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Research Article

Effectiveness of Physical Training Interventions for Work Related Upper Extremity Disorders (Wrued) from A Sports Science Perspective. A Systematic Review!

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Abstract

Objectives: Work-related upper extremity disorders at the computer workplace are a serious health concern and one of the most common reasons for absenteeism. The aim of this systematic review is to gain an overview on exercises and training interventions.

Methods: The literature search was completed using Medline through Ovid. Randomized controlled trials as well as controlled trials from 01.01.2000 to 31.12.2020 were included. The population were office workers, the training interventions were to be performed at the workplace or presented at the workplace. Upper extremity disorders and symptoms were included.

Results: 440 studied were found by Medline through Ovid. Twenty-one studies were reviewed. Six strength training interventions showed significant results in pain reduction. Two studies with two types of interventions showed significant reductions in pain. Similarly, four studies of the strength and endurance groups showed significant decrease of pain. Studies of posture exercises, stretching, manual therapy and qui gong showed also a reduction of pain.

Conclusions: Many interventions, especially strength and combined interventions, proved to be successful and achieved significant results compared to the control groups. The four most common exercises used in the training interventions were reverse fly, lateral raise, rowing and shrugs.

Keywords: Training interventions; Office works; Upper extremity disorders

Introduction

Work-related upper extremity disorders in the workplace have emerged as a major influencing factor in the working environment [1]. On the one hand, they are risk factors for the employee, who is confronted with possible damage and symptoms of the disease. On the other hand, sick workers are a cost factor for the company and the health care system. Absenteeism, therapy and treatments generate costs. A disease or injury cause both direct and indirect costs to society [2]. Direct costs are the costs that are required to treat diseases. These include the medical costs associated with a disease, including labour costs for medical professionals. Indirect costs of diseases or injuries include loss in potential work performance at the workplace [3]. Today the computer workplace is considered to result in negative health effects for employees due to the long hours of one-sided, static work postures and high repetition. Both muscles and passive structures are affected by pathological changes or diseases due to computer work. Repetition, static working posture and mechanical stress have been found to be the main physical causes of work-related upper limb disorders in computer workers [4]. Continuous stress, rapid movements, restricted posture can be other causes. Examples of repetitive strain injuries include tendonitis, neuritis, fasciitis, myositis, cubital tunnel syndrome, thoracic outlet syndrome, carpal tunnel syndrome, degenerative arthritis, tendinosis, fibromyalgia, disc herniation, focal hand dystonia and neuropathic pain [5].

The European Agency for Safety and Health at Work (EU-OSHA), reported in 2017 that 3.9% of global gross domestic product (GDP) and 3.3% of European GDP is spent on managing work-related injuries and diseases [6]. Training interventions have been shown to be effective against upper limb disorders at the computer workplace in numerous studies with remarkably good pain-reducing effects of strength training. Some studies reported the positive results of strength training, especially for office workers with upper limb symptoms [7-9]. In addition significant results have been achieved in endurance training to reduce symptoms in the shoulder and neck area [10], as well as pain-reducing effects by stretching interventions [11,12].

Therefore this review focuses on the most appropriate specific physical training interventions and exercises to reduce upper limb pain and disorders in contrast to earlier reviews. Reviews have already been made regarding exercise interventions. Although some reviews with mixed interventions for upper limb disorders have been publishedn [13,14] and also discuss training interventions for office workers [15] and for office workers with neck pain at baseline of training interventions [16], a systematic review on computer workplace training interventions for the upper extremity with specific symptoms and disorders of the wrist, elbow, shoulder, cervical and thoracic spine and the neck is missing. In addition, it was intended to pay specific attention on training interventions in the areas of strength, endurance, coordination and flexibility to discuss the effectiveness of training interventions and exercises from a sports scientific perspective.

Objectives study selection

This review focuses on the effectiveness of training interventions for computer workers. The following questions are relevant: Which training interventions reduce upper limb symptoms and disorders? Which training interventions achieve muscular improvements?

Eligibility criteria

Randomised controlled trials (RCT) were included. The criterion was that at least one group included an intervention with physical activity or physical training. The training interventions were to be performed at the workplace or presented at the workplace. Controlled trials (CT) were also added if they involved physical interventions during the working day as well. Studies published in English or in German were included. Symptoms or diseases of the upper extremities had to be present at the beginning of the intervention.

Symptoms and diseases of the neck (including resulting headaches), cervical spine, thoracic spine, shoulder, elbow, and wrist were included. Studies were selected that included female and male office workers. The office workers were required to be primarily computer workers during their occupational activities. Studies with ergonomic, preventive, written only exercise advice (brochures) or psychological interventions were excluded. The search for publications has been limited to the period from: 01.01.2000 – 31.12.2020. This review protocol follows the reporting guidelines for systematic (Prisma).17 Results are presented in accordance with PRISMA guidelines.

Data search and literature searches

The databases Medline, MEDLINE (via Ovid) were used for the literature search. Studies from 01.01.2000 – 31.12.2020 are considered. The literature search was checked by the authors. Examples of search terms are given below (work related upper extremity disorders AND workplace interventions AND office workers). The following criteria were used: the subjects studied were computer workers and had symptoms or upper extremity disorders at baseline. The following structures were included. Pain or disease of the upper extremity (neck including resulting headaches, cervical spine, thoracic spine, shoulder, elbow and wrist).

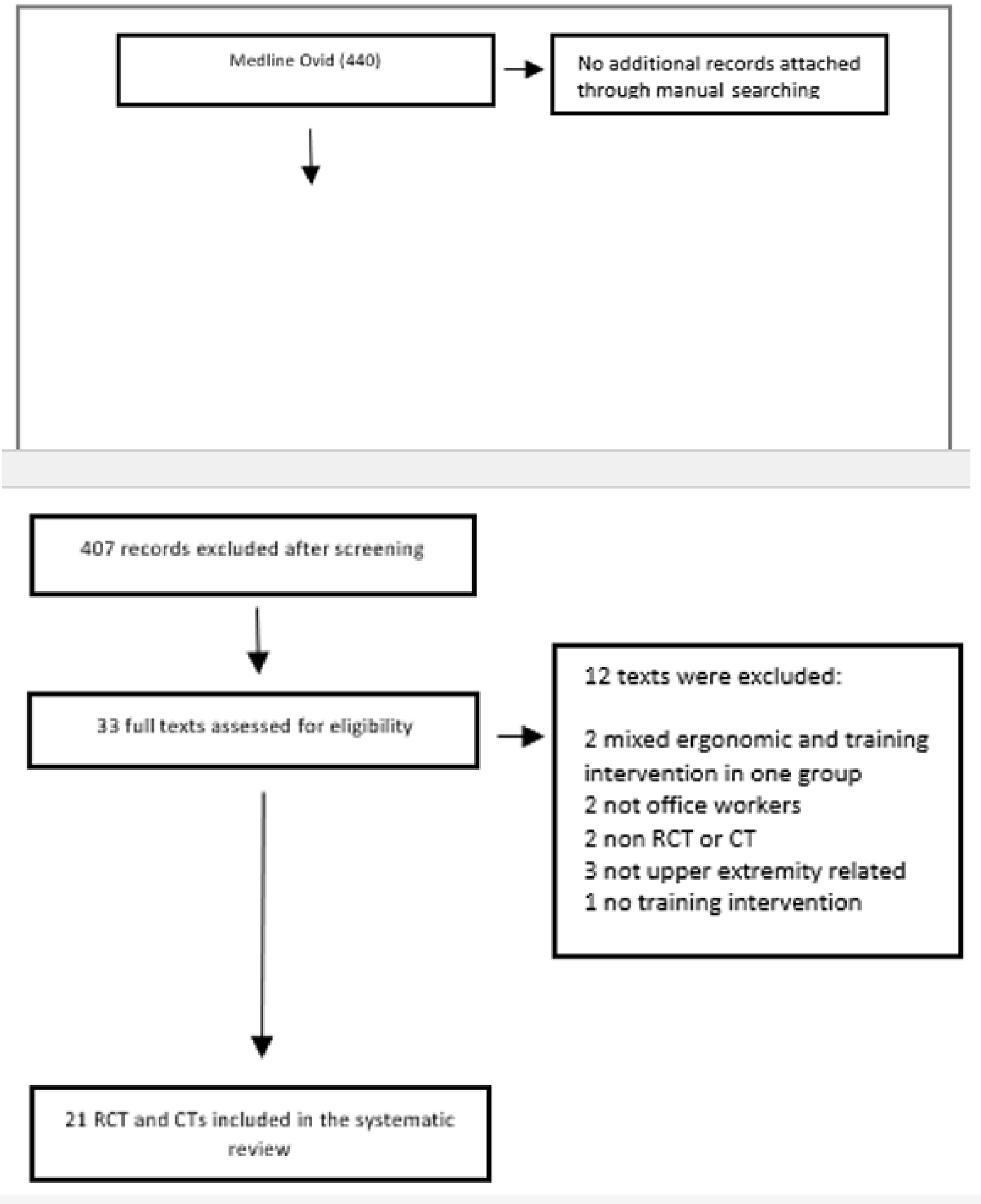

Figure 1: Study selection CT = controlled trial, RCT = randomised controlled trial

Data sources and searches

Data were extracted using predefined data fields. The predefined data fields were adapted based on the PICO (Population, Intervention, Control and Outcomes) process.

In this review, the following data fields were selected:

I. Population: office workers, computer workstation

II. Intervention: physical activity and training programme

III. Control: comparison intervention

IV. Outcome: main criterion of the training programme of the training group

V. Results: What were the results of the study

Data extraction and quality assessment

The predefined data fields were adjusted based on the PICO (Population, Intervention, Control and Outcomes) process. The data were categorised into subgroups based on the type of intervention (e.g. strength, endurance).

Overview interventions

Table 1: Training interventions.

