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Ergonomic and physiotherapeutic interventions for treating work-related complaints of the arm, neck or shoulder in adults

A Cochrane systematic review

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SYNOPSIS

Are physiotherapy or ergonomic workplace adjustments helpful in participants with work-related arm, neck or shoulder complaints?

In the USA, cumulative trauma disorders account for between 56% and 65% of all occupational injuries. Overall, the estimated prevalence of these injuries is approximately 30% and the incidence is rapidly increasing. Conservative interventions such as physiotherapy and ergonomic work-place adjustments play a major role in the treatment. There is a need to determine whether these interventions have a significant impact on short-term and long-term outcomes.

This review shows that there is limited evidence about the positive effect of exercise when compared to massage (one study); adding breaks during computer work (one study); massage as add-on treatment on manual therapy (one study), manual therapy as add-on treatment on exercises (one study); and some keyboards in people with carpal tunnel syndrome when compared to placebo (one study).

There is conflicting evidence concerning the efficacy of exercises over no treatment (eight studies) or as add-on treatment (three studies), and no differences between strength and endurance exercises can be found yet (four studies). At the moment there is also conflicting evidence about the effectiveness of ergonomic programs over no treatment (two studies). No adverse effects were mentioned in the studies. The most important limitations of the included studies are the heterogeneity of the participants, interventions and outcome measures used. No clear definition of work-relatedness could be found in the majority of the studies. Methodological flaws and low power in many of the studies may have influenced the results.

Potential conflict of interest: none known.

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ABSTRACT

***Background*. Conservative interventions such as physiotherapy and ergonomic adjustments (such as keyboard adjustments or ergonomic advice) play a major role in the treatment of most work-related complaints of the arm, neck or shoulder (CANS).**

***Objectives*. This systematic review aims to determine whether conservative interventions have a significant impact on outcomes for work-related CANS in adults.**

***Search strategy*. We searched the Cochrane Bone, Joint and Muscle Trauma Group Specialised Register (March 2005) and Cochrane Rehabilitation and Related Therapies Field Specialised Register (March 2005), the Cochrane Controlled Trials Register (The Cochrane Library, Issue 1, 2005), PubMed, EMBASE, CINAHL, AMED and reference lists of articles. The date of the last search was March 2005. No language restrictions were applied.**

***Selection criteria*. We included randomised controlled trials and concurrent controlled trials studying conservative interventions (*e.g.* exercises, relaxation, physical applications, biofeedback, myofeedback and workplace adjustments) for adults suffering CANS.**

***Data collection and analysis*. Two authors independently selected trials from the search yield, assessed the methodological quality using the Delphi list, and extracted relevant data. We pooled data or, in the event of clinical heterogeneity or lack of data, we used a rating system to assess levels of evidence.**

***Main results.* For this update we included six additional studies; twenty-one trials in total. Seventeen trials included people with chronic nonspecific neck or shoulder complaints, or nonspecific upper extremity disorders. Over twenty-five interventions were evaluated; six main subgroups of interventions could be determined: exercises, manual therapy, massage, ergonomics, energised splint and individual treatment versus group therapy. Overall, the quality of the studies was poor. In 14 studies a form of exercise was evaluated, and contrary**

to the previous review we now found limited evidence about the effectiveness of exercises when compared to massage and conflicting evidence when exercises are compared to no treatment. In this update there is limited evidence for adding breaks during computer work; massage as add-on treatment on manual therapy, manual therapy as add-on treatment on exercises; and some keyboard designs when compared to other keyboards or placebo in participants with carpal tunnel syndrome. ***Conclusions*****. There is limited evidence for the effectiveness of keyboards with an alternative force-displacement of the keys or an alternative geometry, and limited evidence for the effectiveness of exercises compared to massage, breaks during computer work compared to no breaks; massage as an add-on treatment to manual therapy, and manual therapy as an add-on treatment to exercises.**

KEY WORDS: Ergonomics - Physical therapy modalities - Occupational diseases - Arm - Neck - Shoulder.

Background

The term repetitive strain injury (RSI) is not a diagnosis, but an umbrella term for disorders that develop as a result of repetitive movements, awkward postures, and impact of force.[1] Work-related musculoskeletal disorders (WRMD) have been described differently in various countries: RSI in Canada and Europe, both RSI and occupational overuse syndrome (OOS) in Australia and cumulative trauma disorder in the USA.[2] Recently in the Netherlands we have achieved consensus about the term "complaints of the arm, neck and/or shoulder" (CANS) as a better term for these disorders, which can be work-related or not. Work-related CANS can be divided into specific conditions such as carpal tunnel syndrome, which has relatively clear diagnostic criteria and pathology, or nonspecific conditions such as tension neck syndrome. These nonspecific conditions are primarily defined by the location of complaints and the pathophysiology is less clearly defined or relatively unknown.

In the USA, cumulative trauma disorders account for between 56% and 65% of all occupational injuries.[3, 4] Overall, the estimated prevalence of upperextremity WRMD is approximately 30%.[1, 3] Several studies report a rapidly increasing incidence of WRMD of the upper extremities.[1] The costs associated with these disorders are high - over two billion dollars of direct and indirect costs estimated annually in the USA.[4]

Much attention is paid to the prevention and treatment of CANS.[1, 5] Conservative interventions such as physiotherapy and ergonomic adjustments play a major role in the treatment.[4] Therefore, there is a need to determine whether conservative interventions have a significant impact on short-term and long-term outcomes.

