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DOI:
10.1016/j.apergo.2023.104216

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Document Version
Publisher's PDF, also known as Version of record

Citation for published version (Harvard):
Jones, LB, Jadhakhan, F & Falla, D 2024, 'The influence of exercise on pain, disability and quality of life in office workers with chronic neck pain: A systematic review and meta-analysis', *Applied Ergonomics*, vol. 117, 104216. https://doi.org/10.1016/j.apergo.2023.104216

Link to publication on Research at Birmingham portal

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Download date: 03. May. 2024

Applied Ergonomics 117 (2024) 104216

Contents lists available at ScienceDirect

Applied Ergonomics

journal homepage: www.elsevier.com/locate/apergo

The influence of exercise on pain, disability and quality of life in office workers with chronic neck pain: A systematic review and meta-analysis

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ARTICLE INFO

Keywords:
Chronic neck pain
Exercise
Strengthening
Office workers
Effectiveness

ABSTRACT

Background: Exercise is recommended for office workers with neck pain. However, recent reviews evaluated the effectiveness of workplace interventions only.
Objectives: To evaluate the effect of exercise on pain, disability, and quality of life (QoL) in office workers with chronic neck pain.
Design: Systematic review with meta-analysis.
Methods: Electronic databases were searched from inception to April 30, 2022, to identify studies in which participants were adults aged ≥18 years undergoing any form of neck exercises (e.g., strengthening, motor control) or physical activity (e.g., aerobic exercise) performed for a minimum of two-weeks without any other additional treatment besides advice or education. Two reviewers independently screened papers and determined the certainty of the evidence.
Results: Eight randomised controlled trials met the eligibility criteria. Seven studies reported a significant decrease in Visual Analogue Scale (VAS) scores for neck pain intensity and five studies reported a significant decrease in Neck Disability Index (NDI) scores following strengthening exercises. Only one study assessed the effect of strengthening exercises on QoL and reported no significant effect. All eight included studies had a high risk of bias and the overall certainty of evidence was low. Meta-analyses demonstrated a significant decrease of neck pain intensity and disability for strengthening exercises compared to a control ($p < 0.01$).
Conclusion: There is low certainty of evidence that strengthening of the neck, shoulder and scapular musculature is effective at reducing neck pain and disability in office workers. Further research evaluating the effect of exercise on QoL is required.

1. Introduction

Neck pain is a global healthcare burden with 10.2 million annual outpatient care visits in the United States alone (Riddle and Schappert, 2007). Between 20% and 70% of adults will experience neck pain during their lifetime (Sinnott et al., 2017) causing significant disability and decreased quality of life for many (Ehsani et al., 2017).

Office workers report the highest annual incidence of neck pain compared with all other occupations (Côté et al., 2009) with more than 50% experiencing neck pain during their career (Welch et al., 2020). Considerable resources have focused on the treatment and prevention of neck pain in office workers due to the legal responsibility employers have for the health of their employees (Pereira et al., 2019). Workplace interventions have been applied to encourage early return-to-work to reduce the personal and socioeconomic consequences of musculoskeletal disorders (Aas et al., 2011). Both workplace ergonomic optimisation and neck exercises have been shown to reduce neck pain (Mehrparvar et al., 2014). However, Shariat et al. (2018) reported a significant reduction in neck pain intensity (Mean Difference −9.99; 95% Confidence Interval [CI] −13.63 to −6.36) for specific exercise compared to ergonomic modification after 6 months, suggesting that ergonomic modification only is not sufficient to reduce neck pain, emphasising the importance of including exercises.

Due to the COVID-19 pandemic, millions of people were instructed to work from home (WFH) (Bouziri et al., 2020). This further reduced the level of physical activity in office workers who WFH compared to

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https://doi.org/10.1016/j.apergo.2023.104216
Received 25 April 2023; Received in revised form 15 December 2023; Accepted 21 December 2023
Available online 13 January 2024
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pre-COVID-19 levels (Brusaca et al., 2021), which has led to a ~50% increase in neck pain severity (Moretti et al., 2020). Therefore, home-based interventions have become vital for office workers. A recent study showed that neck strengthening and stretching exercises completed at home reduced neck pain in home-office workers (Anand and Goyal, 2020). Furthermore, home-based yoga resulted in a significant reduction in neck pain in office workers during the COVID-19 pandemic (Garcia et al., 2021), suggesting that this could be an effective strategy to reduce neck pain for individuals who WFH.

A review by Louw et al. (2017) evaluated the effectiveness of neck exercises not restricted to the workplace on pain and quality of life in office workers. However, the review demonstrated significant heterogeneity in the effect of combined studies, potentially due to a small number of studies and a large discrepancy in the study sample sizes. Since this review by Louw et al. (2017), further randomised controlled trials have been published evaluating the effectiveness of home-based interventions on neck pain in office workers (e.g., Tersa-Miralles et al., 2021; Andersen et al., 2012). This emphasises the need to re-evaluate the current evidence to assess if exercises are effective, which may change how work-place interventions are applied in the future.

The aim of this review is to systematically evaluate the literature and determine the effectiveness of any form of exercise (home-based or workplace interventions) on reducing neck pain intensity and disability and improving quality of life (QoL) in office workers with chronic neck pain compared to passive treatment or no intervention.

2. Methods

This systematic review was conducted in line with the PRISMA guidelines (Page et al., 2021), described in supplementary file 1. The protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO: CRD42021297535) on December 10th, 2021.

2.1. Eligibility criteria

Selection criteria for inclusion and exclusion of studies were formed following the PICOS framework (Population, Intervention, Comparator, Outcome and Study design) (Methley et al., 2014).

2.2. Population

- Male and or female participants aged ≥18 years
- Self-reported chronic non-specific neck pain lasting ≥6 months.
- Currently working an office-based occupation.

2.3. Interventions

Any form of neck exercises (e.g., strengthening, motor control) or physical activity (e.g., aerobic exercise) performed for a minimum of two-weeks without any other additional treatment besides advice or education were eligible. The effects for each exercise intervention were considered separately for studies comparing two or more types of exercise interventions (e.g., strengthening versus stretching exercises).

2.4. Comparator

No intervention or any non-exercise training intervention e.g., passive treatments which may include, but not limited to, manual therapy or education only.

3. Outcome

The primary outcome was neck pain intensity, of which measures may include the Numerical Pain Rating Scale [NPRS] (Ibrahim et al., 2020) and the Visual Analogue Scale (VAS; Haefeli and Elfering, 2006). The secondary outcomes were disability such as the Neck Disability Index (NDI; Vernon, 2008) and QoL measures such as the Verbal Rating Short-Form Questionnaire (SF-36; Ware, 2000).

3.1. Study design

Randomised Controlled Trials (RCTs) that used one of more types of exercise as a primary intervention published in the English language were included.

3.2. Follow-up

Studies with a minimum of 2-weeks follow-up of outcomes were included.

3.3. Setting

No restrictions were placed on the type of setting of studies.

3.4. Exclusion criteria

- Aged <18 years.
- Diagnosed with spinal pathology such as radiculopathy, whiplash, tumour, fracture, dislocation, infection, or systemic disease.
- Exercise interventions coupled with other treatment techniques such as manual therapy.
- Single case studies, case reports alongside review articles, letters, editorials, pilot studies, study protocols, studies with only abstracts and any other literature with no full text availability.
- Articles not published in English.

3.5. Sources of information

The following electronic databases was searched independently by two reviewers (LBJ, FJ) from inception to April 30, 2022 to identify potential literature: MEDLINE (OVID Interface), EMBASE (OVID Interface), PsychINFO (OVID Interface), Web of Science, PubMed, Google Scholar (first 20 pages), Cumulative Index to Nursing and Allied Health Literature (CINAHL), Physiotherapy Evidence Database (PEDro), Cochrane Library and ZETOC. Key journals and grey literature were also searched. Backward citation chaining was completed for relevant studies. Forward citation chaining was not completed. Medical subject headings (MeSH) and terms related to the eligibility criteria was used with Boolean Operators "AND" and "OR" to conduct the literature search. The full list of search terms and search strategy is presented in supplementary file 2.