Intervention Category Strength	Study / Country	Partici-pants Job Description	Intervention Type, Dosage, Description, Delivery and Duration	Comperator Intervention	Outcome	Findings for Intervention vs Control	Participation of Intervention Group; Period
1. Neck / Shoulder pain	Saeter-bakken et al. 2020, Norway (9)	Office workers mild pain, public workplace	**Resistance Training** Elastic Tubes TG 10: **10 min.** Training per day, TG2: **10 min twice per day** Training at the workplace. **Exercises: 1. one-arm row, 2. upright row, 3. one-arm reverse flies, 4. one-arm lateral raise** Training parameters: • 5 times per week, for 8 weeks • 12–15 repetition maximum (RM) in the first 4 weeks and 8-10 RM in week 5–8 • During the first week an experienced instructor was present to instruct the participants to add the correct resistance from the tubes. • Each exercise 2 sets	No intervention	• Visual analogue scale 0 – 100 mm visual analogue scale (VAS) for pain (primary outcome) • Isometric strength in shrugs and seated row (secondary outcome) • Health related quality of life (secondary outcome).	**All variables:** no differences were observed between the groups in the control period (p=0.27–0.97) or training period (p=0.37–0.68). **Neck/Shoulder Pain:** the mean and worst pain was reduced by 25 and 43% (p=0.05 and <0.01, ES=0.41 and 0.55) in the training period. **Quality of Life:** 10.6 % increase (p=0.01, ES=0.52). **Strength**: No difference in strength was observed (p=0.29–0.85).	30 22 completers Control period: 8 weeks Training Period: 8 weeks
2. Neck / Shoulder	Andersen C.H. et al. 2012, Denmark (18)	Office workers 447 scoring 3 and above on a 0–9 scale During working hours	**Resistance Training** Dumbbell exercises **1 × 60 min. (1 WS), 3 × 20 min. (3 WS), 9 × 7 min. (9 WS)** **Exercises: 1. Front raise, 2. Lateral raise, 3. Reverse flies, 4. Shrugs, 5. Wrist extensions** Training parameters: • 20 weeks duration • With training supervision • 3 × 20 min per week with minimal supervision • Rotational manner • Training loads were progressively increased • 20 repetitions maximum (RM) at the beginning to 8 RM (later phase)	Not offered any physical training, same questionnaires as the intervention groups.	• Modified Nordic questionnaire (ache, pain, discomfort) during last 3 months • Intensity of pain on a scale 0 – 9 Secondary Outcome: • DASH: participants rated work disability at baseline and follow-up by the work module	**Neck and right shoulder pain:** The intention-to-treat analysis showed reduced neck pain (p<0.01). Post-hoc analyses showed a significant difference between the three training groups combined versus REF (p<0.05). Right shoulder pain in the training groups after 20 weeks compared with REF (p<0.05). Those with pain ≥3 at baseline (n=256), all three training groups achieved significant reduction in neck pain compared with REF (p<0.01). **Pain Intensity:** All training better than REF with 31 (~72%) in 1WS, 30 (~75%) in 3WS and 17 (~63%) in 9WS compared with 21 (~44%) in REF (p<0.01). From a baseline pain rating of 3.2 (SD 2.3) in the neck cases: **1WS** experienced a **reduction of 1.14** (95% CI 0.17 to 2.10), **3WS 1.88** (0.90 to 2.87) and **9WS 1.35** (0.24 to 2.46) which is considered clinically significant. **DASH** was reduced in 1WS and 3WS only.	447 280 completers 199 completers Trainingintervention 20 weeks

3. Neck / Shoulder Pain Headache	Gram et al. 2014, Denmark (25)	Office workers, 50 % working day	Described in Andersen C.H. et al., 2012 (18) **Strength Training** 3 WS (with supervision) Group: **3 × 20 min. / week** Training parameters: • Supervising half of the sessions for the training period • 60 sessions (3 × 20 weeks) • Instructors supervising, 10 hours (30 sessions × 20 min), 3 MS (minimal supervision) Group: • 3 times per week • Received minimal supervision for 2 sessions • Instructor supervision for 40–60 min	Without exercise training	• Structured e-mail questionnaires were applied before and after the intervention. • Nordic questionnaire was applied at baseline before the randomization and repeated after the intervention. Secondary outcome variables: • headache characteristics (frequency and pain intensity)	**Neck / Shoulder Pain Intensity:** Intention-to-treat analyses showed a significant decrease in the last 7 days in 3MS compared with REF: −0.5 ± 0.2 (p<0.02) and a tendency for 3WS versus REF: −0.4 ± 0.2 (p<0.07). There was a significant difference between 3WS and 3MS in intensity of neck pain (last 3 months) with better improvement in 3WS (0.8 ± 0.4, p=0.05). **Intensity of headache**: decreased in the last month in both training groups: 3WS versus REF: −1.1 ± 0.2 (p<0.001) and 3MS versus REF: −1.1 ± 0.2 (p<0.001).	351 139 completers 20 weeks
4. Neck / Shoulder symptoms	Blangsted et al.2008, Denmark (26)	Office worker, public administration authority,	**SRT = Specific Resistance Training** Training parameters: • 3 x 20 min / week • 2 x supervised • 2–3 sets of 10–15 repetitions (~10–15 repetition maximum) each exercise in each session • 50 % in the first weeks, technique focus **Resistance training with dumbbells: 1. shoulder extension, 2. shoulder abduction, 3. shoulder abduction with attention to the supraspinatus muscle, 4. shoulder lift** **Introduced by experienced instructors** • **Static exercises for the neck:** sitting position, strap around the head: reps directly forward, sideways and backward • **Explosive rowing or kayaking:** 10 all-out bouts, 15 – 30 sec in each session **APE = All around physical exercise:** The participants were introduced by experienced instructors, they listed physical activity, groups for Nordic walking and running, 8-minute CD-based exercise program, exercise instruments were placed, encouraged to bike to work, to increase daily activity, information about sport facilities	General health promoting activities	• Questions about intensity of pain • Work ability index • Sick leave during the last 3 months	**Neck / Shoulder Pain:** Statistically significant differences between the “physical activity” and the reference group, pain intensity (p=0.0318) and pain duration (p=0.0565) of symptoms. No statistically significant effects from interaction between the body part and the intervention group “physical-activity” groups versus reference group [P(intensity)=0.4502; P(duration)=0.1294]. No statistically significant differences between the outcomes in the two “physical-activity” groups (SRT versus APE), [P(intensity)=0.5327; P(duration)=0.4016. **Work ability index:** At baseline the index (WAI) was close to 90% of the maximum score. The changes in the work ability index were statistically independent of the type of intervention [P (“physical activity” versus reference) = 0.3073, P (SRT versus APE) = 0.4220]. **Sick leave:** the mean sick leave was 5 days per year, both being unaffected by the interventions.	549 292 follow up 12 months 12 months period

Interventions Category Strength	Study / Country	Participants Job Description	Intervention Type, Dosage, Description, Delivery and Duration	Comperator Intervention	Outcome	Findings for Intervention vs Control	Participation of Intervention Group
5. Neck and Shoulder Pain	Andersen C.H. et al. 2014, Denmark (19)	Office worker, Administrative departments University, pain at least 3 on a 0 -9 scale	The **SFT (Scapular function training) group** was allocated to 3, 9, 20 min. training / week for 10 weeks during working hours. • Training for activation of the serratus anterior and lower trapezius muscles • Low level of activation of the upper trapezius • Experienced instructor assisted all training sessions • Elastic tubes were provided for extra resistance **Exercises: 1. Press up 2. Push up plus** Training parameters: • Load and volume varied from 20 Repetition Maximum (RM) in the first week to 10 RM • In the first week 3 sets of each exercise and worked up to a maximum of 5 sets of 10 repetitions in the last weeks • Exercises were alternated in a superset. Each training session started with a short warm-up: neck, upper back, shoulder blades and shoulder joint through pain-free range of motion	No physical training	• Maximum isometric shoulder strength test at baseline and at follow up by a blinded tester • Once a week the participants reported pain intensity of the neck and shoulder during the previous week • Pressure Pain Threshold was measured before and after the intervention	**Neck / Shoulder Pain:** In intention-to-treat analysis neck and shoulder pain decreased 2.0 (95 % CI 0.35, 3.64) in SFT compared with control group (p<0.05). **Pressure Pain Threshold (PPT):** increased 129 kPa in the lower trapezius in SFT compared with the control group (p<0.01). **Strength:** From a baseline mean of 58.2 kg (15.3 kg), SFT increased shoulder elevation strength 7.7 kg (95 %, CI 2.2; 13.3 kg) (p<0.01) more than the control group. The mean difference in protraction strength was 6.5 kg (95 % CI -3.5; 16.6 kg) higher in the SFT group compared to control group, this was not statistically significant.	47 23 Follow up 16 analyzed 10 weeks
6. Neck / Shoulder pain	Andersen L.L. et al. 2011, Denmark (7)	Office workers full time employees, frequent pain Workplace	**Resistance Training** **Elastic Tubes**, for 2 -12 minutes / day, 5 times per week **Exercise: Shoulder abduction (lateral raise)** Training parameters – **12 Min. Group:** • 5 to 6 sets, 25 – 30 sets / week • 8 to 12 reps in a progressive manner, after 2 weeks progression to a higher level of resistance • Increase of resistance, if they could complete 6 sets of 12 reps • Every minute set start • Own records in terms of repetitions Training parameters – **2 Min. Group:** • Shoulder abductions slowly, controlled • Single set to failure • As many repetitions as possible without pause Both groups: During the initial 2 weeks, moderate resistance (red tubing for women and green tubing for men), explained by a physical therapist	Weekly e-mail for general health	• Scale (0 to 10 points) changes in intensity of neck/ shoulder pain • Examiner-verified tenderness of the neck/ shoulder muscles (total score 0-32) • Isometric muscle strength at 10 weeks	**Neck/Shoulder Pain/ Tenderness:** 2 minutes group: decreased 1.4 points (95% confidence interval -2.0 to -0.7, p<0.0001) and 4.2 points (95% confidence interval 5.7 to 2.7, p< 0.0001) 12 minutes group: 1.9 points (95% confidence interval 2.5 to 1.2, p<0.0001) and 4.4 points (95% confidence interval 5.9 to 2.9, p<0.0001). **Muscle Tenderness (examiner verified):** showed a strong group-by-time effect for the total tenderness score (p<0.0001). **Muscle Strength:** 2-minute group: compared with the control group, strength increased 2.0 Nm (95% confidence interval 0.5 to 3.5 Nm, p=0.01). 12-minute group: 1.7 Nm (95% confidence interval 0.2 to 3.3 Nm, p=0.02)	174 128 completers Trainingsintervention 10 weeks

7. Neck pain	Lidegaard et al. 2013, Denmark (21)	Female office workers	**Resistance Training** Smaller parallel group of the Intervention Andersen L.L., 2011 (7) Focus: 2 Minute group: two minutes of shoulder abductions in the scapular plane Added resistance on a daily basis on workdays during their working hours. **Elastic tube** **Exercise: lateral raise** Training parameters: • single set with as many repetitions as possible • muscular fatigue • maximum duration of two minutes	E-mail for general health	• Electromyography (EMG) from the splenius and upper trapezius was recorded during a normal workday. • Frequency of EMG gaps under 0.5% EMGmax (number per minute), Duration per EMG gap under 0.5%, EMGmax (length in seconds), time spent under 0.5%. • EMGmax (percentage distribution). On an exploratory basis, the time spent under 1.0%, 1.5%, and 2.0% EMGmax was also investigated. • Pain intensity 0 – 10 • Isometric muscle strength Nm	**Frequency of EMG gaps**: The training group significantly decreased the frequency of EMG gaps in m. splenius by 35% from 12.3 to 8.0 gaps/minute acutely in response to the training session at follow-up ($p<0.05$). **Neck pain:** and decreased neck/shoulder pain intensity by 40% ($p<0.01$). **Strength:** the training increased isometric muscle strength 6% ($p<0.05$) vs. control.	30 14 completers 10 weeks