Objectives

The objective of this systematic review is to determine the effects of conservative interventions for work-related CANS in adults.

Criteria for considering studies for this review

Types of studies

Randomised controlled trials (RCTs), quasi-randomised trials (methods of allocating participants to a treatment which are not strictly random, *e.g.* date of birth, hospital record number or alternation) and non-randomised controlled trials (CTs). Only trials specifically stating that the conditions under investigation were work-related were included. We considered complaints to be work-related when it was stated in the text, or when people were selected from a specific working population like specific factories or laboratory personnel.

Types of participants

Adults (18 years and over) suffering from CANS. Excluded were people with acute trauma, neoplasm, and inflammatory or neurological diseases.

Types of interventions

All trials studying conservative interventions were included. This includes different types of conservative treatments for upper extremity work-related disorders in adults. Conservative interventions may include exercises, relaxation, physical applications such as ultrasound, biofeedback, myofeedback and workplace adjustments.

To avoid overlap with existing Cochrane reviews,[6, 7] all trials in which a biopsychosocial rehabilitation program was evaluated were excluded. Interventions such as drug treatments, injections and surgical treat-

ments were also excluded when not compared with any conservative treatment.

Types of outcome measures

We were interested in the following outcome measures:

1. Pain (*e.g.* visual analogue scale [VAS], West Haven-Yale Multidimensional Pain Inventory [WHYMPI], ordinal scale).
2. Global status (*e.g.* overall improvement).
3. Functional status or quality of life (*e.g.* SF36, EQ5-D, Sickness Impact Profile, Health Assessment Questionnaire, Disabilities of the Arm, Shoulder and Hand Measurement Tool [DASH]).
4. Ability to work (*e.g.* sickness absence, return to work, number of days off work).
5. Health care consumption (*e.g.* physicians' consultations, physiotherapy, ergonomic adjustments, intake of analgesics).
6. Recurrence of injury.

Search strategy for identification of studies

We searched the Cochrane Bone, Joint and Muscle Trauma Group Specialised Register (March 2005) and Cochrane Rehabilitation and Related Therapies Field Specialised Register (March 2005), the Cochrane Controlled Trials Register (The Cochrane Library, Issue 1, 2005), PubMed (1966 to March 2005), EMBASE (1988 to March 2005), and CINAHL (1982 to March 2005) and reference lists of articles. We also searched the text based Physiotherapy Index/AMED (1988 to March 2005). No language restrictions were applied.

In MEDLINE (OVID WEB) the following subject specific search strategy was combined with all three levels of the optimal trial search strategy,[8] and modified for use in other databases:

1. exp Cumulative Trauma Disorders/
2. Occupational Diseases/
3. Occupational Health/
4. ((occupational overuse or tension neck) adj syndrome).tw.
5. cumulative trauma$.tw.
6. work related.tw.
7. (repetit$ adj (strain or stress or industr$ or motion or movement or trauma)).tw.
8. (vibration adj (induced or related or syndrome$)).tw.
9. or/1-8
10. Neck Pain/ or Shoulder Pain/ or Hand Injuries/ or Wrist Injuries/
11. Musculoskeletal Diseases/
12. (neck$1 or shoulder$1 or arm$1 or upper limb$1 or upper extremit$ or elbow$1 or forearm$1 or wrist$1 or hand$1 or finger$1).tw.
13. carpal tunnel syndrome$.tw.
14. Carpal Tunnel Syndrome/
15. or/10-13
16. and/9,15

Methods of the review

Selection of studies

Two review authors (APV, SMABZ) independently selected the trials initially based on title and abstract. From the title, keywords and abstract they assessed whether the study met the inclusion criteria regarding design, participants and intervention. Full articles of any possible relevance were retrieved for final assessment. Both review authors then independently performed a final selection of the trials to be included in the review using a standardised form.

Disagreement was resolved by consensus and if necessary, by third party adjudication.

Two review authors (S. D., A. P. V.) independently extracted data regarding the interventions, type of outcome measures, duration of follow-up, loss to follow-up, and outcomes, using a standardised form.

Assessment of methodological quality of included studies

Two review authors (A. F., C. K.) independently assessed the methodological quality. Disagreement was resolved by consensus, and if disagreement persisted, a third reviewer (A. P. V.) made a final decision. We used the Delphi list [9] in which all nine criteria carry equal weight. Criteria have a 'yes', 'no' or 'don't know' answer format: 'yes = 1', 'no = 0' or 'don't know' = 0. A quality score was calculated for each study by summing scores for individual Delphi items, resulting in a possible score of 0 to 9.

Methodological quality assessment tool.

1. Was a method of randomisation performed?
2. Was the treatment allocation concealed?
3. Were the groups similar at baseline regarding the most important prognostic indicators?

4. Were eligibility criteria specified?
5. Was the outcome assessor blinded?
6. Was the care provider blinded?
7. Was the patient blinded?
8. Were point estimates and measures of variability presented for the primary outcome measures?
9. Did the analysis include an intention-to-treat analysis?