3.6. Study selection

The search strategy was discussed and finalised by the research team which had expertise to formulate keywords and Boolean operators to limit or expand searches. Two reviewers screened the databases independently (LBJ, FJ). No language, date, study design or participant filters were applied during the search. Data from literature search results was uploaded and managed in EndNote version 20 software (Clarivate Analytics, Philadelphia, PA). The same two reviewers independently removed duplicates, reviewed titles and abstracts for inclusion using the eligibility criteria. This was then completed for full texts to identify the final eligible articles. Any disagreement was discussed between both reviewers and if a consensus was not reached, a third reviewer (DF) was consulted.

3.7. Data collection process

The two reviewers' independently extracted data from each included full text study using a pre-defined data extraction sheet (see supplementary file 3). The following data items were extracted from each study: authors, year of publication, study location, study design, participant's characteristics and outcomes of interest (pain, disability and QoL measures), measures used to identify pain, disability and QoL, intervention type (exercise), sample size, follow-up time, setting, and items associated with risk of bias, summary statistics and methods for statistical analysis. Extracted outcome data was pre- and post-intervention mean and standard deviation (SD)/standardised mean difference (SMD) and associated 95% confidence intervals (CI). In cases where mean and SD were presented only as figures, Web Plot Digitizer software tool (https://apps.automeris.io/wpd/) was used to extract numerical data and this software has high reliability and validity (Drevon et al., 2017). In cases where raw data was not available, primary authors were contacted twice with a third and final email sent two weeks after. Both reviewers discussed and resolved any disagreement and involved a third reviewer (DF) if necessary.

3.8. Risk of bias assessment

The Cochrane Risk of Bias tool V2 [RoB2] (Sterne et al., 2019) was used to assess the risk of bias of all included studies (see supplementary file 4) as recommended in the Cochrane Handbook for Systematic Reviews of Interventions (Higgins et al., 2019). Bias was scored as "low risk", "unclear risk" or "high risk" for each type of bias. Types of bias may include selection bias (random sequence generation and allocation concealment), performance bias (blinding of patients/research team), detection bias (blinding of outcome assessment), attrition bias (incomplete outcome data/lost to follow-up), and reporting bias (selective outcome reporting.

3.9. Data synthesis

Data was pooled based on the following parameters: type, duration, frequency and concentration of exercise intervention; type of effect measures (mean difference/standardised mean difference) and comparator type (e.g., no intervention, education only). For the effects of exercise on pain and disability, a sub-group analysis was completed based on the frequency of exercise completed per week. A meta-analysis was completed using STATA Statistical Software version 17 (StataCorp, College Station, Texas). Standardised mean difference and SD for pain intensity, disability and QoL were extracted if calculable. Effect size (ES) and standard error were calculated using Hedges' g formula. The magnitude of the ES was defined as small (0.2 to under 0.5), medium (0.5–0.8), or large (above 0.8). A random effects meta-analysis using the residual maximum likelihood (REML) estimation method (Partlett and Riley, 2017) was completed when studies effect measures and target parameters (population, intervention, control and outcome) were comparable. Heterogeneity was evaluated using the inconsistency I^2 statistical analysis. The magnitude of heterogeneity was classified according to the I^2 statistic as follows: low heterogeneity ($I^2 = 0$–24%), moderate ($I^2 = 25$–49%), substantial ($I^2 = 50$–74%), and considerable ($I^2 =$ 75–100 %).

3.10. GRADE – certainty of evidence

The certainty of evidence was evaluated using the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach (Balshem et al., 2011). The four domains used to assess the certainty of evidence using GRADE included risk of bias, inconsistency, indirectness and imprecision. The approach outlines four levels of certainty; "high", "moderate", "low" and "very low". Randomised controlled trials start with a maximum four points for a high-certainty rating and non-randomised studies start with two points for a low-certainty rating. Certainty was downgraded by one for each domain rated "serious" and downgraded by two for each domain rated "very serious". Overall risk of bias was scored across all included studies and was downgraded by one if most studies had an unclear risk of bias with potential limitations in multiple criteria or a high risk of bias with a crucial limitation in one criterion. If most studies had a high risk of bias with a crucial limitation in one criterion and potential limitation in multiple criteria or crucial limitation in more than one criterion this was rated as "very serious" and downgraded by two. Inconsistency refers to variability in study results and was downgraded by one for each of the following if present: point estimates vary widely across studies, CIs show minimal or no overlap or the heterogeneity is considerable ($I^2 =$ 75–100%). Imprecision was downgraded by one if the boundaries of the CI cross the clinical decision threshold between recommending and not recommending treatment. The second criterion used to assess imprecision was determining the optimal sample size. One downgrade was applied if the total number of participants included for each domain was less than the number of patients generated by a conventional sample size calculation. This calculation was completed using www.calculator.net/sample-size-calculator.html. Indirectness was downgraded by one if there were differences in one of the following four domains; populations, interventions, outcomes and indirect comparisons. If there were difference in more than one domain, this was downgraded by two. The GRADE assessment was completed by two reviewers independently where disagreement was resolved by discussion. If discussion did not resolve any disagreements, a third reviewer (DF) was consulted.

4. Results

A total of 4671 studies were identified from the initial literature search of databases. After duplicates were removed, 3329 studies remained. A total of 3041 articles were excluded after screening titles and 209 abstracts were excluded. Seventy-one full text articles were excluded after full text review with reasons reported in supplementary file 5. Eight RCT's that met the inclusion criteria were included. Fig. 1 details the process of study selection using the PRISMA flow diagram (Page et al., 2021). Characteristics of the included studies are described in Table 1.

4.1. Study characteristics

A total of 1112 participants were included in the eight studies with sample sizes ranging from 32 to 393 participants. Sixty-seven men (6%) and 1045 women were included across the eight studies. Two of the studies were from Denmark, two from China and Finland respectively, and one each from Thailand and South Korea. Three of the studies recruited participants from office buildings, two recruited from university admin staff, two from occupational healthcare centres and one study recruited elementary school workers. Screening questionnaires were sent via email in two studies, physicians recruited eligible participants in two studies and the exact method of recruitment was not indicated in four studies. All included studies used purposive sampling. Characteristics of included studies are described in Table 1.

4.2. Exercise frequency

Exercise frequency of the included studies ranged from three times per week to daily. The most common exercise frequency was three times per week which was completed by participants in four studies (Andersen et al., 2014; Kang et al., 2021; Li et al., 2017; Viljanen et al., 2003). One study evaluated the effects of exercise completed four times per week (Ma et al., 2011). Participants in two studies completed exercises five times per week (Andersen et al., 2011; Ylinen et al., 2003). The study by Borisut et al. (2013) was the only one where participants completed their exercises daily.