Interventions Category Strength	Study / Country	Participants Job Description	Intervention Type, Dosage, Description, Delivery and Duration	Comparator Intervention	Outcome	Findings for Intervention vs Control	Participation of Intervention Group
1. Neck / Shoulder Pain	Jay et al. 2013, Denmark (20)	Full time office worker	**Resistance Training**: same study design like Andersen et al., 2011(7) After an introductory week, the training was unsupervised, logged all training in a diary, Elastic tube **Exercise: lateral raise** Training parameters **The 12-min group:** • 5–6 sets • 8–12 repetitions in a progressive manner • Maximal voluntary contractions at a static 90-degree shoulder joint angle: Shoulder Abduction **The 2-min group:** • Instructed from day one to reach complete failure • The participants were encouraged to beat their previous best each training session. • 8– 12 RM, the load was increased – by the introduction of a thicker elastic tubing – once the participants could perform 12 repetitions Both groups performed at a slow and controlled pace taking approximately 2 s for the concentric phase, 0 s at the apex of the lift and 2 s for the eccentric phase	Weekly information of general health	• Peak torque (PT; unit Nm) • Rate of torque development (RTD; unit Nm s-1)) were determined as the maximal value of the torque-time and the steepest slope over100 ms of the rising part of the torque-time curve. Determined as the peak value of a moving window (ΛTorque/ΛTime), Λof 100 ms ,	**Peak torque:** Compared with the control group maximal muscle strength as measured by PT increased 2.5 Nm from 44.3 (13.0) Nm to 46.8 (14.4) Nm in the 2-min group [95% confidence interval: (0.05–0.73)] and 2.2 Nm from 43.8 (13.8) Nm to 46.0 (14.3) Nm in the 12-min group [95% confidence interval: (0.01–0.70)] **RTD:** Compared with the control group, rate of torque development increased 31.0 Nm s^{-}1 [95% confidence interval: (1.33–11.80)] in the 2-min group and 33.2 Nm s1^{-} (1.66–12.33) in the 12-min group from baseline to 10-week follow up Corresponding to an increase of 16.0% and 18.2% for the two groups. The increase was significantly different compared to controls (P<0.05) for both training groups.	198 10 weeks 120 Completers
2. Chronic neck pain	Viljanen et al. 2003, Finland (35)	Female office workers, healthcare center	**Resistance Training** **Dumbell exercises** Training parameters • Dynamic muscle training • Weight 1-3 kg each according to maximum repetitions with a test weight of 7.5 kg • Stretching followed each exercise • 5th week, participants were taught three exercises from the programme, with stretching movements • 9th week they were asked to perform the training programme by themselves in the group, instructor gave feedback Relaxation training: progressive relaxation method, autogenic training, functional relaxation, and systematic desensitisation • Different techniques were incorporated into the training during the 12 weeks	Ordinary activity MV instructed the women in the control group not to change their physical activity or means of relaxation during the 12 months of follow up.	• Change in intensity of neck pain at three, six, and 12 months.	**Pain:** Dynamic muscle training or relaxation training had no effect on the intensity of pain, 12 months. Mean (SD) Dynamic muscle training: 3.1 (2.5), Relaxation training 3.3 (2.6), Control 3.2 (2.5) **Pain intensity vs. Control** (95% CI): Dynamic Muscle training 0.5 (−0.1 to 1.0), Relaxation training 0.2 (−0.3 to 0.8), Relaxation training vs. Muscle training −0.2 (−0.8 to 0.3) **Dynamic muscle strength:** Dynamic muscle training: 1.7 (−0.8 to 4.2), Relaxation training 0.6 (−2.0 to 3.1), Relaxation training vs. Muscle training −1.1 (−3.6 to 1.4)	393 221 follow up 12 weeks

3. Headache, symptoms in the neck and shoulders	Sjögren et al. 2005, Finland (34)	Office workers, training part of their paid work	**Resistance Training** • Light resistance training and guidance 30 % of 1 RM • The time training was not determined • During the first 5-week period, non-supervised • In the office departments own training facilities **Six dynamic symmetrical movements: 1. upper extremity extension, 2. upper extremity flexion, 3. trunk rotation to the right, 4. trunk rotation to the left, 5. Knee extension, 6. knee flexion** Training parameters: • Each working day (five times a week) • During the second and third 5-week periods, the resistance training was to be performed 1–2 times each working day (a total of about 7–8 times a week) • A physiotherapist provided training instructions and general guidance on postural and movement control in three group sessions 20 times a 30 s pause between the training movements	No intervention	• **Borg CR10 scale**: Intensity of symptoms in the neck and shoulders experienced during the previous 7 days measured using the at 5-week intervals. • **One repetition maximum (1RM):** for the upper extremities was estimated with sub-maximal 5RM test (McDonagh and Daves, 1984) using air resistance equipment the standardized test movements were upper extremity extension and flexion. • **Weekly diary intervention**: each subject maintained to record training sessions, including the time in minutes	**Intensity of headache:** decrease in headache during the 5-week period was 0.64 CR10 (95% CI 0.28–1.00) (P<0.001) or 49% (95% CI 22–77), and 0.42 CR10 (95% CI 0.11–0.72) (P < 0.002) or 49% (95% CI 13–85). **Intensity of neck symptoms:** mean increase in the extension strength of the upper extremities was 1.3 kg (95% CI 0.5–2.1) (P < 0.001) or 4% (95% CI 1–6). **Shoulder Symptoms:** The intervention had no effect on the intensity of shoulder symptoms or the flexion strength of the upper extremities. **Strength:** light resistance training was statistically significant (P<0.001). **Physical and occupational health activities:** No statistically significant changes in physical activity were found in the time-weighted intensity average or maximum intensity of activity at work	90, 53 completers 30 wks

Interventions Category Mixed Interventions	Study / Country	Participants Job Description	Intervention Type, Dosage, Description, Delivery and Duration	Comperator Intervention	Outcome	Findings for Intervention vs Control	Participation of Intervention Group
4. Chronic neck pain	Ylinen et al. 2003, Finland (30)	Female office workers	**Strength Training and Endurance Training:** Both training groups: • 12-day rehabilitation program • The program was performed as a home training program • The groups exercised 3 x per week, 1 series: 1. squats, 2. sit-ups, 3. back extension exercises • 20 minutes of stretching exercises for the muscles trained **STG (strength training group):** Rubber band Training parameters • Single set, 15 repetitions • Each repetition with a level of 80% of maximum isometric strength • Neck training: Upright position, the rubber band was attached to the patient's head, the other end to a sturdy stand. The patient then bent from hips, forwards, right, left, backwards. • To reach the 80% resistance level was checked with a hand-held isometric strength testing device **Upper body exercises: 1. dumbbell shrugs, 2. presses, 3. Curls, 4. bent-over rows, 5. Flies, 6. pullovers** • Single set of 15 repetitions **ETG (endurance training group):** • Neck muscles by lifting the head up from supine position • 3 sets of 20 repetitions • Dumbbells 2 kg Same upper body exercises like the STG Ylinen et al. 2006, Nikander et al. 2006, Salo et al., 2010, Ylinen et al. 2010, Same Interventions, secondary analyses of Ylinen et al. 2003	The Control Group was instructed to do the same stretching exercises as the training groups: 3 times a week at home. The physiotherapist supervised one stretching session to ensure that all the exercises were performed in a proper manner.	• LOFC principle: the outcome was analysed using the last observation carried forward (LOFC). • VAS: neck pain was assessed by the visual analogue scale (VAS) and • Vernon's Neck Disability Index: neck and shoulder pain and disability index • 6-point scale (1=much more pain and 6 complete relief from pain).12 months follow up, subjects were asked to describe how the training affected their neck pain	**VAS Pain:** at baseline there was no significant difference between groups in pain and median was 58 (IQR = 43,72) mm on VAS. Decrease in neck pain of 69 % in the STG, 61 % in the ETG, and 28 % in the CG at the 12 months follow up compared with the baseline was significant in all groups (p<0.001). At the 12 months follow up a statistically significant difference emerged between the groups (p<0.001). **Vernon Disability Index:** The index dropped most rapidly by the 2 month follow up in both training groups but also continued to show a fall at the 6 and 12 months follow ups.	180, 119 12 months follow up 1 year
5. Chronic neck pain	Nikander et al. 2006, Finland (32)	Female office workers		• 3 days at the rehabilitation center for recreational activities • Advised to perform aerobic exercises three times / week, half hour • Received written information about the same stretching exercises • Supposed to practice the exercises at home for approximately 20 min, 3 x / week Each control participant was trained once to perform exercises properly.	Baseline and after 12 months Maximal oxygen uptake • Physical activity: questionnaire specific training program • All activities were converted into metabolic equivalents (METs) One MET represents the approximate rate of oxygen consumption of a seated individual at rest (3.5 mL.kg-1. min-1) • Training diary • Physical activity: seven-point scale • Perceived neck pain (0–100 mm) was assessed on a visual analogue scale (VAS) Perceived disability (0–100 mm) was assessed neck- and shoulder-pain and disability index.	**MET**: specific neck, shoulder, and upper extremity training for more than 8.75 Met.h.wk-1 was an effective training dose for decreasing neck pain. One MET-hour of training / week accounted for an 0.8-mm decrease of neck pain on a visual analogue scale (VAS) and a 0.5-mm decrease on the disability index. Both strength and endurance training decreased perceived neck pain and disability. **VAS**: MET-hours of STP: (p=<0,001) • Declines in neck pain and disability correlated positively with the amount of specific training both training modes relieved the participants` neck pain significantly (p=<0,001) • Both training modes relieved the participants` disabilities significantly (p=<0,001). • Disability index: MET-hours of STP: (p=<0,001)	180 119 completers 1 year

6. Chronic neck pain	Salo et al.2010, Finland (33)	Female office worker	Program like Ylinen et al., 2006	Information and guidance on stretching exercises; encouraged to do aerobic exercise 30 min 3 times/ week	• HRQoL was measured using the generic self-administered questionnaire 15 D after the 12-month intervention period.	**15 D:** Significant improvement in the 15 D total scores for both training groups. No changes occurred for the control group (p=0.012, between groups). The STG improved significantly in five of 15 dimensions, the ETG improved significantly in two dimensions. Effect size (and 95% confidence intervals) for the 15D total score was: 0.39 (0.13 to 0.72) for the STG, 0.37 (0.08 to 0.67) for the ETG, and -0.06 (-0.25 to 0.15) for the CG. **12 months:** changes in the 15 D total scores (p=0.012; observed power 0.76, α = 0.05) and the dimension sleeping (p=0.0019) between the groups were statistically significant.	180, 119 completers 1 year
7. Headache and upper extremity pain	Ylinen et al. 2010, Finland (31)	Female office worker	Program like Ylinen et al., 2006	The CG was advised to perform aerobic exercise 3 times a week for half an hour. They received written information about stretching exercises. Practise at home for approximately 20 min, and were trained in the correct way to perform these exercises. They received no treatments.	• VAS: Measurements were taken at baseline and after the 12-month intervention period. Perceived headache, neck and upper limb pain during the previous week • Vernon's Neck Disability • VO2peak, ml/kg/min • Isometric neck strength • Neck ROM • METs: All activities were converted into metabolic equivalents	**VAS**: At baseline, the intensity of headache and pain in the neck, upper extremities was at the same level in all 3 groups. The decrease in headache intensity of 69% in the SG, 58% in the EG and 37% in the CG, was significant compared with baseline values (p=<0.001). A significant difference in change in neck pain was found in the SG; those with severe headache showed the greatest reduction in neck pain at the 12-month follow-up (p=0.013). **Upper extremity pain:** The decrease in upper extremity pain, of 58% in the SG, 70% in the EG and 21% in the CG, was also significant compared with baseline values. Each training group showed a significant difference compared with the CG. VO2, Strength, ROM: there was no significant difference between groups. **METs:** In the dose analysis, one metabolic equivalent per hour of training per week accounted for a 0.6-mm decrease in headache on the visual analogue scale.	180, 119 completers 1 year