The interobserver reliability of the overall quality assessment and clinical relevance assessment was derived by Kappa statistics. Kappa values > 0.7 were considered as good agreement, between 0.5 and 0.7 as moderate, and < 0.5 as poor agreement.

Measures of treatment effect

The various outcome measures are presented separately (see 'Analyses'). For dichotomous data results are expressed, if possible, as relative risks (RR) with corresponding 95% confidence intervals, and as standardised mean differences with 95% confidence intervals for continuous data.[10]

Data synthesis

RevMan Analyses (RevMan 2003) was used to analyse the data. Pooling was not implemented, as trials were considered clinically heterogeneous concerning study population and intervention. Should this be possible in the future, results of comparable groups of trials will be pooled using a random effects model and 95% confidence intervals.

In case of clinically heterogeneity, or if data are lacking, we analysed the results using a rating system with levels of evidence.[11] The rating system consisted of five levels of scientific evidence, based on the quality and the outcome of the trials.

1. Strong evidence: provided by generally consistent findings in multiple (two or more) high quality RCTs.
2. Moderate evidence: provided by generally consistent findings in one high quality RCT and multiple (more than two) low quality RCTs.
3. Limited evidence: one RCT or generally consistent findings in multiple CTs.
4. Conflicting evidence: inconsistent findings in multiple RCTs or CTs.
5. No evidence: no RCTs found or just one CT.

High quality is defined as: either "applying an adequate or concealed randomisation procedure and a form of blinding", or "a positive score (yes = 1) on five or more Delphi items *i.e.* an overall quality score of over fifty percent of the maximum attainable score".

Subgroup analysis

Subgroups were planned of trials studying specific CANS and nonspecific CANS. Complaints were labelled 'specific' when a specific cause could be determined, such as carpal tunnel syndrome or impingement syndrome. Within each subgroup preplanned stratified analyses are:

1. trials comparing included conservative treatments with placebo treatment(s), no treatment/waiting list controls or as add-on treatment;
2. trials comparing different types of included conservative treatments.

Description of studies

Results of the search

Two review authors (S. M. A. B. Z., A. P. V.) independently performed the search. This resulted in 1 752 references, including 510 additional references identified for this update. Based on title and abstract, 126 references were selected for full text retrieval. In total 103 references were excluded. Reasons for exclusion included design (not a controlled study; N = 27), the intervention was behavioural therapy (N = 6), lack of appropriate outcome measures (N = 7), study population (*e.g.* healthy volunteers, or no complaints of the upper extremity; N = 19), intervention (N = 3), not work-related complaints (N = 22) or exclusion was based on more than one criteria (N = 19). Out of the 23 references included, three references concerned the same study.

Included studies

The final selection based on consensus resulted in 21 trials (23 references) being included in this review. More than 25 different interventions were evaluated in the included trials. The number of participants in each treatment group varied from 12 to 135; in ten trials the smallest intervention group involved fewer than 25 participants.

Participants

In total, 2 110 participants are included in this review. Most were selected from study populations

such as industrial workers or hospital staff. The definition of 'work-relatedness' in all trials was evaluated. Seventeen trials included people with nonspecific neck and shoulder complaints or nonspecific upper extremity disorders. In one study only participants with nonspecific hand and wrist complaints were included.[12] The other three trials included people with work-related carpal tunnel syndrome,[13, 14] or a 'shoulder impingement syndrome'.[15] Most trials included people with chronic complaints varying between 3 and 12 months. When people with 'prevalent complaints' were included the mean duration of the complaints at baseline appeared to vary between 3 months and 11 years. Two trials involved people with a recent onset of complaints.[14, 16] Ten trials included only women, and one trial included men only.[17] 'Work-relatedness' was variously reported as: "reported a gradual onset of symptoms that were apparently work-related" [18] or "reported pain or complaints during work tasks" or "performed data processing tasks for 8 h a day".[12] In two trials [15, 19] the work-relatedness of the injury was only described in the title or introduction.

Outcomes

Eighteen trials used pain as the main outcome measure, although its measurement differed greatly among trials. Sometimes an index or composite score was used to measure 'complaints', and in four trials 'return to work' or 'sick-leave' was used as an outcome measure. Other frequently used outcome measures were disability (by questionnaire) or strength (by dynamometer). We defined short-term outcomes as outcomes measured within 3 months after randomisation, and long-term outcomes when measured over 3 months after randomisation.

Interventions

Nine studies have more than two comparisons, of which two studies with four study arms. No trials compared a conservative treatment option with other treatments such as oral medication, injection or surgery. Eleven trials compared different conservative treatments and nine compared conservative treatments with placebo, or no treatment/waiting list controls, or an add-on intervention.

The interventions were grouped as follows:

1. Exercises

In 14 trials a kind of exercise therapy is studied including specific forms of exercises such as proprioceptive neuromuscular facilitation (PNF) [17] and Feldenkreis therapy.[20] Exercises were compared with a control group receiving no treatment,[20-27] other exercises,[17, 18, 24-27] massage,[17, 28] behavioural therapy,[23] as an add-on treatment to ergonomic instructions, [19, 29] or in addition to breaks during computer work.[16] Vasseljen in 1995 [30] compared 'physical therapy' individually with group 'physical therapy' both including exercises given at the workplace.

