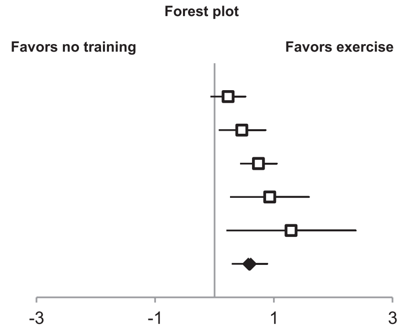
Heterogeneity: $Tau^2 = 0.05$; $Chi^2 = 4.36$, df = 1 ($P = .04$); $I^2 = 77\%$
Test for overall effect: Z = 0.18 ($P = .86$)



(B)

Study	Comparator Mean	Comparator SD	Comparator Total	Experimental Mean	Experimental SD	Experimental Total	Weight	SMD (95% CI)
Andersen et al, 2012[27]	-0.97	2.36	58	-1.46	2.11	198	20.4%	0.23 (-0.07 to 0.52)
Blangsted et al, 2008[32]	-0.2	2.23	55	-1.22	2.11	45	18.2%	0.46 (0.07 to 0.86)
Andersen et al, 2011[47]	0.1	1.63	64	-1.55	2.45	128	20.1%	0.74 (0.43 to 1.05)
Andersen et al, 2014[48]	0.57	2.4	19	-1.7	2.4	20	12.9%	0.93 (0.26 to 1.59)
Andersen et al, 2008b[49]	0	1.4	6	-1.8	1.3	12	7.3%	1.29 (0.20 to 2.38)
Total			**202**			**403**	**100.0%**	**0.59 (0.29 to 0.89)**

Heterogeneity: $Tau^2 = 0.06$; $Chi^2 = 9.29$, df = 4 ($P = .05$); $I^2 = 57\%$
Test for overall effect: Z = 3.80 ($P = .0001$)



(C)

Study	Comparator Mean	Comparator SD	Comparator Total	Experimental Mean	Experimental SD	Experimental Total	Weight	SMD (95% CI)
Andersen et al, 2008b[49]	0	1.4	6	-1.2	3.5	8	10.8%	0.40 (-0.67 to 1.47)
Blangsted et al, 2008[32]	-0.2	2.23	55	-1.21	2.38	58	89.2%	0.43 (0.06 to 0.81)
Total			**61**			**66**	**100.0%**	**0.43 (0.08 to 0.78)**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.00$, df = 1 ($P = .95$); $I^2 = 0\%$
Test for overall effect: Z = 2.39 ($P = .02$)

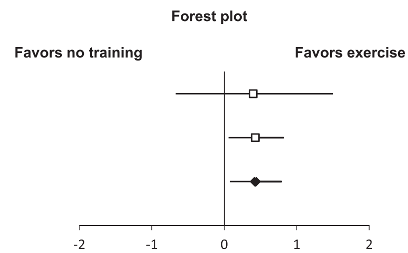


Figure 3.
Standardized mean differences (SMDs) calculated from change from baseline values for individual studies and pooled analysis based on random-effects model (in order of increasing SMD and where weight = weighted average[21]). (A) Forest plot for improvement in pain intensity after neck/shoulder strengthening exercises versus no training in a general population of office workers (with or without neck pain) on the basis of a pooled analysis of 2 trials. (B) Forest plot for improvement in pain intensity after neck/shoulder strengthening exercises versus no training in office workers who were symptomatic (with neck pain) on the basis of a pooled analysis of 5 trials. (C) Forest plot for improvement in pain intensity after general fitness exercises versus no training in office workers who were symptomatic (with neck pain) on the basis of a pooled analysis of 2 trials.

(SMD = 0.43; 95% CI = 0.08 to 0.78) ($I^2 = 0\%$) (Fig. 3C).