Inter-ventions Category Mixed Inter-ventions	Study / Country	Partici-pants Job De-scription	Intervention Type, Dosage, Description, Deliv-ery and Duration	Compera-tor Inter-vention	Outcome	Findings for Intervention vs Control	Participation of Intervention Group
8. Chronic neck muscle pain	Ander-sen L.L. et al. 2008, Den-mark (27)	Female office worker, monot-onous intensive computer work	**Strength Training and general Fitness:** Training parameter: • 1 hour per week. • Both groups: supervised training was per-formed at a high intensity for 20 minutes 3 times per week **Specific strength training (SST)** **5 different dumbbell exercises: 1. arm row, 2. shoulder abduction, 3. shoulder elevation, 4. Reverse flies, 5. upright row** • high intensity specific • locally for the neck and shoulder • Loadings progressively increased • 12 repetitions maximum (RM; 70% of maximal intensity) at the beginning • 8 RM (80% of maximal intensity) • 5 different exercises, 3 sets during each training session • In an alternating manner • Shoulder elevation the only exercise during each session. **General fitness training:** • Performed as leg bicycling (GFT): high-intensity general fitness training with the legs only on a bicycle ergometer • 20 minutes at relative workloads 50 –70% of maximal oxygen uptake (VO2max)	The REF group: 1 hour per week lec-tures giving information on activities promoting general health	**VAS:** The intensi-ty of pain in the trapezius muscle was rated on a 100-mm visual analogue scale. **Pain:** • Since the last training session, • Worst pain since the last training session, • Pain immedi-ately before the present training ses-sion, • Pain immedi-ately after the present train-ing session, • Pain 2 hours after the pres-ent training session.	**VAS:** A decrease of 35 mm (79%; p<0.001) in the worst VAS pain score over a 10-week period was seen with specific strength training. Decrease in pain (5 mm; p<0.05) was found with general fitness training. **10 weeks postinterven-tion**: no change in pain occurred in any of the 3 groups, and the SST group remained at a level that was significantly low-er than the GFT and REF groups and remained at a level that was statistically lower in SST compared with GFT and REF (p<0.001).	48, 34 completers 10 wks.

9. Neck and Shoulder Pain	Saeter-bakken et al. 2017, Norway (10)	Office workers	**Strength Training and Nordic Walking Group:** Both intervention groups attended two training sessions / week. Elastic tubes Training parameters: • each session lasted approximately 30 min. • supervision by an experienced instructor. • controlled tempo (three seconds per repetition) • 3 sets using loads that allowed • 12 repetitions to be performed • ending at fatigue or near fatigue. • 1 min. pause separated the different exercises and sets • resistance was increased when participants could perform 17 repetitions **The ST group:** strength training exercises: **1. shrugs, 2. one-armed row,** **3. one-armed reverse flies, 4. one-armed shoulder abduction, 5. upright row** **The Nordic Walking group:** used the Borg (RPE 6-20 scale) to control the intensity. The intensity of the first five minutes was gradually increased to 12 RPE (light) and then increased to 12-14 RPE (light to moderate intensity) for the remaining 25 minutes.	No Training	• **VAS:** Pain intensity (0-100 mm) • **Isometric abduction strength:** • **Six Minute Walk test (6 MWT)**: were assessed pre, post and 10 weeks postintervention.	**Pain Testing period:** no difference in pain for the control group (p=0.724-1.000) or between the control group and the training groups (p=0.421-0.802). **Strength and 6 MWT:** No changes in were observed between or within the groups (p=0.184-0.870). **Pain Intensity:** Both training groups demonstrated a similar, but significant reduction (p=0.014-0.018). **Postintervention:** Between post-test and the 10 weeks postintervention test, similar pain intensity was observed in the NW (p=0.932) while the ST demonstrated an increase (p=0,136).	34 21 completers 10 wks

Inter-vention Category Exercises	Study / Country	Partici-pants Job De-scription	Intervention Type, Dosage, De-scription, Delivery and Duration	Comperator Intervention	Outcome	Findings for Intervention vs Control	Participation of Interven-tion Group
10. Headache, Neck and Shoulder Pain	Mongini et al. 2012, Italy (46)	Office workers	**Shoulder, neck and a relaxation exercise** Instructions on how to reduce parafunction / hyperfunction of the craniofacial and neck muscles **Relaxation exercise**: • 1 – 2 / day • Sit down in an armchair in a quiet room: Let your lower jaw drop completely for 10–15 min-utes. Apply warm pads to your cheeks and shoulders. **Posture exercises:** 1. Stand upright with your heels, hips and nape of the neck against a wall. Without moving the rest of your body, **bring your shoulders into contact with the wall and release**, rhythmically 2. With your body and head against the wall, make **horizontal movements of the head**, forwards and backwards 3) Cup your hands behind your neck. **Stretch your head back-wards** against counterpressure from your hands. Relax after 2–3 seconds. Training parameters: Each exercise 8–10 times in a session • Perform a session every 2–3 hours • Visual feedback: Place red labels in strategic sites to remind you to avoid excessive contraction of your head and neck muscles • The program was explained in each IG department with a prac-tical demonstration and training to groups of no more than 40 workers	No interven-tion Diaries for recording the pain episodes	• **Change in the fre-quency of headache**: expressed as the proportion of subjects with a 50% reduction of frequency; responder rate; among the **Secondary outcome:** • Number of days per month with headache and neck/ shoulder pain	**Headache:** The Interven-tion group showed a higher responder rate ((risk ratio, 95 % confidence interval (CI)) for headache (1.58; 1.28 to 1.92) **Neck/shoulder pain**: (1.53; 1.27 to 1.82) **Reduction of the days per month:** larger reduction (95% CI) with headache (1.72; 2.40 to 1.04) and with neck/ shoul-der pain (2.51; 3.56 to 1.47).	1457 In-tervention group, Analysed: 909 Interven-tion group 6 months

11. Headache, Neck pain	Rota et al. 2016, Italy (47)	Office workers	Exercises like Mongini et al. (47) Relaxation/posture exercises and a visual feedback, was carried out for Group 1 for 6 months and, afterwards, also for group 2 for the same follow-up period throughout.	Same Intervention	Scoring each patient for: • Pericranial Muscle Tenderness (PTS) (0-3) • Cervical Muscle Tenderness (CTS) (0-3) • Cumulative Muscle Tenderness (CUM) (0-6).	**Difference between Groups:** A significant difference was observed between the groups: Group 1 had an average change from baseline in PTS of - 0.19, a CTS of - 0.2 and a CUM score of -0.36. **Difference between Groups (384 subjects):** A significant difference between PTS: (p<0.001) and CUM: (p=0.001) **Headache, neck, shoulder pain**: The difference between the groups in PTS, CTS and CUM scores was no longer detectable at the end of the study, after also Group 2 performed the programme.	384 319 Completers 6 months
12. Neck pain	Tunwattanapong et al. 2016, Thailand (22)	Office workers, Analogue Scale 5/10	Stretching exercises: • The treatment group performed stretching exercises of the neck and shoulder Training Parameter: • The stretching exercise program included 20–30 repetitions/ session: 1. neck stretching, 2. shoulder stretching, 2. shoulder rolling, 3. trunk stretching, 4. back extension • 10–15 minutes. Two sessions were prescribed per day • 5 days a week • Duration: 4 weeks • Participants recorded the frequency of exercise in a logbook All participants received a brochure indicating the proper position and ergonomics to be applied during daily work.	Received a brochure indicating the proper position and ergonomics to be applied during daily work	• Pain, neck functions (VAS, Northwick Park Neck Pain Questionnaire, and Short Form-36) • Quality of life were evaluated at baseline and week 4	**Pain VAS**: scores from baseline 6.6 (1.2) to post intervention 4.8 (1.8) within the intervention group compared with the control group (6.2 [1.0] to 5.6 [1.8], post-intervention (p=0.001). **The Northwick Park Neck Pain Questionnaire (NPQ):** score for the intervention group improved from baseline 28.2 (12.0) to 22.2 (11.3) post-intervention and the control group improved from baseline 28.9 (12.5) to 26.7 (14.5), but this was not significant (p=0.055). **Between groups:** the magnitude of improvement was significantly greater in the treatment group than in the control group −1.4; 95% CI: −2.2, −0.7 for VAS; −4.8; 95% CI: −9.3, −0.4 for Northwick Park Neck Pain Questionnaire; 14.0; 95% CI: 7.1, 20.9 for physical dimension of the Short Form-36. **Quality of Life:** Compared with the patients who performed exercises <3 times/ week, those who exercised ⩾3 times/week yielded significantly greater improvement in neck function and physical dimension of quality of life scores (p=0.005 and p=0.018).	96, 41 completers 3 months

Interventions Category	Study / Country	Participants Job Description	Intervention Type, Dosage, Description, Delivery and Duration	Comperator Intervention	Results	Findings for Intervention vs Control	Participation of Intervention Group
13. Cervical and Shoulder pain	Seong-Uk et al. 2016, Korea (48)	Office workers, who used IT devices for > 8 hours per day	**Manual therapy and stabilization exercises** Training parameters: 2 times 40-minute / week for 6 weeks The manual therapy group: • soft-tissue mobilization • 3 minutes on the upper trapezius, levator scapulae, suboccipital, sternocleidomastoid, pectoral, cervical deep flexor, serratus anterior, rhomboid, and middle and upper trapezius muscles • Prone thoracic mobilization, prone selected thoracic mobilization, cervical mobilization, and thoracic manipulation	Stabilization exercises: for the shoulder joint to correct abnormal scapular location Training parameters: • Stretching of the 1. upper trapezius, 2. levator scapulae, 3. suboccipital, sternocleidomastoid 4. pectoral muscles • Isometric contraction of the deep cervical muscle**s**: knee push-up, prone row, modified prone cobra, cow posture, cat posture, cat postures for thoracic mobilization, dead bug, and flank. • Each exercise: 10 seconds per session in 10 sets • Stage 2: Deep cervical flexor isometrc contraction exercises, supine row, flank, Y exercise, supine pull, modified cobra posture, thoracic mobilization, dead bug posture on a foam roller were performed, • 10 seconds per session in 10 sets	• Pressure pain threshold (PPT) in the splenius capitis, upper trapezius, middle trapezius, and lower trapezius muscles was measured on both sides for all subjects.	**PPT:** In the manual therapy group, the PPT on the left side was 3.07 kg/cm2 before training and 6.20 kg/cm2 after training, indicating a statistically significant increase of 3.69 kg/cm2 ($p<0.001$). **PPT in the splenius capitis**: in the scapular stabilization exercise group was 6.39 kg/cm2 before training and 9.46 kg/cm2 after training, indicating a statistically significant increase of 3.89 kg/cm2 ($p<0.001$). Significant increases were also observed in the upper, middle, and lower trapezius muscles on both sides in both groups.	38 19 MTG 19 SSEG 6 wks