2. Ergonomics

Various ergonomic strategies are evaluated in seven trials.[13, 14, 16, 20, 21, 31, 32] In three trials ergonomic programs are compared to a no treatment or waiting list control group,[16, 20, 32] and in one study an alternative keyboard is compared to placebo.[14] In one study ergonomic changes at the workplace were an add-on treatment on exercises.[21] Also, in one study a comparison was made between intensive ergonomic guidance or education in ergonomics [32] or an ergonomic program was compared to an exercise group [20] or to 'usual care', which was not defined.[31] In two high quality trials including participants with specific CANS (carpal tunnel syndrome), the efficacy of various keyboards (in total six different keyboards) is compared on reduction of complaints.[13, 14]

3. Massage

In three trials massage is evaluated as a (part of the) treatment; twice compared to exercises,[17, 28] once as an additional treatment on manual therapy.[33]

4. Manual therapy/chiropractic treatment

In Bang,[15] a form of manual physical therapy is evaluated as an additional treatment to exercise in participants with a specific form of CANS (shoulder impingement syndrome).

5. Energised splint

There is one study comparing an 'energised splint' with placebo.[12]

Methodological quality of included studies

The results of the methodological assessment are presented in Table I.[12-34] Initially, there was disagreement between both review authors in 24 out of 198 items (Kappa = 0.76), meaning a high level of agreement. The third reviewer made a final decision for 10 items.

TABLE I.—*Study characteristics.*

Study	Design	Population	Intervention	Outcome (instrument)	Results	Notes
Bang [15]	RCT; observer blinded	Prevalent 'shoulder impingement syndrome' (specific); n=52 (22 women). Work overload is theorized as primary cause of impingement	I: Manual physical therapy + exercise: standardised exercise program + 'manual physical therapy', n= 28. C: Exercise: standardised exercise program, n=24; 6 sessions, in 3-4 weeks	Pain (composite score); Function (Q); Isometric strength (dynamometer)	Function: 37% improvement I *vs* 17% in C; RR=2.1 (0.8; 6); SMD=0.8 (0.2; 1.3). Pain: 70% reduction in I *vs* 35% in C; RR=2.1 (1.2; 3.9); SMD=0.8 (0.2; 1.4) Strength: I *vs* C: SMD=0.8 (0.3; 1.4)	2 dropouts QS: 4 (items 1,4,5,8)
Ferguson [17]	RCT; crossover trial; randomisation of interventions; partly observer blinded	Prevalent neck/shoulder complaints (non-specific); only men; n=40. Full-time operating telegraphists	I1: Group A: active exercise + US I2: Group B: PNF-training + ice C: Group C: massage 4 week intervention, cross over after 2, 4 months	Interview; observation; self-assessment; fear	Self-assessment: moderate and marked improvement: n=13 in I1, n=10 in I2 and C	11 dropouts. No separate data before the crossover. QS: 2 (items 1,5)
Feuerstein [31]	CCT	Chronic (> 3 months) complaints upper extremity (non-specific); n=34 (21 women). Work related diablement	I: multidisciplinary 'work re-entry rehabilitation program', n=19 C: usual care, n=15 4-6 weeks. Follow-up 17 months (3-35 months)	Return to work	Return to work: 73,7% in I *vs* 40% in C; RR=1.8 (0.9; 3.6)	Selection bias: "control group is not eligible for intervention .. . ". QS: 2 (items 8,9)
Hagberg [18]	RCT; concealed randomisation	Chronic (3 months) neck/shoulder complaints (non-specific); only women; n=77. Industrial workers with gradual onset of symptoms during work	I: Endurance training: n=43; C: Strength training: n=34; 12 weeks. Follow-up 24 weeks	Pain (VAS); ROM; sick-leave; strength (dynamometer); endurance (RPE)	Both groups tended to improve in pain and sick leave tended to decrease	8 dropouts (5 in I, 3 in C). Descriptive statistics, pre-post analysis. QS: 4 (items 1,2,3,4)
Van den Heuvel [16]	RCT; group randomisation	Neck, shoulder or arm pain (> 2 weeks) (non-specific); n=286. Workers from an office organisation who considered complaints work related	I1: Breaks: breaks of 5 min every 35 min, n=97; I2: Breaks + exercises: breaks + exercises (45 s) at the start of each break; n=81; C: Control: no intervention, n=90	Perceived recovery (7-point Likert), pain (11point NRS), Sick leave (days)	Perceived recovery: n= 42 in I1, n=37 in I2, and n=25 in C; I1 *vs* C: RR=1.6 (1.04; 2.3); I2 *vs* C: RR=1.6 (1.1; 2.5); I2 *vs* I1: RR=1.05 (0.8; 1.5) Sick leave: no statistical sign differences	49 dropouts (18 in I1, 15 in I2, 16 in C). QS: 4 (items 1,3,4,8)
Kamwendo [21]	RCT	Chronic (> 12 months) neck/shoulder complaints	I1: Traditional neck school: advice + exercises,	Pain (VAS); Workload (VAS); Fatigue (VAS);	I1 decreased in fatigue compared with C	3 dropouts. Attendance rate between 98-

(to be continued)