4.3. The effect of exercise on pain intensity

- ***Three times per week***

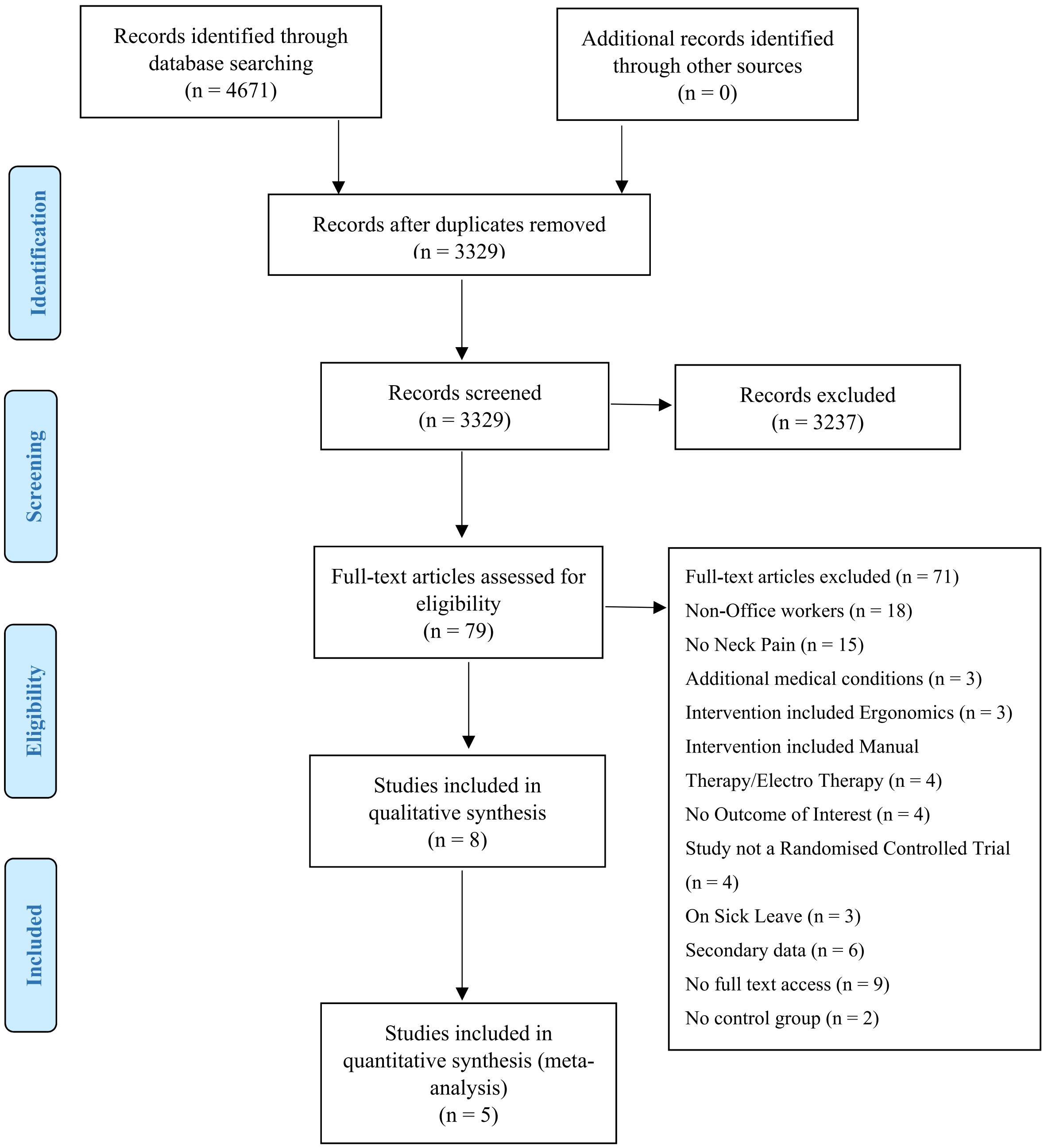

Fig. 1. Flow diagram of the study selection process and included studies.

Andersen et al. (2014) and Kang and colleagues (2021) evaluated the effects of scapula training on neck pain. Both studies reported a significant decrease in pain intensity (VAS) for the intervention group over the intervention period. However, a greater decrease was observed by Kang et al. (2021) in VAS scores (SMD -3.94, SD 0.6, d = 1.2) compared to Andersen et al. (2014; SMD -1.9, SD 0.5). Andersen et al. (2014) reported a between group difference of 2.0 (95% CI 0.4–3.6) in favour of the intervention group in the post-hoc analysis. Compared to cervical spine stabilization exercises and stretches, scapula training significantly reduced VAS ($t = -2.712$, $p = 0.013$) with strong effect size ($d = 0.9$; Kang et al., 2021). Li et al. (2017) observed a significant decrease in VAS scores for progressive neck resistance training (PRT) and fixed neck resistance training (FRT) groups at 4-weeks ($p < 0.001$), 6-weeks ($p < 0.001$) and 3-months ($p < 0.001$) compared to the control group. Both intervention groups demonstrated a significant between group difference compared to the control ($p < 0.05$). However, the PRT was more effective compared to FRT in reducing VAS scores at 4-weeks ($p = 0.031$), 6-week ($p = 0.035$) and 3-month follow-ups ($p = 0.026$). Viljanen et al. (2003) found no significant difference ($p > 0.05$) in VAS score at 3-month follow up for dynamic resistance training of the neck and shoulder musculature (SMD -1.9, SD 0.3). Additionally, no significant difference was observed between the training group and relaxation group (ES -0.1, 95% CI -0.6 to 0.5), and control group (ES 0.2, 95% CI -0.4 to 0.7) respectively.

- ***Four times per week***

Ma et al. (2011) found that active exercise four times per week lead to a significant decrease ($p < 0.05$) in VAS scores at a 6-week follow-up (SMD -2.65, SD -0.25; Ma et al., 2011). Furthermore, a significant ($p < 0.05$) decrease was observed for the active exercise group compared to the control group ($p < 0.001$). However, no difference was observed

Table 1
Characteristics of included studies.

Study	Author	Year	Country	Setting	Intervention			Control		
					Number of participants	Mean age (SD) years	Gender (N)	Number of participants	Mean age (SD) years	Gender (N)
Effect of scapular function training on chronic pain in the neck/shoulder region: a randomised controlled trial	Andersen et al.	2014	Denmark	University admin staff	24	44 (13)	19 (females and 5 males	23	45 (11)	18 females and 5 males
Effectiveness of small daily amounts of progressive resistance training for frequent neck/shoulder pain: randomised controlled trial	Andersen et al.	2011	Denmark	University admin staff	**2-min** 66 **12-min** 66	**2-min** 44 (11) **12-min** 42 (11)	**2-min** 58 females and 8 males **12-min** 58 females and 8 males	66	43 (10)	58 females and 8 males
Effects of strength and endurance training of superficial and deep neck muscles on muscle activities and pain levels of females with chronic neck pain	Borisut et al.	2013	Thailand	Office workplaces	**SEE** 25 **CFE** 25 **Combination** 25	**SEE** 32.72 (3.11) **CFE** 30.40 (3.54) **Combination** 30.16 (2.96)	Females only	25	29.32 (3.11)	Females only
Effects of a combination of scapular stabilization and thoracic extension exercises for office workers with forward head posture on the craniovertebral angle, respiration, pain, and disability: A randomised-controlled trial	Kang	021	South Korea	Elementary school staff	16	37.5 (10.6)	10 females and 6 males (62.5%)	16	35.8 (8.0)	9 females and 7 males (56.3%)
Comparison of the effectiveness of resistance training in women with chronic computer-related neck pain: a randomised controlled study	Li et al.	2017	China	Office workplaces	**PRT** 36 **FRT** 32	**PRT** 35.6 (7.9) **FRT** 33.7 (9.0)	Females only	34	34.1 (8.2)	Females only
Comparing biofeedback with active exercise and passive treatment for the management of work-related neck and shoulder pain: a randomised controlled trial	Ma et al.	2011	China	Outpatient physiotherapy clinics	**Biofeedback** 15 **Active exercise** 15 **Passive treatment** 15	**Biofeedback** 31.3 (8.6) **Active exercise** 34.2 (10.3) **Passive treatment** 35.3 (9.4)	**Biofeedback** 10 females and 5 males **Active exercise** 11 females and 4 males **Passive treatment** 10 females and 5 males (.)	15	30.0 (10.3)	9 females and 6 males
Effectiveness of dynamic muscle training, relaxation training, or ordinary activity for chronic neck pain: randomised controlled trial	Viljanen et al.	2003	Finland	Occupational healthcare centres	**DMT** 135 **RT** 128	**DMT** 45 (6.6) **RT** 43 (7.3)	Females only	130	44 (7.4)	Females only
Active neck muscle training in the treatment of chronic neck pain in women: a randomised controlled trial	Ylinen et al.	2003	Finland	Occupational healthcare centres	**Strength** 60 **Endurance** 59	**Strength** 45 (6) **Endurance** 46 (6)	Females only	60	46 (5)	Females only

Abbreviations: SEE: Strength Endurance Exercise; CFE: Craniocervical Flexion Exercise; SD: Standard Deviation; PRT: Progressive Resistance Training; FRT: Fixed Resistance Training; DMT: Dynamic Relaxation Training; RT: Relaxation Technique.

between the active exercise group and passive treatment group ($p = 0.455$) and biofeedback training was significantly better at decreasing VAS score compared to all other groups ($p < 0.001$).

- ***Five times per week***

Both intervention groups in a study by Andersen et al. (2011) demonstrated a significant reduction ($p < 0.05$) in VAS scores at a

10-week follow-up (12-min SMD -1.8, 95% CI -2.4 to −1.2: 2-min SMD -1.3, 95% CI -1.9 to −0.7). Furthermore, a significant decrease ($p < 0.05$) in VAS scores was observed when comparing a 12-min PRT and a 2-min PRT to the control group (SMD 0.1, 95% CI -0.3 to 0.5). However, no significant difference was present between the two training groups ($p = 0.12$). Ylinen et al., (2003) reported a significant decrease in VAS for both strength and endurance groups compared to a control group ($p < 0.001$). However, no significant difference was observed between the training groups, with 73% in the strength training group and 59% in the endurance training group obtaining complete relief from pain.