14. Neck, Shoulder Pain	Skoglund et al. 2011, Sweden (23)	Office workers	**Qigong** • Training was performed as a group activity • Watching a video daily 17-25 min during working days • Practical information about using the video equipment • One person from each group was chosen by their colleagues to document the participants and to manage the technical equipment Training parameters: 25 min session • movements, breathing and verbal instruction 17 min version consisted • Movements with simultaneous breathing • A Qigong master demonstrated the content of the training program video The study leader introduced and joined participants during the first three days during the 1st week 1. After one week the 17 min version of the Qigong program was used.	No Intervention	• **Questionnaire about health state, health grading**: Self-reported general health was assessed by two different instruments. • **A rating scale originated from EQ5D:** It has a visual analogue scale (similar to a thermometer) to assess current health **related quality of life** state. The scale ranges from 0 to 100. • **A validated questionnaire (von Korff's)**: grade severity of chronic pain and reduced function in neck/shoulder and lumbar spine region. Three questions addressed pain intensity in the neck/shoulder region.	**Quality of life:** improved from 70 % before to 76 % after Qigong. **Pain intensity**: There was a numerical reduction of pain intensity in the neck from 32 to 23 points. **Neck disability:** There was a numerical reduction of neck disability from 5 to 4 points after the training. Pain intensity neck von Korff 0.12, 0.17 to 0.41 Disability neck von Korff, 0.29, 0.52 to 0.07.	42 37 completers 6 wks

Discussion

Duration of the intervention

Of course, implementability plays a major role in the effectiveness of workplace training programmes. Several authors [7,9,18-22] in this review have shown that short sessions lead to a significant reduction in neck and shoulder pain. Studies of 2 to 15 minutes have shown a reduction in pain. Training interventions of short duration can be easily included in the daily work routine. Some authors [7,20,21] presented a training intervention of 2 or 12 minutes. Andersen C.H. et al. [18], presented different durations in their study, the shortest training intervention time in their study lasts 7 minutes. In the same study another training format lasted 60 min.

All training groups in this study [18] 1x60 min, 3x20 min. and 9x7 achieved a significant pain reduction (p<0,01). Theoretically, short intense training sessions repeated through a day, may improve the restitution, reduce muscle tension, increase temperature and blood flow in the painful muscles when compared to longer sessions. The use of such pain-reducing sessions should ideally be done without or with simple equipment, like tubes, small dumbbells or even without equipment. All authors in the review used elastic tubes, dumbbells or used no additional equipment.

Frequency

Andersen C.H. et al. [18] showed in their study on frequency and duration of strength training that one hour (1 x 60 minutes), 3 x 20 minutes and 9 x 7 minutes per week achieved a reduction in pain. Of course, studies with a short duration of the training intervention had a higher frequency per week [7]. In summary, for interventions of less than 15 minutes, scientists opted for a minimum frequency of five times every working day [7,9,20,21,23]. As soon as the duration was over 20 minutes, two to three times per week were sufficient [25-27]. One example is the study by Blangsted et al. [26], which also achieved a statistically significant reduction in pain with a training intervention of three times a week. As different frequencies achieved significant pain-reducing effects, an employer can choose between different times and associated frequencies of training interventions. Experience shows that employees can cope better with short daily sessions than with longer sessions three times a week. The issue of non-motivation arises less when the intervention is daily and shorter.

Intensity

The American College of Sports Medicine (ACSM) minimum exercise guidelines recommend 1 set (8–12 repetitions) of 8 to 10 resistance exercises to train the major muscle groups 2 days per week.28 Progressive strength training has been proven to reduce pain. Some interventions included resistance progression in intensity. Due to the results of Andersen L.L. et al. [27] almost all interventions since than had a moderate start and increased in repetition maximum and resistance over the duration of the intervention. Andersen L.L. et al. [29] identified a risk factor in rapid-impact strength training in people with neck pain. Feedforward mechanisms like fear of increased pain reduces rate of descending drive of both painful and pain free synergistic muscles during the phase of rapid rise in muscle force. Neural inhibitory feedback mechanisms limit maximal activation of painful muscles during the stable high-force phase of maximum voluntary contraction. Andersen L.L. et al. [29] suggests that a feedback mechanism is responsible for the impairment of painful muscles during maximal force development coming from muscle spindles and Golgi tendon organ. Jay et al. [24] mentioned a pain reducing mechanism in a study investigating the effects of explosive resistance training on non-chronic muscle pain. The desensitization of chemo nociceptive nerve endings by local functional hyperaemia mechanisms normalizing intramuscular metabolite concentrations. Flushing of metabolite build-up might also play a role locally in the muscles when looking for possible explanations to reductions in pain following light and frequent resistance training.

The fear of performing rapid movements in conditions of chronic pain, designates that during the initial phase of rehabilitation, exercises should be performed in a controlled manner to ensure a high level of muscle activation in both painful and pain free muscles. During later phases of rehabilitation, more powerful execution of exercises may be employed [29].

Measuring method

Eight studies included elastic tubing for strength interventions (Table 2). Measurements of maximum strength were checked in several studies with handheld isometric strength testing device [30-33]. An examiner determined muscle strength as the maximal torque value [7,20]. Saeterbakken et al. [10] performed with the participants isometric shoulder elevation (shrugs). The participants were holding a barbell standing in an upright position vertical above a force cell attached to the floor. The participants performed three tests with 1-2 minutes pause between each attempt. The greatest mean force output over a three seconds window from a five seconds maximal voluntary contraction was used in the analyses. Each exercise was conducted with two sets.

Table 2: Training intensity strength training.

Authors	Training Parameter
Andersen CH. et al.[18]	From 20 repetitions maximum (RM) at the beginning to 8 RM (later phase)
Saeterbakken et al.[9]	12–15 repetition maximum (RM) in the first 4 weeks, 8-10 RM in week 5–8
Andersen CH. et al.[19]	20 Repetition Maximum (RM) in the first week to 10 RM in the last weeks
Blangsted et al.[26]	10–15 repetitions with 50 %
Ylinen et al.[30,31,] Salo et al.[33,] Nikander et al.[32]	Single set, 15 repetitions, each repetition with a level of 80% of maximum isometric strength
Andersen L.L. et al.[27]	12 repetitions maximum (RM, 70% of maximal intensity) at the beginning, 8 RM (80% of maximal intensity)
Sjögren et al.[34]	30% of one repetition maximum (1RM) for each movement were estimated at 5 weeks intervals with a sub-maximal 5RM test performed using air resistance equipment. 20 times a 30 s pause between the training movements.
Viljanen et al.[35]	Weight 1-3 kg each according to maximum repetitions with a test weight of 7.5 kg
Saeterbakken et al.[10]	The exercises were performed with a controlled tempo (three seconds per repetition),
	3 sets at least with 12 repetitions. One minute pause between sets. The resistance was increased when participants could perform 17 repetitions.
Andersen L.L. et al.7, Jay et al.[20], Lidegaard et al.[21]	The 12 min group performed 8 to 12 repetitions. Progression, if the participants could compete 12 reps. The 2 Minute group only performed 1 set to failure. They had a progression if they could finish the 2 minutes of lateral raise.

Strength exercises

Most of the authors reported in this review have shown an activation of the shoulder girdle [7,9,18,20,21,25-27]. Interventions applying intensive muscle training have used exercises which besides the targeted painful muscles have shown to activate the majority of muscles in the shoulder girdle. Another influencing factor for both neck and shoulder pain seem to be the position of the scapula and the humeral head. Significant results in pain reduction could be achieved in studies with direct involvement of the shoulder muscles. Three studies used in their exercise program only one exercise lateral raise [7, 20,21].

Very remarkable is the result of Andersen C.H. et al. [19] with a training approach involving the scapula fixators without direct training stimulus, training exercise for the neck muscles.

Therefore, an abnormal location of the scapula caused by abnormal muscle action around the shoulder joint can lead to limitation of scapulothoracic joint movement. Eventually, this causes stress to the joint capsule of the scapulohumeral joint causing impingement syndrome and instability in the shoulder girdle [34]. Ludewig & Cook [36] found in their study of subjects with impingement symptoms that reduced serratus anterior function in subjects with shoulder impingement was consistent with reduced posterior tipping. Symptom-enhancing changes in the scapula are thought to be a decrease in the serratus anterior muscle and an increase in the muscular activity of the upper part of the trapezius muscle. Another reason is a dysbalance between the upper and lower parts of the trapezius muscle. Stability and muscle strengthening are more important because the shoulder is very mobile. Among the muscles that act to maintain shoulder stability, the serratus anterior is important for maintaining scapulohumeral rhythm [37]. When elevating the upper limb, it helps upward rotation and posterior tilt /retroversion of the scapula and holds the scapula to the thoracic cage to prevent winging scapula [38].

Table 3: Exercise Intervention: an overview of exercises that occur in the studies with significant results.

Exercises	Occurance of exercise	Authors Nr.
1. Lateral Raise, Shoulder abduction	9	7,9,10,18,20,21,25,26,27
2. Reverse Flies (one arm, both arms)	9	9,10,18,25,27,30,31,32,33
3. Shrugs, Shoulder Lift	8	10,18,25,26,30,31,32,33
4. Row (one arm, both arms, bent over row)	7	9,10,27,30,31,32,33
5. Shoulder press	4	30,31,32,33
6. Pullovers	4	30,31,32,33
7. Curls	4	30,31,32,33
8. Neck flexor head lift from supine position (ETG)	4	30,31,32,33
9. Neck flexor multidirectional exercise with band (STG)	4	30,31,32,33
10. Upright Row	3	9,10,27
11. Wrist extension	2	18,25
12. Front raise	2	18,25
13. Push up plus (Scapula push up)	1	19
14. Press up	1	19
15. Shoulder elevation	1	27
16. Shoulder extension	1	26
17. Shoulder abduction with supraspinatus attention	1	26
18. Explosive Kayaking	1	26
19. Static exercises for the neck	1	26
20. Upper extremity extension	1	34
21. Upper extremity flexion	1	34
22. Trunk rotation	1	34
23. Knee flexion	1	34
24. Knee extension	1	34

The four most common exercises used in the training interventions were Lateral Raise, Reverse Fly, Rowing and Shrugs (Table 4), these are exercises that train the posterior shoulder girdle muscles. They are exercises that directly target the affected structures. In the interventions, no rotational exercises were used in the shoulder girdle. They could place the humeral head centrally in the shoulder girdle. The study by Blangsted et al. [26] showed an abduction with supraspinatus attention in the programme. This study showed statistical significance in pain intensity and duration (Table 5: p=0.0318 pain intensity and p=0.0565 pain duration). The studies that included shoulder girdle exercises achieved a statistical reduction in pain (Table 5). Many events in daily life are characterised by a limited time for developing strength in postural coordination and control strategies [20]. Therefore Jay et al. [20] investigated peak torque (PT) and rate of torque development (RTD). The highest obtained values for PT and RTD were selected for statistical analysis.