Effects of Other Exercise Types

Three trials studied the impact of other exercise types, including stretching,[52] light whole-body resistance exercise,[53] and Qigong (Chinese martial arts).[54] A single trial (n = 90) of very low-quality evidence (downgraded for risk of bias and imprecision) found that 8 weeks of neck/shoulder stretching exercise alone was ineffective in reducing neck pain intensity compared to no stretching in a general population of office workers.[52] In another single trial (n = 126) of moderate-quality evidence (downgraded for imprecision), 15 weeks of whole-body resistance exercise was found to be effective in reducing neck pain in office workers who were symptomatic compared to no intervention.[53] A further single trial of moderate-quality evidence (downgraded for imprecision) found 6 weeks of daily Qigong ineffective in reducing neck pain in a general population of office workers compared to no intervention.[54]

Effects of Ergonomic Interventions

The effect of multiple adjustments to the workstation (eg, combined keyboard, monitor, and mouse changes) was studied in 4 trials.[35,40,45,55] Of these, 3 trials (n = 571) found low-quality evidence (downgraded for inconsistency and imprecision) of conflicting results for the effectiveness of multiple workstation

Study	Comparator Events	Comparator Total	Experimental Events	Experimental Total	Weight	Relative risk (95% CI)
Conlon et al, 2008[43]	11	103	7	103	28.6%	1.57 (0.63 to 3.89)
Rempel et al, 2006[56]	25	83	14	75	71.4%	1.61 (0.91 to 2.87)
Total		**186**		**178**	**100.0%**	**1.60 (0.99 to 2.60)**

Heterogeneity: $Tau^2 = 0.00$; $Chi^2 = 0.00$, df = 1 ($P = .96$); $I^2 = 0\%$

Test for overall effect: Z = 1.90 ($P = .06$)

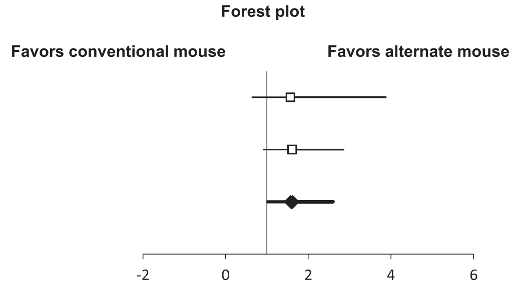


Figure 4.
Forest plot for improvement in pain incidence with an alternative mouse intervention versus a conventional mouse in a general population of office workers (with or without neck pain) on the basis of a pooled analysis of 2 trials (in order of increasing relative risk [RR] and where weight = weighted average[21]). The RRs were calculated using pain incidence or prevalence values of the individual studies, and the pooled analysis was based on the random-effects model (in order of increasing RR and where weight = weighted average[21]).

adjustments on neck pain incidence in a general population of office workers compared to no intervention.[35,40,55] Only one 26-week trial (n = 80) studied the impact of multiple workstation adjustments on office workers who were symptomatic and found it efficacious compared to no intervention ($P < .0001$).[45] This trial was, however, of very low quality (downgraded for risk of bias and imprecision), and participation was not reported.[45]

Three RCTs studied the impact of an alternative mouse[43,56] and arm support[41,43,56] on neck pain incidence/prevalence in a general population of office workers. Meta-analysis of two 52-week trials (of moderate-quality evidence, downgraded for imprecision) (n = 364) suggested the alternative mouse (eg, vertical handle/trackball) may be important in reducing neck pain incidence, as the results neared significance (RR = 1.60; 95% CI = 0.99 to 2.60) ($I^2 = 0\%$) ($P = .06$) (Fig. 4).[43,56] Three trials (n = 447) of low-quality evidence (downgraded for inconsistency) found conflicting evidence for the effect of arm support compared to no arm support in reducing neck pain incidence/prevalence. Two of these trials found 6 weeks or 52 weeks of arm support ineffective.[41,43] The third 52-week trial found a beneficial effect of arm support; however, there was no assessor blinding and the attrition rate was 31%.[56] The 3 trials also had large differences in intervention lengths (6 versus 52 weeks).[41,43,56]

A single 52-week trial (n = 150) found a downward-angled computer monitor more effective compared to an upward-angled monitor in reducing neck pain ($P = .04$), but this was low-quality evidence (downgraded for imprecision).[57]

Effects of Other Workplace-Based Interventions

Eight trials studied the effects of other workplace-based interventions, including education,[36,42] CBT,[44] work breaks,[52,58,59] and myofeedback.[38,60] Two trials (n = 545) of moderate-quality evidence (downgraded for imprecision) supported the ineffectiveness of 4 to 26 weeks of group education versus no intervention on reducing neck pain intensity in office workers who were symptomatic ($P > .05$).[36,42] There was low-quality evidence (downgraded for risk of bias and imprecision) based on a single trial (n = 79) for the ineffectiveness of 10 weeks of CBT on reducing neck pain intensity in a general population of office workers ($P > .05$).[44] Two trials (n = 191) of very low-quality evidence (downgraded for risk of bias and imprecision) found that 8 weeks of supplementary work breaks were effective in reducing neck pain intensity in a general population of office workers[52,58] ($P < .05$), but another trial (n = 268), which was of moderate quality (downgraded for imprecision), failed to find its effectiveness in office workers who were symptomatic.[59] Two trials (n = 144) of moderate quality (downgraded for risk of bias) found myofeedback (muscle biofeedback) intervention ineffective in reducing neck pain intensity in office workers who were symptomatic ($P > .05$), but the intervention periods were only 4 weeks in both trials.[38,60]