- ***Daily***

Borisut et al., (2013) reported a significant decrease in VAS scores from baseline to 12-weeks for strength-endurance, cranio-cervical and combined exercise groups ($p = 0.002$). No significant difference was observed in the control group ($p = 0.575$). Post-hoc analysis showed a significant difference ($p < 0.001$) between all four groups for VAS except between the strength-endurance and cranio-cervical exercise groups where no significant difference was observed.

4.4. The effect of exercise on disability

Six of the eight included studies evaluated disability using the NDI.

- ***3 times per week***

Kang et al. (2021) and Li et al. (2017) reported a significant decrease in NDI scores for all training groups. Furthermore, Li et al. (2017) demonstrated a significant difference between the 2 training groups and control group ($p < 0.001$). However, both studies found no significant difference in NDI scores between the intervention groups. Viljanen et al. (2003) was the only included study that observed no significant difference in NDI scores for the intervention group (SMD -14, SD -0.8). Additionally, no significant ($p < 0.05$) difference in NDI scores was observed between all 3 groups.

- ***4 times per week***

Ma et al. (2011) reported a significant decrease in NDI scores for the active exercise group (SMD -5.72, SD -2.9) and a significantly greater decrease compared to the control group at a 6-week follow-up ($p < 0.001$). No significant difference was found when comparing the active exercise group to the passive treatment group ($p = 0.076$) and the biofeedback group was found to be more effective in reducing NDI scores ($p = 0.003$).

- ***5 times per week***

A significant decrease in NDI scores was observed for both training groups (strength, SMD -40, 95% CI -48 to −32; endurance, SMD -35, 95% CI -42 to −28) in the study by Ylinen et al. (2003) at 12-months follow-up. The between groups analysis demonstrated a significant difference between the training groups and control ($p < 0.001$). However, no significant difference was observed between the strength and endurance groups.

- ***Daily***

Borisut et al. (2013) reported a significant decrease at 12-weeks follow-up for the 3 intervention groups ($p = 0.001$) but not for the control group ($p = 0.091$). Furthermore, a significant difference was observed between all treatment groups and the control but no significant difference between all intervention groups.

4.5. The effect of exercise on quality of life

Viljanen et al. (2003) was the only study that assessed QoL using the normal life limited by neck pain (0–10), subjective workability (0–10) and work limited by pain scales (0–100). At a 3-month follow-up, no significant difference was observed for the dynamic muscle training group from baseline for all 3 outcome measures (normal life limitation scale, SMD -1.5, SD -0.3; subjective workability, SMD -6.5, SD 0.4; work limited by pain, SMD 5, SD -0.2). Furthermore, no significant difference was observed for all 3 outcome measures of QoL when comparing the dynamic muscle training to relaxation training and the control group.

4.6. Methodological appraisal

Risk of bias using the RoB2 is presented in Table 2. All eight studies had an overall high risk of bias. Seven studies (Andersen et al., 2014; Borisut et al., 2013; Kang et al., 2021; Li et al., 2017; Viljanen et al., 2003; Ylinen et al., 2003) did not state if the allocation sequence was concealed thus scoring some concerns to risk of bias for domain 1. Andersen et al. (2011) was the only study that indicated concealment thus scoring a low risk of bias. All studies scored some concerns to risk of bias for domain 2.1 because participants were not blinded from the assigned intervention and deviations from the intended intervention were not indicated. Andersen et al. (2011, 2014) , Borisut et al. (2013); Kang et al. (2021), Li et al. (2017), Viljanen et al. (2003) and Ylinen et al. (2003) used an intention-to-treat analysis thus scoring a low risk of bias for domain 2.2. Ma et al. (2011) scored a high risk of bias as intent-to-treat analysis was not indicated and 12 participants dropped out (16.6%) before 6-week follow up. Seven (87.5%) studies (Andersen et al., 2014; Andersen et al., 2011; Borisut et al., 2013; Kang et al., 2021; Li et al., 2017; Viljanen et al., 2003; Ylinen et al., 2003) scored a low risk of bias for domain 3 as data was available for >95% of participants. Ma et al. (2011) scored a high risk of bias as the reason for why participants dropped out was not indicated. All 8 included studies had a high risk of bias in measurement of the outcome. Blinding of participants in such studies is difficult because participants must actively take part in the intervention. Liu et al. (2011) reported 74% of trials involving muscle strength training did not blind assessors. Self-reported outcomes were included in all studies (e.g. VAS, NDI), thus the assessor being the participant could not be blinded. A low risk of bias in selection of the reported results was scored by all eight studies.

4.7. The effect of exercise on pain intensity – meta-analysis

Comparable data was combined for VAS (SMD and SD) from 5 studies (Andersen et al., 2014; Borisut et al., 2013; Li et al., 2017; Ma et al., 2011; Viljanen et al., 2003) with similar population, intervention and control to complete a meta-analysis. The forest plot showing the overall effect of neck, shoulder and scapula strengthening exercises versus no exercise for neck pain intensity (VAS) is shown in Fig. 2 and reveals a significant overall effect for training. Sensitivity analysis removed Viljanen et al. (2003) from the quantitative analysis due to the low completion rate of the exercise intervention with an average of 13.6 training sessions completed over the 12-weeks (39% of maximum). This forest plot is shown in Fig. 3. This was completed to assess the impact of individual studies on the overall meta-analysis result. The meta-analysis revealed a significant overall effect for training ($z = 6.08$, $p = 0.01$) with a pooled effect size of 7.31 (95% CI, 4.95 to 9.67). However, heterogeneity was considerable ($I2 = 95.25\%$).

4.8. The effect of exercise on disability – meta-analysis

Comparable data was combined for NDI (SMD and SD) from 3 studies (Borisut et al., 2013; Li et al., 2017; Ma et al., 2011) with similar population, intervention and control to complete the meta-analysis. A forest plot was completed for improvements in disability for neck/shoulder

Table 2
Scoring of risk of bias items and overall bias of the included studies.

Studies	1	2.1	2.2	3	4	5	Overall Bias
Andersen et al. 2014	?	?	+	+	−	+	−
Andersen et al. 2011	+	?	+	+	−	+	−
Borisut et al. 2013	?	?	+	+	−	+	−
Kang, Im & Kim 2021	?	?	+	+	−	+	−
Li et al. 2017	?	?	+	+	−	+	−
Ma et al. 2011	?	?	−	−	−	+	−
Viljanen et al. 2003	?	?	+	+	−	+	−
Ylinen et al. 2003	?	?	+	+	−	+	−

Note: Levels of risk of bias: − High risk; ? Some concerns; + Low risk, 1= Risk of bias arising from the randomisation process, 2= Risk of bias due to deviations from the intended intervention, 3=Risk of bias due to missing outcome data, 4=Risk of bias in measurement of the outcome, 5=Risk of bias in selection of the reported result