The increase was significantly different compared to controls ($p<0.05$, Table 5) for both training groups. Epidemiological studies are often based on questionnaires or software-based registrations of computer use but lack physiological measurements, for example, muscle activity patterns. Tension or activity of the neck/shoulder muscles may play an important role in the development of neck/ shoulder pain and can be measured with electromyography during work [21]. Specifically, Lidegaard et al. [21] hypothesised that the training group would have an increased frequency of EMG gaps, a prolonged duration of EMG gaps and a greater proportion of time with minimal muscle activity compared to the control group. Compared with control, training increased isometric muscle strength 6% (p<0.05) and decreased neck/shoulder pain intensity by 40% (p<0.01, Table 5). Sjögren et al. [34] examined the effectiveness of light resistance training with guidance. They choose different exercises in their study. Exercises for upper extremity flexion, extension, trunk and legs. Light resistance training and guidance can decrease headache and neck symptoms among symptomatic office workers (p=0.001, Table 5). Apart from Andersen C.H. et al. [18], another four 30,31,32,33 studies completed an exercise for the serratus anterior (pullovers).

All studies that included the serratus anterior also had statistical results regarding pain reduction (Table 5). The pullover exercise is also a pectoral muscle exercise. Exercises for the pectoral muscles are therefore only found in the form of pullovers in the same four studies. However, the pectoral muscles create a balance to the already tense back musculature and would also lead to structural relief for the participants directly in the programme. In the longer term, a balanced programme in the shoulder girdle is essential. Viljanen et al.35 had no significant effects on pain intensity. The intervention consisted of light strength training and relaxation training techniques.

Table 4: Significant results on main outcome.

Shoulder girdle exercises focus	p(value)	Outcome
Saeterbakken et al., 20209	p=0,05, p<0,01	VAS (mean and worst pain)
Andersen C.H. et al., 201218	p<0.01	Nordic Questionnaire 0-9, neck pain
Andersen L.L. et al., 200827	p<0.001	VAS, neck pain
Gram et al., 201425	p<0.02	Nordic Questionnaire, neck/shoulder pain
Blangsted et al., 200826	(P=0.0318) pain intensity,	Questionnaire about intensity of pain, neck/shoulder pain
	(P=0.0565) pain duration	
Lateral raise	**p(value)**	**Outcome**
Andersen L.L. et al., 20117	p<0.0001	Scale 0-10, neck/shoulder pain (2 and 12 min. group)
Jay et al., 201320	p<0.05	The peak torque (PT; unit Nm) and rate of torque development (RTD; unit Nm s-1)
Lidegaard et al., 201321	p<0.01	Frequency of EMG gaps under 0.5% EMGmax
Trunk and leg exercises	**p(value)**	**Outcome**
Sjögren et al., 200534	P=0.001	Borg CR10 scale, neck symptoms
Serratus anterior exercise included		
Andersen C.H. et al., 201419	p<0.05	Scale 0 – 9, neck and shoulder pain
Ylinen et al., 200330	p<0.001	VAS, neck pain
Ylinen et al., 201031	(p=<0.001)	VAS, headache intensity
Nikander et al., 200632	(p=<0.001)	VAS, neck pain
Salo et al., 201033	P=0.012	15D questionnaire, neck pain

Aerobic exercise

Saeterbakken et al.10 presented a study with two different training interventions. One group performed a strength training and the other group performed Nordic walking. The differing patterns could be caused by the nature of the activities. Nordic walking is not very fatiguing for the neck and shoulder muscles, whereas specific strength training is. Initially Nordic walking could be a softer option for these muscle groups.

Both training groups demonstrated a similar, but significant reduction in pain intensity (P=0.014-0.018). Nordic walking could be a gentler start for painful upper extremity disorders. Therefore, aerobic exercise may modulate central sensitization mechanisms, increase pain thresholds, and reduce the formation of Myofascial Trigger Points. Aerobic exercise provides a potential non-invasive and cost effective alternative or complementary treatment to current management strategies.39

Aerobic exercise has been shown to increase circulating concentrations of the angiogenic cytokines PlGF, bFGF and sFlt-1, as well as IL-6 and IL-8 in both endurance trained and sedentary young men.40 The exercise-training status significantly affect the circulating cytokine response to 30 minutes of acute exercise at the same relative exercise intensity. Regular endurance exercise training is associated with lower levels of inflammatory markers in the basal state compared to pre-training levels.41 Endurance training such as Nordic walking relieves tension and reduces the risk of inflammation in the body. It is likely that the use of aerobic exercise at lower levels of perceived tension would be a helpful approach to minimise the risk of a continuing chronic pain condition. Movement restrictions of ROM cannot be satisfactorily improved with Nordic Walking. Therefore, endurance training combined with specific exercises for the upper extremities should be offered. The technique and use of this form of exercise is easy to train and perform. Due to the longer duration, it is probably too time-consuming during working hours.

Stretching interventions

Tunwattanapong et al.22 reported in their stretching intervention a duration of 15 minutes. Stretching exercises of the neck and shoulder area can reduce pain, and improve neck function and quality of life of office workers. In this study22 significant results were found with respect to VAS pain scores from baseline 6.6 (1.2) to post intervention 4.8 (1.8) within the intervention group compared with the control group (6.2 [1.0] to 5.6 [1.8], post-intervention p=0.001).

Several laboratory researches have demonstrated that stretching leads to elongation of the muscle tendons unit, reductions in maximum force, rate of pressure production, and tensile tension on the muscle tendon device. Therefore, stretching seems to alter the viscoelasticity of the muscle tendon unit, leading to less stiff tissues. These types of changes increase the distance the tissue can stretch and also the force required to tear the muscle tendon unit, producing injury less likely. The supposition is that, for individuals with brief or "tight" muscles, stretching out increases flexibility by lengthening the tissues to a more physiologically normal range, promoting ideal function and reducing the chance of musculoskeletal injury.42 According to Hess and Hecker,43 recommend the following criteria for an effective stretching program:

a) Warm-up for five minutes prior to stretching.

b) Exercises should be tailored to commonly performed job duties.

c) Stretch regularly: a minimum of two–three days/week.

d) Perform stretches correctly.

e) Hold stretch 15–30 seconds.

f) Two-three repetitions per muscle group

g)

Tunwattanapong et al. [22][reported that a stretching program 10 – 15 Minutes, twice a day, 5 times a week, can reduce pain. Perhaps the stretching approach is effective for office workers who have a very high level of perceived pain and can therefore imagine themselves in a slower, more deliberate approach to movement. It may be that people inexperienced in movement start with static stretching to first become aware of the affected muscles. Subsequently, other interventions may make additional sense.

Combined Interventions Cardio Training and Strength Training

Pain education combined with specific training and aerobic exercise reduce neck pain more than pain education alone in women with chronic neck pain [44]. Sjøgaard et al. [45] described in their study benefits of a combined training intervention. Intelligent physical exercise training at work as IPET benefits the worker in terms of decreasing health risk indicators, improving physical capacity and functions as well as perceived health. The employer also benefits in several ways from combined training, as absenteeism due to sickness is reduced and productivity increases. Sjøgaard et al. [45] mentioned that on the societal level exercise can be "more than medicine" since exercise in a specific manner can maintain the individual's ordinary daily physical functions and ability to move (walk and run).

Blangsted et al. [26] reported statistically significant differences between those who performed "physical activity" and the reference group, both with regard to improvements in the intensity and the duration of symptoms according to tests of one-sided hypotheses. In their study, Blangsted et al. [26] could not find a significant difference between the strength group and the "all around fitness exercise group" in terms of pain intensity and duration of pain. There were no statistically significant differences between the outcomes in the two "physical-activity" groups for pain intensity (p=0.5327) and pain duration (p=0.4016). The Results in Andersen et al. [27], showed that during the 10-week postintervention follow up period, no change in pain occurred in any of the 3 groups, and the SST (Strength) group remained at a level that was significantly lower than the GFT (General Fitness) and the reference group. The results of the combined interventions show no significant reduction in pain intensity in some studies. They do not only target the affected muscles. Of course, combined interventions have a general health effect. Health risk indicators are reduced and physical capacity is increased.

Posture exercises

Mongini et al. [46] and Rota et al. [47] included neck, shoulder and relaxation exercises in their study. The advantage of this intervention was the simple composition of the programme, which could be completed both at work and at home. The postural exercises focused on mobility of the thorax and neck. A restricted ROM can be influenced by a postural misalignment and muscle imbalance. The literature suggests that there is evidence that exercise may improve posture in the upper thoracic area, helping improve mobilization of the shoulder muscles, and consequently leading to an increase in ROM [46]. Mongini et al. [46] found a higher responder rate for neck/shoulder pain (95% CI 1.53; 1.27 to 1.82) and a larger reduction of the days per month (95% CI) with neck / shoulder pain (2.51; 3.56 to 1.47). Rota et al. [47] found statistically significant results -0.19 (95% CI: -0.3 to - 0.07) for Pericranial Muscle Tenderness, -0.20 (95% CI: -0.31 to -0.08) for Cervical Muscle Tenderness, -0.36 (95% CI: -0.57 to -0.16) for Cumulative Muscle Tenderness.

Studies with Qui gong [28] and manual therapy [48] were also included in the training interventions. Both studies had significant results. The manual therapy study found a significant increase in PPT. The PPT on the left side was 3.07 kg/cm2 before training and 6.20 kg/cm2 after training, indicating a statistically significant increase of 3.69 kg/cm2 (p<0.001). Qui gong showed a small significant reduction in disability neck (Disability neck von Korff, 0.29, 0.52 to 0.07, Confidence Interval 95 %, 0.52 to 0.07). Simple exercises without resistance are probably the easiest way to become aware of one-sided postures. Through mobility exercises, very high levels of pain and limited range of motion can be experienced without the stress of resistance.

Conclusion

Many interventions, especially strength and combined interventions, proved to be successful. They achieved significant results compared to the control groups. When used in the workplace, it makes sense to choose short and effective strength interventions. The most frequently mentioned exercises were lateral raise, shoulder abduction, reverse flies and shrugs. It probably makes sense to start a gentler exercise path with lower intensities in the strength area or in the mobility and stretching area [22,46,47,10] at the beginning of the intervention, especially in high pain states, in order to improve feedforward mechanisms mentioned by Andersen et al. [27] With lower pain levels at baseline, it is important to use the strength interventions to change the muscle fibres in a sustainable way and to better tolerate future occupational loads.