TABLE I.—*Study characteristics (Continued).*

Study	Design	Population	Intervention	Outcome (instrument)	Results	Notes
		(non-specific); medical secretaries currently working (women); n=79	n=25 I2: traditional neck school + ergonomic changes, n=28 C: controls: n=26 2 sessions/ week, 4 weeks. Follow-up: 6 months	ROM (goniometer); sick-leave; expectation	At follow-up no between group differences	100%. QS: 2 (items 1,4)
Ketola [32]	RCT	Neck/shoulder complaint (> 1 month) (non-specific); n=124. Employees who use the mouse currently	I1: Intensive ergonomics, physiotherapists changed worksite according to checklist, n=39 I2: Education ergonomics, 1 h training session in ergonomics, n=35 C: Control group, one-page leaflet, n=35	Discomfort (6 point Likert), strain (6 point Likert), pain (yes/no)	Neck pain: I1 *vs* C: SMD=0.6 (0.03; 1.1) I2 *vs* C: SMD=0.7 (0.2; 1.3) I1 *vs* I2: SMD=0 (-0.5; 0.5)	7 dropouts (2 in I1 and I2, 3 in C) QS: 5 (items 1,3,4,8,9)
Klemetti [34]	CCT, matched	Chronic tension neck (non-specific); n=170. Bank office workers	I: Exercise, physical training course, n=80 C: Control, no treatment, n=90	Pain, disability, sick leave	Pain: I *vs* C: SMD=0.1 (-0.2; 0.4) Sick leave: no significant differences	QS: 2 (items 3,8)
Leboeuf [33]	RCT	Chronic (> 3 months) complaints upper extremity (non-specific); n=38 (35 women). Symptoms considered due to repetitive strain	I: Spinal manipulative therapy + massage: n=21 C: Spinal manipulative therapy (SMT): n=17 5 weeks, 2 sessions/week. Follow-up 3 en 12 months	Degree of symptoms; frequency of symptoms (Likert)	Improvement: 41% in C *vs* 80% in I; RR=0.5 (0.3; 0.9)	No dropouts. Descriptive statistics. QS: 4 (items 1,3,4,9)
Levoska [28]	RCT	Prevalent neck/shoulder complaints (non-specific); female office workers on a local bank; n=47	I: Active PT: dynamic exercise; n=23 C: Passive PT: massage, heat etc.; n=24	Pain, tender points; symptoms (Q); strength (dynamometer); endurance	Symptom free: 5 weeks: n=22 in I *vs* n=18 in C; RR=1.3 (1; 1.6); 3 months: n=8 in I *vs* n=4 in C; RR=2.1 (0.7; 6). Strength (5 weeks): I *vs* C: SMD=0.9 (0.3; 1.5)	3 dropouts (1 in I; 2 in C). Compliance 60% - 80%. QS: 3 (items 1,4,8) 39 dropouts (17 in I1, 13 in I2, 9 in C). QS: 4 (items 1,3,4,8)
Lundblad [20]	RCT	Prevalent neck/shoulder complaints (non-specific); female employees currently wor-	5 weeks, 3 sessions/ week. Follow-up 3 months I1: Physical the-	Pain (VAS); function (Q); complaints (Q); ROM; sick-leave	Pain 1 year: I1 *vs* C: SMD=0.1 (-0,5; 0.8); I2 *vs* C: SMD=0.7 (0.1; 1.3); I1 *vs* I2: SMD=-0.6	

(to be continued)

TABLE I.—*Study characteristics (Continued).*

Study	Design	Population	Intervention	Outcome (instrument)	Results	Notes
		king; n=97	rapy: ergonomic program; n=32; 2 sessions/week I2: Feldenkreis: n=33; 1 session/week. C: Control group: n=32 16 week. Follow-up 1 year		(-1.3; 0.1) Function 1 year: I1 *vs* C: SMD=-0,1 (-0.7; 0.6); I2 *vs* C: SMD=0,2 (-0.4; 0.8); I1 *vs* I2: SMD=-0.3 (-1.0; 0.4) Sick leave 1 year: PT *vs* C: SMD=0.2 (-0.4; 0.9); I2 *vs* C: SMD=0.2 (-0.4; 0.8); I1 *vs* I2: SMD=0.1 (-0.7; 0.7)	
Omer [29]	RCT	Neck and upper extremity complaints (non-specific); n=50 (41 women). Computer operators > 6 h a day.	I: Education +Exercises: education (1 h) + mobilisation, stretching, strengthening and relaxation exercises C: Education: education 1 h 3 sessions a week, 8 weeks training	Pain (NRS, PDI) Tiredness, Depression (BDI)	Pain: 8 weeks: I *vs* C: SMD=2.1 (1.4; 2.7) Depression: 8 weeks: I *vs* C: SMD=0.5 (-0.1; 1.1)	QS: 3 (items 1,4,8)
Rempel [13]	RCT, matched pairs; patient and observer blinded	Prevalent carpal tunnel syndrome (CTS) (specific), n=24 (16 women). Full-time laboratory personnel used a computer for > 2 h a day	I: Keyboard A (Protouch): n=12 C: Keyboard B (MacProPlus): n=12 12 week, 1 h training	Pain (Likert); nerve conduction (electromyography); function and keyboard characteristics (Q)	Pain 6 weeks: I *vs* C, SMD=0.1 (-0.7; 1). 12 weeks: I *vs* C, SMD=1 (0.1; 1.9)	4 dropouts, 2 in each group. QS: 7 (items 1,3,4,5,6,7,8)
Rundcrantz [19]	CCT	Chronic (> 12 months) neck/shoulder complaints (non-specific); n=45 (18 women). Official dentists with occupational cervico-brachial disorders	I: adjusted PT + ergonomic instructions; n=22; 1-8 sessions C: ergonomic instructions; n=23; 1-2 sessions. Follow-up: 5 weeks after intervention	Pain (VAS); Well-being (VAS)	Pain neck I *vs* C: SMD=0.2 (-0.4; 0.8). Pain shoulder I *vs* C: SMD=0 (-0.6; 0,6). Well-being I *vs* C: SMD=-0.1 (-0.7; 0.5)	1 dropout in C. QS: 2 (items 3,8)
Stralka [12]	RCT, even/odd numbers. Care provider and patient blinded	Prevalent hand and wrist complaints (non-specific); factory employees (data-processing); n=141 (84 women). CTD	I: Energized splint: n=60 C: Non-energized splint (placebo): n=60 7 week; 30 min stimulation/ 20 sessions	Pain (VAS); ROM; strength (dynamometer); swelling (volume measurement)	Improvement in energized splint group	21 dropouts. Pre-post analysis. QS: 4 (items 1,5,6,7)
Takala [22]	RCT, matched,	Neck/shoulder com-	I: Exercise; n=22	Pain (VAS);	Pain 10 weeks: I *vs*	14 dropouts (9 in