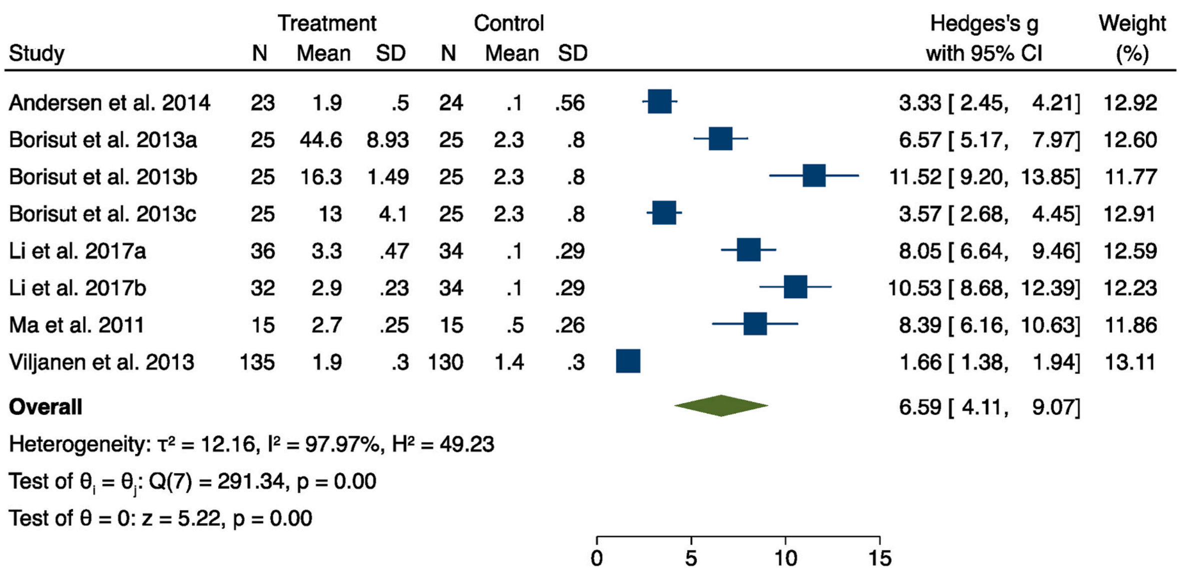

Fig. 2. Forest plot for the reduction in neck pain intensity (VAS) after neck, shoulder and scapula exercises versus no training with results highlighting a significant overall effect for the training (results to the right of 0 favour training).
Borisut et al., 2013a strength-endurance and cervical flexion exercises.
Borisut et al., 2013b strength-endurance exercises.
Borisut et al., 2013c cervical flexion exercises.
Li et al., 2017a progressive resistance exercises.
Li et al., 2017b fixed resistance exercises.

exercises versus no training (Fig. 4). The results showed a significant overall effect for training ($z = 2.44$, $p < 0.01$) with the pooled effect size of 13.75 (95% CI, 2.69 to 24.83). However, there was considerable heterogeneity ($I2 = 99.6\%$).

4.9. Certainty of the evidence

The certainty of evidence sub-grouped by outcome is outlined by the GRADE framework in supplementary file 6. A total of 296 participants from 4 RCTs were pooled to assess the certainty of evidence for the effect of neck and shoulder exercises on neck pain intensity (VAS) compared to no training. A total of 249 participants from 3 RCTs were pooled to assess the certainty of evidence for the effect of neck and shoulder exercises on disability (NDI) compared to no training. All included studies were RCTs therefore both outcomes started with a baseline four points for a high-certainty rating. Overall risk of bias was rated very serious as all included studies had a crucial limitation in the measurement of the outcome and potential limitations in at least two other criteria. Inconsistency was downgraded by one due to the considerable heterogeneity for both pain intensity ($I^2 = 99.65\%$) and disability ($I^2 = 95.25\%$). Imprecision was rated not serious because the CI did not cross the threshold between recommending and not recommending the treatment. The sample size required to have a confidence level of 95% and a margin of error of 5% for pain intensity and disability was calculated using the sample size calculator (www.calculator.net/sample-size-calculator.html). This was 168 and 152 for disability and pain respectively which is less than the number of participants included thus no downgrade is required. Indirectness was rated as not serious as included studies used the same outcomes (VAS and NDI), comparator (no training) and population (office workers with non-specific neck pain). Although differences in load and frequency were present in the interventions between studies, all used strengthening exercises targeting

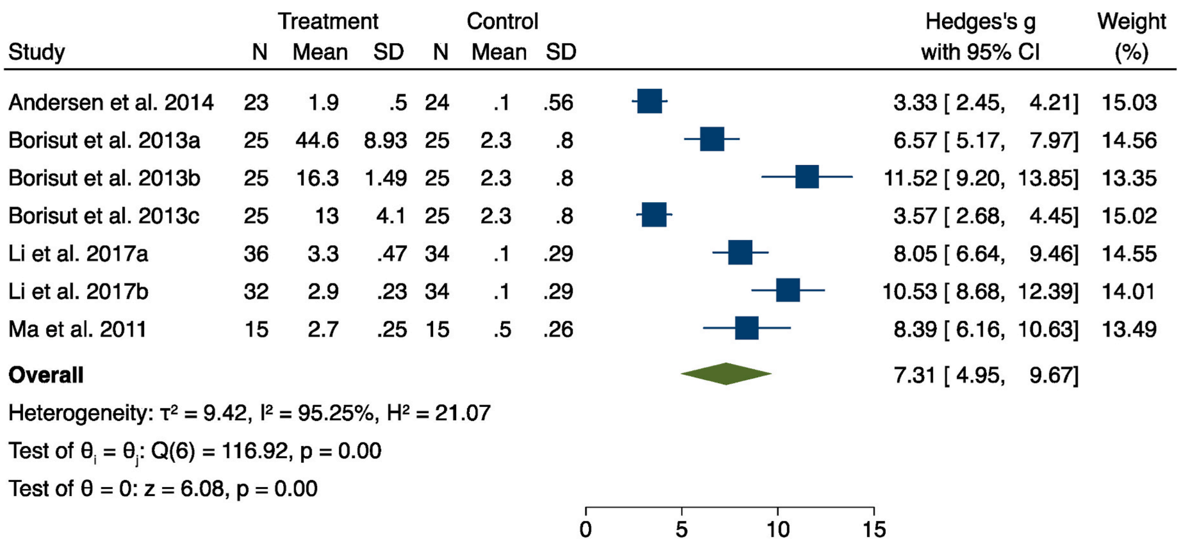

Fig. 3. Forest plot for the reduction in neck pain intensity (VAS) after neck, shoulder and scapula exercises versus no training following sensitivity analysis. Results to the right of 0 favour training.

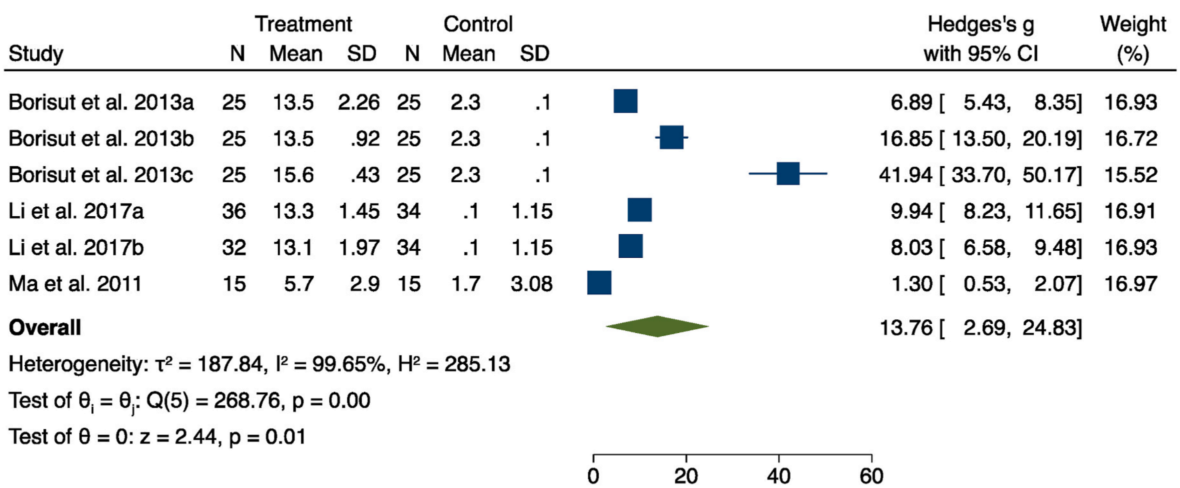

Fig. 4. Forest plot for the change in disability (NDI) after neck/shoulder exercises versus no training. Results to the right of 0 favour training.

Table 3
Summary of findings.