Apart from strength training, there was also a significant reduction in pain during endurance training (Nordic walking). Nordic walking circulates the entire body through the endurance approach and reduces inflammation in the body. A combination with strength and mobilisation exercises makes sense, as complaints often go hand in hand with ROM restrictions and Nordic walking does not increase ROM in the affected joints of the upper extremity. Exercise variations that specifically relax the neck and shoulder muscles also produced significant results.

Exercises help employees become aware of tension in the affected areas and learn to reduce tension through mobilisation and stretching exercises during working hours. In the meantime, there is a wide range of training methods that can be used in everyday work to reduce pain.

Table 5: Recommended training exercises from the reviewed literature.

Exercises	Description	Reps	Sets	Equipm.
1. Posture exercise	Stand upright with your heels, hips and nape of the neck against a wall.	12 x	3	-
	Without moving the rest of your body, bring your shoulders into contact			
	with the wall and release.46			
2. Press up	The subject sits erect on a training bench, feet on the floor with straight	12 x	3	chair
	arms and the palms on the edge of the bench fingers pointing forward.			
	Lift the body off the bench and then dips down in front of the seat moving the shoulder girdle. Progression: placing weight plates on the thigh.19			
3. Lateral raise	Stand at the middle of the elastic tubing while holding the handles on each side of the body, then raise both arms slightly in front of the body to 90° shoulder abduction and 30° shoulder horizontal flexion. The elbows were in a slightly flexed position (~5°) during the entire range of motion.7	12 x	3	Elastic band
4. Shrugs	The participants elevate their shoulders without extending the hip, legs or arms.10	12 x	3	Elastic band
5. Reverse fly	The participants had 45° flexion in the hip with the contralateral foot on the elastic tube. The arm was abducted from a vertical position to a horizontal position.10	12 x	3	Elastic band
6. Neck Stretching	Participants slowly flex and extend the neck, then bend to the left and to the right, finally, slowly turn the neck to the left and to the right for 5-10 times per direction.22	5-10 times per direction	1	-

Highlights

i. Many interventions, especially strength and combined interventions, proved to be successful

ii. At the workplace, it makes sense to choose short and effective strength interventions.

iii. The most frequently mentioned exercises were lateral raise, shoulder abduction, reverse flies and shrugs

iv. In high pain states it makes sense to start a gentler exercise path with lower intensities in the strength area or in the mobility and stretching area

Appendix

Appendix: Literature Search Strategy used in this review.

Upper extremity symptom+G64+G8:I54+G8:G8:I54	Interventions	Working population / Type of study
musculoskeletal diseases/ or fasciitis/ (15714)	57 exp Exercise/ (204673)	92 Sedentary Behavior/ (10372)
2 shoulder injuries/ or rotator cuff injuries/ or shoulder impingement syndrome/ (9321)	58 exp Exercise Therapy/ (53220)	93 (office adj3 work*).ti,ab,kf. (3414)
3 Back Pain/ (17869)	59 exp Exercise Movement Techniques/ (8624)	94 (computer adj3 (work* or operator?)).ti,ab,kf. (2477)
4 Neck Pain/ (7286)	60 walking/ or exp gait/ or stair climbing/ (56655)	95 (display adj3 operator?).ti,ab,kf. (135)
5 Neuralgia/ (14531)	61 "Physical Education and Training"/ (13639)	96 (desk adj3 work*).ti,ab,kf. (223)
6 Radiculopathy/ (5258)	62 exp Muscle Strength/ (35804)	97 Workplace/ (24095)
7 cumulative trauma disorders/ or carpal tunnel syndrome/ or exp ulnar nerve compression syndromes/ (13924)	63 Weight Lifting/ (4709)	98 (call center adj3 (operator? or work*)).ti,ab,kf. (75)
8 musculoskeletal pain/ or myalgia/ (5392)	64 Gymnastics/ (2246)	99 Call Centers/ (87)
9 arm injuries/ or forearm injuries/ or tennis elbow/ or wrist injuries/ (15937)	65 physical therapy modalities/ (37498)	100 sedentary behavio?r*.ti,ab,kf. (7542)
10 exp elbow tendinopathy/ (1729)	66 exp Breathing Exercises/ (3744)	101 (employee* and office).ti,ab,kf. (1553)
11 Tenosynovitis/ (2964)	67 exercise?.ti,ab,kf. (309725)	102 92 or 93 or 94 or 95 or 96 or 97 or 98 or 99 or 100 or 101 (44032)
12 exp Hand Injuries/ (18357)	68 (physical adj3 activit*).ti,ab,kf. (125393)	103 91 and 102 (1298)
13 Chronic Pain/ (15857)	69 training*.ti,ab,kf. (438923)	104 randomized controlled trial?.pt. (524334)
14 exp Thoracic Outlet Syndrome/ (2243)	70 (stretching* or isometric* or active dynamic*).ti,ab,kf. (64591)	105 exp Randomized Controlled Trials as Topic/ (144456)
15 Nerve Compression Syndromes/ (10133)	71 pilates*.ti,ab,kf. (541)	106 exp controlled clinical trials as topic/ (149937)
16 Occupational Diseases/ (84113)	72 yoga.ti,ab,kf. (5121)	107 exp controlled clinical trial/ (614639)
17 Shoulder Pain/ (5026)	73 (tai ji or tai chi or taj ji or taj chi or taijiquan).ti,ab,kf. (1939)	108 (rct or rcts).ti,ab,kf. (54413)
18 exp upper extremity/ (169026)	74 (qi gong or qigong).ti,ab,kf. (880)	109 trial.ti,ab,kf. (639463)
19 (musculoskeletal adj3 (disorder* or disease* or pain* or complaint* or symptom* or syndrome*)).ti,ab,kf. (22379)	75 walking.ti,ab,kf. (75387)	110 Random Allocation/ (104770)
20 (fasciitis or fasciitides).ti,ab,kf. (8190)	76 (stair adj1 climb*).ti,ab,kf. (2003)	111 random*.ti,ab,kf. (1204587)
21 (shoulder adj3 (injur* or syndrome* or pain* or symptom* or disorder* or disease*)).ti,ab,kf. (15161)	77 (physical adj3 intervention?).ti,ab,kf. (9658)	112 assigned.ti,ab,kf. (253511)
22 rotator cuff injur*.ti,ab,kf. (503)	78 movement?.ti,ab,kf. (329512)	113 (groups or groups).ti,ab,kf. (2197584)

23 back pain.ti,ab,kf. (49966)	79 (muscle strength* or hand strength*).ti,ab,kf. (25011)	114 104 or 105 or 106 or 107 or 108 or 109 or 110 or 111 or 112 or 113 (3586862)
24 (neck adj2 (pain* or symptom* or tenderness* or problem?)).ti,ab,kf. (12251)	80 (strength adj3 train*).ti,ab,kf. (7941)	115 103 and 114 (477)
25 neuralgi*.ti,ab,kf. and (neck or shoulder? or arm? or chest or upper extremit*).mp. [mp=title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms] (1030)	81 (weight? adj3 (lifting? or train*)).ti,ab,kf. (4128)	116 limit 115 to yr="2000 - 2021" (454)
26 (cervical adj3 radiculopath*).ti,ab,kf. (1697)	82 gymnastic*.ti,ab,kf. (2510)	117 limit 116 to (english or german) (440)
27 cumulative trauma disorder*.ti,ab,kf. (368)	83 gymnastic*.ti,ab,kf. (2510)	
28 (repetit* strain adj3 injur*).ti,ab,kf. (359)	84 (physical adj3 activit*).ti,ab,kf. (125393)	
29 (strain injur* adj3 repetit*).ti,ab,kf. (360)	85 (physical adj3 fitness*).ti,ab,kf. (12364)	
30 (overuse adj3 (injur* or syndrome* or symptom*)).ti,ab,kf. (2793)	86 elastic tube?.ti,ab,kf. (272)	
31 (stress injur* adj3 repetit*).ti,ab,kf. (83)	87 (kettle bell? or kettlebell?).ti,ab,kf. (72)	
32 (motion disorder* adj3 repetit*).ti,ab,kf. (28)	88 dumbell?.ti,ab,kf. (62)	
33 carpal tunnel syndrome*.ti,ab,kf. (8870)	89 (muscle? adj3 activit*).ti,ab,kf. (30767)	
34 (carpal tunnel adj3 (neuropath* or compression*)).ti,ab,kf. (303)	90 or/57-89 (1331606)	
35 (media* nerv* adj3 (syndrome* or neuropath* or compression*)).ti,ab,kf. (979)	91 56 and 90 (75599)	
36 (nerve compression adj3 (radial or ulnar or cervical or forearm? or wrist?)).ti,ab,kf. (517)		
37 (nerve adj3 symptom* adj3 (ulnar or radial or cervical)).ti,ab,kf. (187)		
38 myalgi*.ti,ab,kf. (10622)		
39 ((arm? or wrist? or shoulder?) adj3 (injur* or pain* or syndrome* or nerv* neuropath* or neuralgi* or tender*)).ti,ab,kf. (21482)		
40 (forearm adj3 (injur* or pain* or syndrome* or nerv* neuropath* or neuralgi* or tender*)).ti,ab,kf. (1484)		
41 (elbow? adj3 (tennis or golf* or tendinopath* or tendinitis* or tendinos*)).ti,ab,kf. (1246)		
42 (epicondylit* adj2 lateral*).ti,ab,kf. (1078)		
43 humeral epicondylit*.ti,ab,kf. (96)		
44 (medial adj3 epicondylit*).ti,ab,kf. (170)		
45 tenosynovitis*.ti,ab,kf. (3472)		
46 trigger finger?.ti,ab,kf. (836)		
47 (hand adj1 injur*).ti,ab,kf. (2885)		
48 (pain adj3 chronic*).ti,ab,kf. (68542)		
49 (outlet syndrome? adj3 thoracic).ti,ab,kf. (1888)		
50 (compression syndrome* adj3 nerv*).ti,ab,kf. (498)		
51 (occupation* adj3 (disease* or disorder*)).ti,ab,kf. (14672)		
52 (upper extremit* adj3 (disorder* or disease* or pain* or symptom*)).ti,ab,kf. (2057)		

53 (limb? adj3 (disorder* or disease* or pain* or symptom*)).ti,ab,kf. (8556)		
54 (upper body* adj3 (disorder* or disease* or pain* or symptom*)).ti,ab,kf. (108)		
55 brachial neuralgi*.ti,ab,kf. (139)		
56 or/1-55 (510304)		

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Conflict of interest

No conflict of interest.