(to be continued)

TABLE I.—*Study characteristics (Continued).*

Study	Design	Population	Intervention	Outcome (instrument)	Results	Notes
	cross-over, observer blinded	plaints (> 1 month) (non-specific); female employees of printing company; n=44. Repetitive movements	C: Controls; n=22 10 week, 10 sessions. After 4 months cross-over	pressure pain (algometer)	C, SMD= 0.1 (-0.5; 0.7)	I, 5 in C). Analysis only in first period. Compliance 80% QS: 4 (items 1,3,5,8)
Tittiranonda [14]	RCT, placebo controlled, random permuted block method, observer blinded	Carpal tunnel syndrome (CTS) or tendinitis wrist (complaints > 1 week) (specific); n=80 (46 women). Computer users	I1: Applied adjusted keyboard; n=20 I2: Comfort keyboard system; n=20 I3: Microsoft natural keyboard; n=20 C: Placebo group; n=20	Pain (VAS), hand function (Q/VAS); physical examination; keyboard comfort (VAS)	Improvement n=9 in I1; RR=1.8 (0.7; 4.4) or n=11 in I2, I3; RR=2.2 (0.9; 5.2) compared to n=5 in C. Pain I1 *vs* C: SMD=0.4 (-0.2; 1); I2 *vs* C: SMD=0.6 (0; 1.3); I3 *vs* C: SMD=0.8 (0.1; 1.4); I1 *vs* I2: SMD=-0.2 (-0.8; 0.4); I1 *vs* I3: SMD=-0.5 (-1.1; 0.2); I2 *vs* I3: SMD=0.1 (-0.2; 0.3). Function I1 *vs* C: SMD=0.6 (0; 1.3); I2 *vs* C: SMD=0.8 (0.2; 1.5); I3 *vs* C: SMD=0.7 (0.1; 1.3); I1 *vs* I2: SMD=-0.3 (-1.0; 0.3); I1 *vs* I3: SMD=-0.3 (-1.0; 0.3); I2 *vs* I3: SMD=-0.1 (-0.7; 0.5)	11 dropouts (1 in I1, 9 in I2, 1 in I3). QS: 8 (items 1,3,4,5,6,7,8,9)
Vasseljen [30]	RCT	Chronic (> 6 months) neck/shoulder complaints (non-specific); female office workers; n=24. Work related complaints	I: Individual PT: massage, exercise, mobilisation, ergonomic adjustments; n=12; 10 weeks, 2 sessions/week. C: Group PT: exercise at workplace; n=12; 6 week, 3 sessions/week Follow-up: 6 months	Pain (VAS), trigger points (algometer), strength; muscle activity (EMG)	Benefit at end of treatment: I (n=9) *vs* C (n=2): RR=4.5 (1.2; 16.6); at 6 months: I (n=6) *vs* C (n=3): RR=2 (0.6; 6.2)	No dropouts. QS: 5 (items 1,3,4,8,9)
Viljanen [23]	RCT, concealed randomisation, outcome	Chronic (> 3 months) neck/shoulder com-	I1: Dynamic muscle training: n=135	Neck pain (VAS); Neck disability (Q); Work ability (Likert);	Pain I1 *vs* C: SMD=0.1 (-0.2; 0.3);	52 dropouts, no difference between groups

(to be continued)