The Effect of Neck and Shoulder Exercises Compared with No Training on Pain Intensity (VAS) and Disability (NDI) in Office Workers with Non-specific Neck Pain

Patient or population: Office workers with non-specific neck pain
Setting: Office or home based
Intervention: Neck and shoulder exercises
Comparison: No training

Outcomes	Anticipated Absolute Effect (95% CI)[a]		Effect Measure (95% CI)	No. Of Participants (studies)	Certainty of evidence (GRADE)	Comments
	Control risk	Intervention risk				
	No training	Neck and shoulder exercises				
Pain Intensity (VAS) Scale 0-100	The mean pain intensity was 56.2 points	Mean pain intensity in the intervention group was 27.4 lower (range, 16.9 to 43)	7.31 (4.95, 9.67)	296 (4)	⊕○○○ Very low	Double downgrade for ROB because all studies had at least one crucial limitation in one criterion and a potential limitation in at least two other criteria. One downgrade for Inconsistency due to considerable heterogeneity (Pain: $I^2 = 95.25\%$; Disability: $I^2 = 99.65\%$)
Disability (NDI) Scale 0-50	The mean Disability score was 28.3 points	Mean Disability score in the intervention group was 14 points lower (range, 10.3 to 15.8)	13.76 (2.69, 24.83)	249 (3)	⊕○○○ Very low	

CI: Confidence interval; **ROB:** Risk of bias.
[a] **The risk in the intervention group** (and its 95% confidence interval) is based on the assumed risk in the comparison group and **the relative effect** of the intervention (and its 95% CI).

the same muscle groups therefore this does not constitute a downgrade. No study was industry sponsored or likely to be industry sponsored thus having low concerns regarding publication bias. Overall, there is a low certainty of evidence supporting the effectiveness of neck and shoulder exercises for changing self-reported neck pain intensity and disability in office workers. A summary of these findings is presented in Table 3. No two studies compared each of the following: neck and shoulder strengthening versus passive treatment (Ma et al., 2011), neck and shoulder strengthening versus relaxation training (Viljanen et al., 2003), neck and shoulder strengthening versus aerobic exercise (Ylinen et al., 2003) and scapular strengthening versus neck strengthening (Kang et al., 2021).

4.10. GRADE working group grades of evidence

High certainty: We are very confident that the true effect lies close to that of the estimate of the effect.

Moderate certainty: We are moderately confident in the effect estimate: The true effect is likely to be close to the estimate of the effect, but there is a possibility that it is substantially different.

Low certainty: Our confidence in the effect estimate is limited: The true effect may be substantially different from the estimate of the effect.

Very low certainty: We have very little confidence in the effect estimate: The true effect is likely to be substantially different. From the estimate of effect.

4.10.1. GRADE rules

Starting Level: RCTs start with four points and non-RCTs start with two points.

Risk of Bias: One downgrade if most studies had an unclear risk of bias with potential limitations in multiple criterion or high risk of bias with a crucial limitation in one criterion. Two downgrades if most studies had a crucial limitation in one criterion with potential limitations in other criterion or crucial limitations in more than one criterion.

Inconsistency: One downgrade for each of the following if present; point estimates vary widely across studies, CIs show minimal or no overlap or if the heterogeneity is considerable ($I^2 = 75–100\%$)

Imprecision: One downgrade if the boundaries of the CI cross the clinical decision threshold between recommending and not recommending treatment and one downgrade if the total number of participants is less than the number of participants generated by a conventional sample size calculation.

Indirectness: One downgrade for any differences in one of the following four domains; populations, interventions, outcomes and indirect comparisons. Two downgrades for any difference in more than one of the domains.

5. Discussion

This review investigated the effects of exercise on pain, disability and QoL in office workers with chronic non-specific neck pain and identified that there is low certainty of evidence that strengthening exercises decreases self-reported neck pain intensity and disability in office workers. Apart from one study by Viljanen et al. (2003), strengthening exercises did not significantly improve QoL, and thus there is a paucity of evidence to draw meaningful conclusions for this variable.

5.1. Exercise type and frequency

All studies within the review included an exercise-based intervention targeting either neck, shoulder or scapula musculature. This included a range of stabilization, endurance, strengthening and isometric exercises. The review was unable to conclude if a specific type of strengthening training was more effective due to the inconsistency in the type of exercise between studies.

Sub-group analysis on exercise frequency was completed to determine if exercises completed daily or less frequent had a greater effect on pain and disability. The lowest frequency was three times per week in which three out of four studies (75%) reported a significant improvement in pain and disability. All studies where exercises were completed more frequently reported a similar significant improvement. This suggests that an exercise frequency of three times per week would be sufficient to reduce self-reported pain and disability. This agrees with a review by O'Riodran and colleagues (2014) who concluded that the most beneficial frequency of exercise to improve pain and QoL in a chronic neck pain population was three times per week.

5.2. Pain intensity

Seven (87.5%) out of the eight included studies reported a significant decrease in self-reported pain intensity. All studies used VAS, which has good reliability and validity in participants with neck pain (Modarresi et al., 2022). The results of the meta-analysis support these quantitative findings. A recent meta-analysis (Frutiger and Borotkanics, 2021) included two studies (Bernaards et al., 2007; Viljanen et al., 2003) with longer follow-ups (6-months). One of the studies included interactive group meetings only, with no prescription of exercise (Bernaards et al., 2007). The second study (Viljanen et al., 2003) which was also included within the current review, reported no significant difference in VAS scores for the intervention group. Adherence rates were low with an average of 13.6 (39% of maximum) training sessions being completed by the training group. This equates to only 1.13 sessions on average per week for the duration of the study (12-weeks). This is significantly less than the minimum frequency (3-times per week) of the other included studies that reported a significant effect in the current review and findings of the recent review by O'Riordan et al. (2014). This may explain the difference in meta-analysis results between the current study and the findings of Frutiger and Borotkanics (2021).

5.3. Disability

From six included studies that assessed disability, five (83.3%) reported a significant decrease in NDI scores following strengthening exercises of the neck, shoulder and scapula muscles. All studies assessed disability using the NDI, which has good reliability and validity in participants with neck pain (Young et al., 2019). The meta-analysis agrees with the qualitive findings with a significant pooled effect. In disagreement with these findings, Bertozzi et al. (2013) reported no significant effect on disability for exercise compared with no exercise at similar follow-up times (1–6 months). Two studies included by Bertozzi and colleagues were excluded in the review as both included participants of any occupation and not office workers only (Beer et al., 2012; Chiu et al., 2005). Beer and colleagues reported no significant difference in disability however, participants only completed exercises for 2-weeks which is significantly less than the included studies. Additionally, two studies included in the meta-analysis (Borisut et al., 2013; Li et al., 2017) were published after Bertozzi et al. (2013) completed their literature search (August 2012). This may explain why difference were observed in meta-analysis results between the reviews.

5.4. Quality of life

The lack of evidence on the effect of exercise on QoL in office workers with neck pain restricted the ability to complete a quantitative analysis and thus provide a meaningful conclusion. Viljanen et al. (2003) reported no significant difference from baseline to 3-month follow up in QoL for strengthening exercises. Reliability and validity of the outcome measures used to assess QoL have not been reported within the literature which may explain why no significant effect was observed (Frost et al., 2007). The review by Louw et al. (2017) showed contrasting results in QoL for strengthening exercises, with two studies reporting a significant decrease, whilst two others reported no significant difference. These four studies were included within the full-text review of the current study with only one being included (Viljanen et al., 2003). One was excluded because all participants did not have neck pain (Andersen et al., 2012) and two were excluded for utilising secondary data (Nikander et al., 2006; Salo et al., 2010). Prior knowledge of data can cause confirmation bias thus affecting the analysis and reporting of results (Baldwin et al., 2022). This may explain why the evidence for QoL within the Louw et al. (2017) review was contradictory.

5.5. High heterogeneity

Heterogeneity in the summary effect of the combined studies was significantly high ($I^2 = 95.2\%$). This was likely attributable to the low number of studies and the methodological differences in intensity, frequency, and duration between interventions (Gagnier et al., 2012). There was also a large discrepancy in the study sample sizes. This is consistent with other systematic reviews describing strengthening exercises in office workers with neck pain (Chen et al., 2018; Frutiger and Borotkanics, 2021). Further research with methodological consistency and larger sample sizes needs to be implemented to address the high heterogeneity when combining study results in this field of research.

5.6. Strengths and limitations

The strengths of this review include its systematic approach through the application of PRISMA guidelines (Page et al., 2021) and the CHSRI (Higgins et al., 2019). Two reviewers completed the study selection and data extraction processes separately to avoid potential reviewer bias (McDonagh et al., 2013). Additionally, the retrieval of potential studies was maximised by searching multiple databases and grey literature. Data was extracted using software of high reliability and validity to minimize visual error. One limitation was the exclusion of articles not in the English language due to the cost associated with professional translation services and time commitment. Although this may introduce language bias, only 18 non-English articles were excluded, thus the team are confident that this has not impacted the study results. Other limitations include that the search strategy was not peer reviewed by a librarian and the length of time since the last search was completed (April 2022). Both factors increase the risk of potentially eligible articles being missed within this review.