Discussion

This systematic review of 27 RCTs provides evidence for the impact of workplace-based interventions on neck pain in office workers. Most evidence focused on exercise interventions, with less attention directed toward ergonomic interventions. A key finding of the review was that neck/shoulder-specific strengthening exercise was effective in reducing neck pain intensity in office workers who were symptomatic, but did not demonstrate effectiveness in a general population of office workers. The latter finding may represent a floor effect, as individuals who are pain free at baseline may dilute the impact of the intervention on pain intensity. Evidence on the prevention of neck pain in office workers was very limited. However, there is high-quality evidence based on a single trial that combined neck endurance and stretching exercises might be efficacious for the "at risk office workers."[5] For ergonomic interventions, the available, albeit limited evidence suggests that multiple workstation adjustments are effective in office workers who are symptomatic,[45] while evidence for a general population of office workers was conflicting and of low quality. The lack of high-quality ergonomic intervention trials targeted at office workers who were symptomatic warrants future research.

This study extends previous reviews by examining the impact on both intensity and incidence/prevalence of neck pain. Moreover, analysis was performed separately for a general population of office workers (ie, with or without neck pain), as well as a subpopulation of office workers who were symptomatic. As intervention effects were unique to the subpopulation studied, this represents an important strength of the review. Several limitations were associated with the interpretation of this review's results. First, data could not be obtained from some authors for a more comprehensive analysis. Second, our review has focused on self-reported pain. While pain is often the major concern of an affected individual, future reviews may need to also target more functional outcomes (ie, neck disability, sick leave). Third, reporting bias might be present, as only studies in the English language were included.

In comparison to the present review, a previous review found exercise interventions ineffective compared to no interventions in workers with work-related arm, neck, or shoulder complaints.[12] The review was, however, not specific to office workers, and hence only 1 of their 5 studies was included in this review.[51] Our results were consistent with another review of neck/shoulder strengthening and stretching exercises for neck disorders in the symptomatic (working/nonworking) population.[61] However, the same review also found evidence for the ineffectiveness of general fitness exercises. In comparison, our review included an additional large study (n = 549)[32] for meta-analysis, and found a small effect in favor of general fitness exercises for office workers who were symptomatic. The present review also explored factors that may influence the effectiveness of exercise training regimens on pain outcomes. The type of training was one of the factors that appeared important because in office workers who were symptomatic, strengthening exercises that were specifically targeted to the neck/shoulder region produced superior effect sizes than general fitness training. Additionally, this review observed that higher participation in exercise influences the size of the effect, with SMDs ranging from 0.74 to 1.29 for studies reporting participation rates of 66% to 87% but SMDs of 0.23 and 0.46 for studies with participation rates of 56% and 45%, respectively. Interestingly, the longer-duration RCTs (20–52 weeks)[27,32] reported reduced participation (45%–56%), which may have also influenced their pain outcomes. Our findings support previous evidence which found a significant dose-response relationship between participation in a training intervention and neck pain reduction.[62,63] As it is out of scope of this review to robustly analyze the effect of participation on effect size, future studies should consider using specific methods such as the complier average causal effect to estimate treatment effect among compliers.[64] Although ergonomic strategies are considered best practice at workplaces for office workers,[65] our review found low-quality and conflicting evidence to support the implementation of multiple workstation adjustments in a general population of office workers. Ergonomic interventions which directly influence neck posture, such as varying monitor angle placement, may be efficacious for some office workers,[57] while an alternative mouse use may be promising in reducing neck pain incidence. Generally, this review found the ergonomic trials were of lower quality and smaller sample size than the ergonomic interventions, and hence more ergonomic RCTs are required to form firmer conclusions. Evidence was generally not in favor of the other workplace-based interventions such as group education, CBT, and myofeedback in office workers who were symptomatic. These interventions were not specifically targeted to the neck/shoulder, which may explain the lack of effect. There was very low-quality evidence to suggest that taking additional work breaks can help reduce discomfort in a general population of office workers.[52,58] However, no effect was found in office workers who were symptomatic, which suggests that work breaks alone are probably insufficient for the individuals who were symptomatic and might benefit more from exercise.