TABLE I.—*Study characteristics (Continued).*

Study	Design	Population	Intervention	Outcome (instrument)	Results	Notes
	assessor blinded	plaints (non-specific), female employees; n=393. Occupational complaints	I2: Relaxation training: various relaxation techniques, n=128 C: Control: ordinary activity, n=130 Training for 12 weeks. Follow-up 3, 6, 12 months	Sick leave	I2 *vs* C: SMD=0.1 (-0.2; 0.3); I1 *vs* I2: SMD=0.0 (-0.2; 0.2). Disability: I1 *vs* C: SMD=0.1 (-0.2; 0.3); I2 *vs* C: SMD=0.0 (-0.2; 0.2); I1 *vs* I2: SMD=0.1 (-0.2; 0.3). Sick leave I1 *vs* C: SMD=0.1 (-0.1; 0.4); I2 *vs* C: SMD=0.0 (-0.2; 0.3); I1 *vs* I2: SMD=0.1 (-0.1; 0.4)	QS: 7 (items 1,2,3,4,5,8,9)
Waling [24, 26] Ahlgren [25]	RCT, group randomisation	Chronic (>12 months) neck/shoulder complaints (non-specific); female employees; n=126. Work 'contributed' to the disorder	I1: Coordination training: body awareness therapy, n=31 I2: Strength exercises: n=34 I3: Endurance training: n=34 C: Controls: discussion + stress management, n=27 10 weeks, 3 sessions/week	Pain (VAS), trigger points (algometer), function (Q), satisfaction (Q)	Improvement: 8 m: I1 (n=23) *vs* I3 (n=21): RR=1.2 (0.9; 1.7); I2 (n=29) *vs* I3 (n=21): RR=1.4 (1.0; 1.9). Pain: I1 *vs* C: SMD=-0.8 (-1.4; -0.2); I2 *vs* C: SMD=-0.3 (-0.9; 0.2); I3 *vs* C: SMD=-0.4 (-1.0; 0.2); I1 *vs* I2: SMD=0.5 (-0.0; 1.0); I1 *vs* I3: SMD=0.5 (-0.1; 1.0); I2 *vs* I3: SMD=0.1 (-0.5; 0.6) Pain 3 years: I1 *vs* C: SMD=0.5 (-0.1; 1.0); I2 *vs* C: SMD=0.6 (0.1; 1.1); I3 *vs* C: SMD=0.5 (0.0; 1.0); I1 *vs* I2: SMD=-0.1 (-0.6; 0.4); I1 *vs* I3: SMD=0.0 (-0.5; 0.5); I2 *vs* I3: SMD=-0.1 (-0.6; 0.3)	24 subjects did not complete training and are excluded from analysis short-term. 23 dropouts after 3 years (6 in I1, 5 in I2, 6 in I3, 6 in C). No data concerning of improvement at 3 year follow-up. QS: 5 (items 1,3,4,8,9)
Ylinen [27]	RCT, concealed randomisation	Chronic neck pain (> 6 months); female office workers;	I1: Strength exercises: n=60 I2: Endurance trai-	Neck pain (VAS), disability (Q), depression,	Neck pain: I1 *vs* C: SMD=2.1 (1.7; 2.5)	QS: 6 (items 1,2,3,4,8,9)

(to be continued)

TABLE I.—*Study characteristics (Continued)*

Study	Design	Population	Intervention	Outcome (instrument)	Results	Notes
		n=180. Work related complaints	ning: n=60 C: Controls: home stretching exercises, n=60 5 sessions/week, 9 sessions in total, 1 month intervals during 12 months	neck muscle strength, ROM	I2 *vs* C: SMD=1.4 (1.0; 1.8) I1 *vs* I2: SMD=0.4 (-0.01; 0.7)	

RCT: randomised clinical trial; PT: physical therapy; EMG: electromyography; US: ultra sound; PNF: proprioceptive neuromuscular facilitation; NRS: numerical rating scale; ROM: range of motion; RPE: rating perceived exertion; RSI: repetitive strain injury; CTD: cumulative trauma disorder; SIP: sickness impact profile; PDI: Pain disability index; Q: questionnaire; STAI: Spielberger state-trait anxiety inventory; BDI: Beck depression inventory; CSQ: coping strategies questionnaire; PBQ: pain beliefs questionnaire; POMS: profile of mood states; RR: relative risk. SMD: standardised mean difference, QS: quality score; *vs: versus*.

Overall, the quality of the trials was poor with a mean quality score of 4.1 (range 2 to 8 points). The overall quality score increases over time (P=0.0001).

The main methodological flaws in the included trials were a nonconcealed randomisation procedure, unblinded participants, caregivers and observers, and the lack of an 'intention-to-treat' analysis. Based on our criterion of high quality: "presenting a concealed randomisation procedure and adequate blinding", only one study was found to be of high quality.[23] A concealed randomisation procedure was described in three trials,[18, 23, 27] and in one of them [23] the outcome assessor was blinded. Based on our criterion of high quality: "an overall quality score higher than 50% of the maximum score", seven trials could be categorised as high quality.[13, 14, 23-27, 30, 32] We consider these trials to be of high quality in our level of evidence analysis. Four trials described observer blinding,[17, 22, 23] in two trials participants, as well as caregivers or observers, were blinded,[12, 13] and in one study only the patient was blinded.[15]

Results

Sixteen trials presented point estimates and measures of variability of their primary outcomes, and in one study a recovery percentage could be calculated.[33] None of the original authors presented a RR, effect-size (ES) or odds ratio (OR) themselves.

We were able to calculate relative risks for seven trials with dichotomous data, and standardised mean differences for 13 trials with continuous data, but because of the clinical heterogeneity of the trials we refrained from pooling. We performed a 'best evidence synthesis' within the several subgroups and according to the intervention.