5.7. Implications

The results of the meta-analysis are in favour of the use of shoulder and neck exercises in the management of chronic neck pain in office workers to reduce neck pain intensity and disability. An exercise frequency of 3 times per week was found to be the minimum required to achieve a significant reduction in pain and disability scores. Future intervention studies must strengthen their methodological design which includes the blinding of participants to the active ingredient of the intervention received as best as possible to minimize bias. It is advised that future studies improve the reporting of the intervention specifics using guidelines such as the Template for Intervention Description and Replication (TIDieR) checklist (Hoffmann et al., 2014). The implication of this would allow easier grouping of studies in reviews and the potential for more informed conclusions. It is evident that more studies evaluating the effects of general physical exercise on neck pain, disability and QoL in office workers are required; the current review was unable to analyse this due to the lack of evidence. A recent review (de Zoete et al., 2020) reported general physical activity had a positive effect on neck pain intensity, disability and QoL in participants of difference occupations. Clinicians and ergonomic professionals must apply the results of this review with caution due to the high heterogeneity and high risk of bias of the included studies.

6. Conclusion

This review identified a small number of studies that provide low certainty of evidence that neck, shoulder and scapula strengthening exercises is effective at decreasing neck pain intensity and disability in office workers with chronic neck pain. An exercise frequency of 3 times per week appears to be sufficient in reducing neck pain and disability. A conclusion could not be made regarding the effects of exercise on QoL due to the absence of evidence. Due to the high heterogeneity and low certainty evidence, further high-quality research evaluating the effects of exercise on pain, disability and QoL in office workers with chronic neck pain is required to make a confident recommendation for clinicians.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial or not-for-profit sectors.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.apergo.2023.104216.

References

Aas, R.W., Tuntland, H., Holte, K.A., Røe, C., Lund, T., Marklund, S., Moller, A., 2011. Workplace interventions for neck pain in workers. Cochrane Database Syst. Rev. (4).
Anand, B., Goyal, V., 2020. Effectiveness of neck and shoulder stretching Program among professionals working from home during covid–19. Physioth. Occupat. Therapy J. 13 (2), 61–65.
Andersen, L.L., Saervoll, C.A., Mortensen, O.S., Poulsen, O.M., Hannerz, H., Zebis, M.K., 2011. Effectiveness of small daily amounts of progressive resistance training for frequent neck/shoulder pain: randomised controlled trial. Pain 152 (2), 440–446.
Andersen, C.H., Andersen, L.L., Gram, B., Pedersen, M.T., Mortensen, O.S., Zebis, M.K., Sjøgaard, G., 2012. Influence of frequency and duration of strength training for effective management of neck and shoulder pain: a randomised controlled trial. Br. J. Sports Med. 46 (14), 1004–1010.
Andersen, C.H., Andersen, L.L., Zebis, M.K., Sjøgaard, G., 2014. Effect of scapular function training on chronic pain in the neck/shoulder region: a randomized controlled trial. J. Occup. Rehabil. 24 (2), 316–324.
Baldwin, J.R., Pingault, J.B., Schoeler, T., Sallis, H.M., Munafò, M.R., 2022. Protecting against researcher bias in secondary data analysis: challenges and potential solutions. Eur. J. Epidemiol. 37 (1), 1–10.
Balshem, H., Helfand, M., Schünemann, H.J., Oxman, A.D., Kunz, R., Brozek, J., Vist, G. E., Yyter-Falck, Y., Meerpohl, J., Norris, S., Guyatte, G.H., 2011. Grade guidelines: 3. rating the quality of evidence. J. Clin. Epidemiol. 64 (4), 401–406.
Beer, A., Treleaven, J., Jull, G., 2012. Can a functional postural exercise improve performance in the cranio-cervical flexion test?–A preliminary study. Man. Ther. 17 (3), 219–224.
Bernaards, C.M., Ariëns, G.A., Knol, D.L., Hildebrandt, V.H., 2007. The effectiveness of a work style intervention and a lifestyle physical activity intervention on the recovery from neck and upper limb symptoms in computer workers. Pain 132 (1–2), 142–153.
Bertozzi, L., Gardenghi, I., Turoni, F., Villafañe, J.H., Capra, F., Guccione, A.A., Pillastrini, P., 2013. Effect of therapeutic exercise on pain and disability in the management of chronic nonspecific neck pain: systematic review and meta-analysis of randomized trials. Phys. Ther. 93 (8), 1026–1036.
Borisut, S., Vongsirinavarat, M., Vachalathiti, R., Sakulsriprasert, P., 2013. Effects of strength and endurance training of superficial and deep neck muscles on muscle activities and pain levels of females with chronic neck pain. J. Phys. Ther. Sci. 25 (9), 1157–1162.
Bouziri, H., Smith, D.R., Descatha, A., Dab, W., Jean, K., 2020. Working from home in the time of COVID-19: how to best preserve occupational health? Occup. Environ. Med. 77 (7), 509–510.
Brusaca, L.A., Barbieri, D.F., Mathiassen, S.E., Holtermann, A., Oliveira, A.B., 2021. Physical behaviours in brazilian office workers working from home during the COVID-19 pandemic, compared to before the pandémic: a cómpósitiónal data analysis. Int. J. Environ. Res. Publ. Health 18 (12), 6278.

Chen, X., Coombes, B.K., Sjøgaard, G., Jun, D., O'Leary, S., Johnston, V., 2018. Workplace-based interventions for neck pain in office workers: systematic review and meta-analysis. Phys. Ther. 98 (1), 40–62.

Chiu, T.T., Lam, T.H., Hedley, A.J., 2005. A Randomized Controlled Trial on the Efficacy of Exercise for Patients with Chronic Neck Pain.

Côté, P., van der Velde, G., Cassidy, J.D., Carroll, L.J., Hogg-Johnson, S., Holm, L.W., Carragee, E.J., Haldeman, S., Nordin, M., Hurwitz, E.L., Guzman, J., 2009. The burden and determinants of neck pain in workers: results of the bone and joint decade 2000–2010 task force on neck pain and its associated disorders. J. Manipulative Physiol. Therapeut. 32 (2), S70–S86.

de Zoete, R.M., Brown, L., Oliveira, K., Penglaze, L., Rex, R., Sawtell, B., Sullivan, T., 2020. The effectiveness of general physical exercise for individuals with chronic neck pain: a systematic review of randomised controlled trials. Euro. J. Physioth. 22 (3), 141–147.

Drevon, D., Fursa, S.R., Malcolm, A.L., 2017. Intercoder reliability and validity of WebPlotDigitizer in extracting graphed data. Behav. Modif. 41 (2), 323–339.

Ehsani, F., Mosallanezhad, Z., Vahedi, G., 2017. The prevalence, risk factors and consequences of neck pain in office employees. Middle east J. Rehabil. Health 4 (2), e42031.

Frost, M.H., Reeve, B.B., Liepa, A.M., Stauffer, J.W., Hays, R.D., Mayo, /FDA., 2007. Patient-reported outcomes consensus meeting group. What is sufficient evidence for the reliability and validity of patient-reported outcome measures?. Value in Health 10, S94–S105.

Frutiger, M., Borotkanics, R., 2021. Systematic review and meta-analysis suggest strength training and workplace modifications may reduce neck pain in office workers. Pain Pract. 21 (1), 100–131.

Garcia, M.G., Estrella, M., Peñafiel, A., Arauz, P.G., Martin, B.J., 2021. Impact of 10-Min Daily Yoga Exercises on Physical and Mental Discomfort of Home-Office Workers during COVID-19. *Human Factors*, 00187208211045766.

Gagnier, J.J., Moher, D., Boon, H., Beyene, J., Bombardier, C., 2012. Investigating clinical heterogeneity in systematic reviews: a methodologic review of guidance in the literature. BMC Med. Res. Methodol. 12 (1), 1–15.

Haefeli, M., Elfering, A., 2006. Pain assessment. Eur. Spine J. 15 (1), S17–S24.