The results from this review are relevant for employers and policymakers. Our results suggest that exercise interventions are best targeted toward symptomatic or "at risk" office workers. However, given that approximately half of office workers may suffer from neck pain within a 12-month period,[1,2,5,8] it could be argued that interventions should be offered to all office workers irrespective of their neck pain status. Logistical and equity issues may also limit undertaking workplace interventions for select groups of workers. This review could not make firm conclusions on the effects of most ergonomic interventions due to the lack of RCTs targeted at office workers who were symptomatic.

Several methodological issues were identified in this review. Forty-one percent of the RCTs were rated "unclear" for participation, as most of these studies did not report participation (performance bias). In addition, most studies did not report concealed allocation, potentially contributing to selection bias. However, it is understood that concealed allocation can be difficult to perform logistically due to the risk of contamination (eg, in an open-plan workplace). Furthermore, 30% of the RCTs had unclear randomization methodologies. There were also issues surrounding the use of neck pain as a measurement of intervention impact. Pain intensity was of limited value in detecting intervention impact in individuals without neck pain at baseline (ie, many of those in the general population). In addition, the surveyed time frames for pain varied considerably, from pain in the last 3 days[49] to pain in the last 12 weeks.[27] We suggest future studies use a combination of pain intensity and incidence outcomes, particularly for those studying the prevention of neck pain. Future studies should also provide clear criteria for the classification of neck case/incidence status and pain survey time frames. We also recommend subgroup analyses of symptomatic, asymptomatic, and possibly "at risk" groups to be performed. Inconsistencies in definitions have been acknowledged in previous studies to affect study outcomes,[66,67] hence future research with specific case definitions and subgrouping of the study population may yield more consistent and stronger clinical recommendations. Future studies should also consider reporting both intention-to-treat and per-protocol results based on achieving a minimum participation level. A recent study recommended 70% participation as the cutoff point for per-protocol analysis,[68] a recommendation that is supported by our observation that participation of greater than or equal to 66% was associated with a larger effect size. However, more studies are needed to confirm the recommendations for cutoffs and standards for reporting participation. We additionally recommend future studies to adopt transparency with the reporting of adverse effects. Finally, research on primary neck pain prevention was limited and more studies in this area are warranted.

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All authors made substantial contributions to the concept and design, data acquisition, data analysis and interpretation, and writing and revision of the paper and approved the final version for submission.

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Systematic Review Registration

This systematic review was registered with PROSPERO (no. 42014006905). The review protocol is available on the PROSPERO website at http://www.crd.york.ac.uk/PROSPERO/.

Disclosures/Presentations

The authors completed the ICJME Form for Disclosure of Potential Conflicts of Interest and reported no conflicts of interest.

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Appendix.
General Search Strategy Used in This Study[a]

Neck Pain Terms	Work Setting Terms	Population Terms
Neck pain[b] Cervicalgia Cervicodynia "Trapezius myalgia" Complaints of the arm, neck, shoulder, "Tension neck syndrome" "Tension neck syndromes"	"Workplace intervention" "Workplace interventions" Workplace[b] Work Worksite[b] "Work environment" Compan[b] Office[b] Organization[b] Organisation[b] "on-site"	Office work[b] Visual display operator[b] Visual display unit[b] Visual display terminal[b] Computer[b] Employ[b]

[a]Terms in each column were combined using a Boolean "OR" operator. The 3 main categories were then combined using a Boolean "AND" operator. The restrictions "English language" and "human studies" were applied when available.
[b]Truncation was used in this term.

Following is an example of the search strategy applied in one of the electronic databases used in this review.

MEDLINE Search Strategy

(neck pain* or cervicalgia or cervicodynia or "trapezius myalgia" or complaints of the arm neck shoulder or "tension neck syndrome" or "tension neck syndromes") AND ("workplace intervention" or "workplace interventions" or workplace* or worksite* or "work environment" or company* or office* or organization* or organisation* or "on-site") AND (office work* or visual display operator* or visual display unit* or visual display terminal* or computer* or employ*) NOT surger*

Added filters: "English" and "Human"