References

1. Huang GD, Feuerstein M, Sauter SL (2002) Occupational stress and work-related upper extremity disorders: Concepts and models. American journal of industrial medicine, 41(5): 298-314.
2. Baldwin ML, Butler RJ (2006) Upper extremity disorders in the workplace: costs and outcomes beyond the first return to work. Journal of Occupational Rehabilitation, 16: 296 - 316.
3. Baldwin ML (2004) Reducing the costs of work-related musculoskeletal disorders: targeting strategies to chronic disability cases. Journal of Electromyography and Kinesiology (14): 33-41.
4. Seidel DH, Ditchen DM, Hoehne-Hückstädt UM, Steinhilber B, Rieger MA, et al. (2019) Quantitative measures of physical risk factors associated with work-related musculoskeletal disorders of the elbow: A Systematic Review. International Journal of Environmental Research and Public Health, 16(1): 130.
5. Byl N (2020) repetitive strain injury.
6. European Agency for Safety and Health at Work (2017) Estimating the cost of work-related accidents and ill-health: an analysis of European data sources.
7. Andersen LL, Saervoll CA, Mortensen OS, Poulsen OM, Hannerz H, Zebis MK (2011) Effectiveness of small daily amounts of progressive resistance training for frequent neck/shoulder pain: randomised controlled trial. Pain, 152: 440-446.
8. Pedersen MT, Andersen LL, Jørgensen MB, Søgaard K, Sjøgaard G (2013) Effect of specific resistance training on musculoskeletal pain symptoms: a dose-response relationship. Journal of Strength and Conditioning Research, 27(1): 229-235.
9. Saeterbakken AH, Makrygiannis P, Stien N, Solstad TEJ, Shaw M, et al. (2020) Dose-response of resistance training for neck-and shoulder pain relief: a workplace intervention study. BMC Sports Science, Medicine and Rehabilitation, 12: 8.
10. Saeterbakken AH, Nordengren S, Andersen V, Fimland MS (2017) Nordic walking and specific strength training for neck- and shoulder pain in office workers: a pilot study. European Journal of Physical and Rehabilitation Medicine, 53(6): 928 - 935.
11. Holzgreve F, Maltry L, Lampe J, Schmidt H, Bader A, et al. (2018) The office work and stretch training (OST) study: an individualized and standardized approach for reducing musculoskeletal disorders in office workers. Journal of Occupational Medicine and Toxicology, 13: 17.
12. Sitthipornvorakul E, Sihawong R, Waongenngarm P, Janwantanakul P (2019) The effects of walking intervention on preventing neck pain in office workers: a randomized controlled trial. Journal of Occupational Health, 62(1): e12106.
13. Van Eerd D, Munhall C, Irvin E, Rempel D, Brewer S, et al. (2015) Effectiveness of workplace interventions in the prevention of upper extremity musculoskeletal disorders and symptoms: an update of the evidence. Occupational Environmental Medcine, 73: 62-70.
14. Hoosain M, de Klerk S, Burger M (2019) Workplace-based rehabilitation of upper limb conditions: a systematic review. Journal of Occupational Rehabilitation, 29: 175-193.
15. Louw S, Makwela S, Manas L, Meyer L, Terblanche D, et al. (2017) Effectiveness of exercise in office workers with neck pain: A systematic review and meta-analysis. South African Journal of Physiotherapy, 73(1): 392.
16. Chen X, Coombes BK, Sjøgaard G, Deokhoon J, O'Leary S et al. (2018) Workplace-based interventions for neck pain in office workers: systematic review and meta-analysis. Physical Therapy, 98(1): 40-62.
17. Moher D, Liberati A, Tetzlaff J, Altmann DG (2011) Bevorzugte Report Items für systematische Übersichten und Meta-Analysen: Das PRISMA-Statement. Deutsche medizinische Wochenschrift, 163(8): e9-e15.
18. Andersen CH, Andersen LL, Gram B, Pedersen MT, Mortensen OS, et al. (2012) Influence of frequency and duration of strength training for effective management of neck and shoulder pain: a randomised controlled trial. British Journal of Sports Medicine, 46(14): 1004 - 1010.
19. Andersen CH, Andersen LL, Zebis MK, Sjøgaard G (2014) Effect of scapular function training on chronic pain in the neck/shoulder region: a randomized controlled trial. Journal of Occupational Rehabilitation, 24(2): 316-324.
20. Jay K, Schraefel MC, Andersen CH, Ebbesen FS, Christiansen DH, et al. (2013) Effect of brief daily resistance training on rapid force development in painful neck and shoulder muscles: randomized controlled trial. Clinical Physiology Functional Imaging, 33(5): 386-392.
21. Lidegaard M, Jensen RB, Andersen CH, Zebis MK, Colado JC (2013) Effect of brief daily resistance training on occupational neck/shoulder muscle activity in office workers with chronic pain: randomized controlled trial. BioMed Research International 2013: 262386.
22. Tunwattanapong P, Kongkasuwan R, Kuptniratsaikul V (2016) The effectiveness of a neck and shoulder stretching exercise program among office workers with neck pain: a randomized controlled trial. Clinical Rehabilitation, 30(1): 64-72.
23. Skoglund L, Josephson M, Wahlstedt K, Lampa E, Norbäck D (2011) Quigong training and effects on stress, neck-shoulder pain and life quality in a computerised office environment. Complementary Therapies in Clinical Practice 17(1): 54-57.
24. Jay K, Frisch D, Hansen K, Zebis MK, Andersen CH, et al. (2011) Kettlebell training for musculoskeletal and cardiovascular health: a randomized controlled trial. Scandinavian Journal of Work Environmental Health 37: 196-203.
25. Gram B, Andersen C, Zebis MK, Bredahl T, Pedersen MT, et al. (2014) Effect of training supervision on effectiveness of strength training for reducing neck/shoulder pain and headache in office workers: cluster randomized controlled trial. BioMed Research International, 2014: 693013.
26. Blangsted AK, Søgaard K, Hansen EA, Hannerz H, Sjøgaard G (2008) One-year randomized controlled trial with different physical-activity programs to reduce musculoskeletal symptoms in the neck and shoulders among office workers. Scandinavian Journal of Work Environmental Health, 34(1): 55 - 65.
27. Andersen LL, KjÆr M, Søgaard K, Hansen L, Kryger AI et al. (2008) Effect of two contrasting types of physical exercise on chronic neck muscle pain. Arthritis & Rheumatism (Arthritis Care & Research), 59(1): 84-91.

28. Westscott WL, Winett RA, Annesi JJ, Wojcik JR, Anderson ES, et al. (2009) Prescribing physical activity: Applying the ACSM protocols for exercise type, intensity, and duration Across 3 Training Frequencies. The Physician and Sportsmedicine, 37(2): 51-58.

29. Andersen LL, Holtermann A, Jørgensen MB, Sjøgaard G (2008) Rapid muscle activation and force capacity in conditions of chronic musculoskeletal pain. Clinical Biomechanics, 23(10): 1237-1242.

30. Ylinen JJ, Takala EP, Nykänen MJ, Häkkinen AH, Mälkiä EA, et al. (2003) Active neck muscle training in the treatment of chronic neck pain in women: a randomized controlled trial. Journal of the American Medical Association, 289(19): 2509-2516.

31. Ylinen J, Nikander R, Nykänen M, Kautiainen H, Häkkinen A (2010) Effect of neck exercises on cervicogenic headache: a randomised controlled trial. Journal of Rehabilitation Medicine, 42(4): 344 - 349.

32. Nikander R, Mälkiä E, Parkkari J, Heinonen A, Starck H, Ylinen J (2006) Dose-response relationship of specific training to reduce chronic neck pain and disability. Medicine and science in sports and exercise, 38(12): 2068-2074.

33. Salo PK, Häkkinen AH, Kautiainen H, Ylinen JJ (2010) Effect of neck strength training on health-related quality of life in females with chronic neck pain: a rondomized controlled 1-year follow-up study. Health and Quality of Life Outcomes, 8: 48.

34. Sjögren T, Nissinen KJ, Järvenpää SK, Ojanen MT, Vanharanta H, et al. (2005) Effects of a workplace physical exercise intervention on the intensity of headache and neck and shoulder symptoms and upper extremity muscular strength of office workers: A cluster randomized controlled cross-over trial. Pain, 116(1-2): 119-128.

35. Viljanen M, Malmivaara A, Uitti J, Rinne M, Palmroos P, et al. (2003) Effectivness of dynamic muscle training, relaxation training, or ordinary activity for chronic neck pain: randomised controlled trial. BMJ, 327(7413): 475.

36. Ludewig PM, Cook TM (2000) Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. Physical Therapy, 80(3): 276-291.

37. Cools AM, Geerooms E, Van den Berghe DFM, Cambier DC, Witvrouw EE (2007) Isokinetic scapular muscle performance in young elite gymnasts. Journal of Athletic Training, 42(4): 458-463.

38. Lin JJ, Hanten WP, Olson SL, Roddey TS, Soto-quijano DA, et al. (2006) Shoulder dysfunction assessment: self-report and impaired scapular movements. Physical Therapy, 86(8): 1065-1074.v

39. Ahmed S, Khattab S, Haddad C, Babineau J, Furlan A, et al. (2018) Effect of aerobic exercise in the treatment of myofascial pain: a systematic review. Journal of Exercise Rehabilitation, 14(6): 902-910.v

40. Landers-Ramos RQ, Jenkins NT, Spangenburg EE, Hagberg JM, Prior SJ (2017) Circulating angiogenic and inflammatory cytokine responses to acute aerobic exercise in trained and sedentary young men. European Journal of Applied Physiology, 114(7): 1377-1384.

41. Gokhale R, Chandrashekara S, Vasanthakumar KC (2007) Cytokine response to strenuous exercise in athletes and non-athletes-an adaptive response. Cytokine, 40: 123-127.

42. Taylor DC, Dalton JD, Seaber AV, Garrett WE (1990) Viscoelastic properties of muscle-tendon units: The Biomechanical Effects of Stretching. American Journal of Sports Medicine, 18(3): 300-309.

43. Hess JA, Hecker S (2003) Stretching at work for injury prevention: issues, evidence and recommendations. Applied occupational and environmental hygiene, 18(5): 331-338.

44. Brage K, Ris I, Falla D, Søgaard K, Juul-Kristensen B (2015) Pain education combined with neck- and aerobic training is more effective at relieving chronic neck pain than pain education alone - A preliminary randomized controlled trial. Manual Therapy, 25(5): 686-693.

45. Sjøgaard G, Christensen JR, Justesen JB, Murray M, Dalager T, et al. (2016) Exercise is more than medicine: The working age population's well-being and productivity. Journal of Sport and Health Science, 5(2): 159 - 165.

46. Mongini F, Evangelista A, Milani C, Ferrero L, Ciccone G, et al. (2012) An educational and physical program to reduce headache, neck/shoulder pain in a working community: A cluster-randomized controlled trial, Plos One, 7(1):e29637.

47. Rota E, Evangelista A, Ceccarelli M, Ferrero L, Milani C, et al. (2016) Efficacy of a workplace relaxation exercise program on muscle tenderness in a working community with headache and neck pain: a longitudinal, controlled study. European Journal of Physical and Rehabilitation Medicine, 52(4):457-465.

48. Seong-Uk G, Byoung-Hee L (2016) Effects of manual therapy on shoulder pain in office workers. The Journal of Physical therapy on shoulder pain in office workers, 28(9): 2422-2425.v