Higgins, J.P., Savović, J., Page, M.J., Elbers, R.G., Sterne, J.A., 2019. Assessing risk of bias in a randomized trial. Cochrane Handbook for Systematic Rev. Interventions 205–228.

Hoffmann, T.C., Glasziou, P.P., Boutron, I., Milne, R., Perera, R., Moher, D., Altman, D. G., Barbour, V., Macdonald, H., Johnston, M., Lamb, S.E., 2014. Better reporting of interventions: template for intervention description and replication (TIDieR) checklist and guide. Br. Med. J. 348.

Ibrahim, A.A., Akindele, M.O., Bello, B., Kaka, B., 2020. Translation, cross-cultural adaptation, and psychometric properties of the Hausa versions of the Numerical Pain Rating Scale and Global Rating of Change Scale in a low-literate population with chronic low back pain. Spine 45 (8), E439–E447.

Kang, N.Y., Im, S.C., Kim, K., 2021. Effects of a combination of scapular stabilization and thoracic extension exercises for office workers with forward head posture on the craniovertebral angle, respiration, pain, and disability: a randomized-controlled trial. Turkish J. Phys. Med. Rehabilit. 67 (3), 291.

Li, X., Lin, C., Liu, C., Ke, S., Wan, Q., Luo, H., Huang, Z., Xin, W., Ma, C., Wu, S., 2017. Comparison of the effectiveness of resistance training in women with chronic computer-related neck pain: a randomized controlled study. Int. Arch. Occup. Environ. Health 90 (7), 673–683.

Liu, C.J., LaValley, M., Latham, N.K., 2011. Do unblinded assessors bias muscle strength outcomes in randomized controlled trials of progressive resistance strength training in older adults? Am. J. Phys. Med. Rehabil. 90 (3), 190–196.

Louw, S., Makwela, S., Manas, L., Meyer, L., Terblanche, D., Brink, Y., 2017. Effectiveness of exercise in office workers with neck pain: a systematic review and meta-analysis. S. Afr. J. Physiother. 73 (1).

Ma, C., Szeto, G.P., Yan, T., Wu, S., Lin, C., Li, L., 2011. Comparing biofeedback with active exercise and passive treatment for the management of work-related neck and shoulder pain: a randomized controlled trial. Arch. Phys. Med. Rehabil. 92 (6), 849–858.

McDonagh, M., Peterson, K., Raina, P., Chang, S., Shekelle, P., 2013. Avoiding Bias in Selecting Studies. *Methods Guide for Effectiveness and Comparative Effectiveness Reviews [Internet]*.

Mehrparvar, A.H., Heydari, M., Mirmohammadi, S.J., Mostaghaci, M., Davari, M.H., Taheri, M., 2014. Ergonomic intervention, workplace exercises and musculoskeletal complaints: a comparative study. Med. J. Islam. Repub. Iran 28, 69.

Methley, A.M., Campbell, S., Chew-Graham, C., McNally, R., Cheraghi-Sohi, S., 2014. PICO, PICOS and SPIDER: a comparison study of specificity and sensitivity in three search tools for qualitative systematic reviews. BMC Health Serv. Res. 14 (1), 1–10.

Modarresi, S., Lukacs, M.J., Ghodrati, M., Salim, S., MacDermid, J.C., Walton, D.M., 2022. A systematic review and synthesis of psychometric properties of the numeric pain rating scale and the visual analog scale for use in people with neck pain. Clin. J. Pain 38 (2), 132–148.

Moretti, A., Menna, F., Aulicino, M., Paoletta, M., Liguori, S., Iolascon, G., 2020. Characterization of home working population during COVID-19 emergency: a cross-sectional analysis. Int. J. Environ. Res. Publ. Health 17 (17), 6284.

Nikander, R., Malkia, E., Parkkari, J., Heinonen, A., Starck, H., Ylinen, J., 2006. Dose-response relationship of specific training to reduce chronic neck pain and disability. Med. Sci. Sports Exerc. 38 (12), 2068.

O'Riordan, C., Clifford, A., Van De Ven, P., Nelson, J., 2014. Chronic neck pain and exercise interventions: frequency, intensity, time, and type principle. Arch. Phys. Med. Rehabil. 95 (4), 770–783.

Page, M.J., McKenzie, J.E., Bossuyt, P.M., Boutron, I., Hoffmann, T.C., Mulrow, C.D., Shamseer, L., Tetzlaff, J.M., Akl, E.A., Brennan, S.E., Chou, R., 2021. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. Int. J. Surg. 88, 105906.

Partlett, C., Riley, R.D., 2017. Random effects meta-analysis: coverage performance of 95% confidence and prediction intervals following REML estimation. Stat. Med. 36 (2), 301–317.

Pereira, M., Comans, T., Sjøgaard, G., Straker, L., Melloh, M., O'Leary, S., Chen, X., Johnston, V., 2019. The impact of workplace ergonomics and neck-specific exercise versus ergonomics and health promotion interventions on office worker productivity: a cluster-randomized trial. Scand. J. Work. Environ. Health 45 (1), 42–52.

Riddle, D.L., Schappert, S.M., 2007. Volume and characteristics of inpatient and ambulatory medical care for neck pain in the United States: data from three national surveys. Spine 32 (1), 132–140.

Salo, P.K., Häkkinen, A.H., Kautiainen, H., Ylinen, J.J., 2010. Effect of neck strength training on health-related quality of life in females with chronic neck pain: a randomized controlled 1-year follow-up study. Health Qual. Life Outcome 8 (1), 1–7.

Shariat, A., Cleland, J.A., Danaee, M., Kargarfard, M., Sangelaji, B., Tamrin, S.B.M., 2018. Effects of stretching exercise training and ergonomic modifications on musculoskeletal discomforts of office workers: a randomized controlled trial. Braz. J. Phys. Ther. 22 (2), 144–153.

Sinnott, P.L., Dally, S.K., Trafton, J., Goulet, J.L., Wagner, T.H., 2017. Trends in diagnosis of painful neck and back conditions, 2002 to 2011. Medicine 96 (20).

Sterne, J.A., Savović, J., Page, M.J., Elbers, R.G., Blencowe, N.S., Boutron, I., Cates, C.J., Cheng, H.Y., Corbett, M.S., Eldridge, S.M., Emberson, J.R., 2019. RoB 2: a revised tool for assessing risk of bias in randomised trials. Br. Med. J. 366.

Tersa-Miralles, C., Bravo, C., Bellon, F., Pastells-Peiro, R., Rubinat-Arnaldo, C., Rubi-Carnacea, F., 2021. Effectiveness of workplace exercise interventions in the treatment of musculoskeletal disorder in office workers: a systematic review. BMJ Open 12, e054288.

Vernon, H., 2008. The neck disability index: state-of-the-art, 1991-2008. J. Manipulative Physiol. Therapeut. 31 (7), 491–502.

Viljanen, M., Malmivaara, A., Uitti, J., Rinne, M., Palmroos, P., Laippala, P., 2003. Effectiveness of dynamic muscle training, relaxation training, or ordinary activity for chronic neck pain: randomised controlled trial. Br. Med. J. 327 (7413), 475.

Ware Jr., J.E., 2000. SF-36 health survey update. Spine 25 (24), 3130–3139.

Welch, A., Healy, G., Straker, L., Comans, T., O'Leary, S., Melloh, M., Sjøgaard, G., Pereira, M., Chen, X., Johnston, V., 2020. Process evaluation of a workplace-based health promotion and exercise cluster-randomised trial to increase productivity and reduce neck pain in office workers: a RE-AIM approach. BMC Publ. Health 20 (1), 1–15.

Ylinen, J., Takala, E.P., Nykänen, M., Häkkinen, A., Mälkiä, E., Pohjolainen, T., Karppi, S. L., Kautiainen, H., Airaksinen, O., 2003. Active neck muscle training in the treatment of chronic neck pain in women: a randomized controlled trial. JAMA 289 (19), 2509–2516.

Young, I.A., Dunning, J., Butts, R., Mourad, F., Cleland, J.A., 2019. Reliability, construct validity, and responsiveness of the neck disability index and numeric pain rating scale in patients with mechanical neck pain without upper extremity symptoms. Physiother. Theor. Pract. 35 (12), 1328–1335.