Trials comparing conservative treatments with placebo, no treatment/waiting list controls or an add-on intervention

1. PLACEBO

Keyboard.—One high quality study [14] evaluated the efficacy of three different keyboards in people with carpal tunnel syndrome on reduction of complaints and improvement of function with a placebo (an unchanged keyboard). They reported significant positive results of some keyboards compared with the placebo. Therefore we conclude that there is limited evidence for the efficacy of alternative keyboards over a placebo.

Energised splint.—One low quality RCT compared an 'energised splint' with placebo,[12] but no data were available to calculate effect sizes.

2. NO TREATMENT/WAITING LIST CONTROLS OR AN ADD-ON TREATMENT

Exercises.—In seven trials exercises are compared to a control group receiving no treatment of which three trials are of high quality and one did not provide data.[21] In one high quality study no differences were found in pain, function and sick leave between exercises and no treatment.[23] In two other high quality trials strength and endurance training seem to be beneficial when compared to no treatment controls, on short-term [27] or at long-term.[24-26] In two low quality tri-

als, no differences were found between exercises and no treatment.[22, 34] Feldenkreis therapy was shown to be beneficial only on pain reduction compared to the control group.[20]

When exercise is evaluated as an add-on treatment on computer breaks [16] or ergonomic instructions [19] no additional benefit can be found, but Omer [29] showed beneficial effects on pain when exercises were an add-on treatment on education.

We conclude that there is conflicting evidence concerning the efficacy of exercises over no treatment or as an add-on treatment.

Ergonomics.—One high quality study found significant differences between two ergonomic programs (intensive ergonomic guidance or educational) and a no treatment group,[32] while one low quality study evaluating a physical therapy ergonomic intervention [20] found no difference. When breaks during computer work using signals are compared to no breaks significant differences in favour of breaks were found.[16]

Therefore we conclude that there is conflicting evidence concerning the effectiveness of ergonomic programs over no treatment, although there is limited evidence that breaks during computer work are effective.

Massage.—In one low quality study massage was evaluated as an add-on treatment on manual therapy and significant results in favour of additional massage was found.[33] We conclude that there is limited evidence for the effectiveness of massage as an add-on treatment to manual therapy.

Manual therapy/chiropractic treatment.—In the study of Bang [15] significant results were found in pain reduction and isodynamic strength in participants with a shoulder impingement syndrome when manual therapy is an add-on treatment to exercises. Therefore, we conclude that there is limited evidence for the efficacy of manual therapy in participants with a shoulder impingement syndrome as an add-on treatment to exercises.

Trials comparing different types of included conservative treatments

1. Exercises

Strength exercises were compared to endurance exercises in three trials (of which two were of high quality); no differences can be found between strength and endurance training,[24, 27] and one did not provide elementary data about the sizes of the effect.[18] Body awareness exercises resulted in a statistically significant improvement in long-term function, but not in short-term function or pain, when compared to endurance exercises.[24-26] One study compared PNF exercises with standard exercises, but did not provide elementary data about the effect size.[17] Exercises seem to be beneficial when compared to massage in one low quality study at short term, not after 3 months.[28] Exercises seem equally effective when compared to behavioural therapy (relaxation) in one high quality study.[23] No difference is found between Feldenkreis therapy (exercises) and an ergonomic program.[20] The study of Vasseljen [30] is considered of high quality and shows significant short-term positive results in favour of an individual approach when compared to a group approach.

Therefore, we conclude that there is limited evidence that exercises are more effective compared to massage and that there is limited evidence on short-term efficacy for individual exercises when compared to exercises in a group. No differences between various kinds of exercises can be found yet.

2. Ergonomics

No difference is found between an ergonomic program and Feldenkreis therapy,[20] between intensive or educational ergonomic guidance [32] or between a multidisciplinary work 're-entry' program and usual care.[31] In people with carpal tunnel syndrome, one high quality trial found no differences between different keyboards with an alternative geometry.[14] Rempel *et al.* [13] found that an alternative force-displacement of the keys is effective after 3 months in reducing complaints compared to a conventional keyboard. The results of these two trials cannot be combined because of differences in keyboard characteristics. Therefore we conclude that there is conflicting evidence of the efficacy of some keyboards in people with carpal tunnel syndrome compared to other keyboards.

3. Massage

In one study massage was compared to PNF or exercises,[17] but no elementary data about the sizes of the effect were provided. In one low quality study exercises seem to be beneficial only at short term over massage.[28]

Discussion

This review shows that there is limited evidence about the positive effectiveness of exercises when compared to massage; adding breaks during computer work; massage as add-on treatment on manual therapy, manual therapy as add-on treatment on exercises; and some keyboards in people with carpal tunnel syndrome when compared to placebo. There is conflicting evidence concerning the efficacy of exercises over no treatment or as an add-on treatment, and no differences between various kinds of exercises can be found yet. At the moment there is also conflicting evidence about the effectiveness of ergonomic programs over no treatment.

The aim of this review was to summarise the existing knowledge and evidence concerning the efficacy of frequently preformed interventions in work-related neck, arm or shoulder musculoskeletal disorders (CANS). A systematic review is a form of observational research and, therefore, susceptible to bias. One of the possible biases this review might suffer from is selection bias. We performed a broad search strategy aiming at finding all trials including people suffering from work-related CANS. No specific search strategy can be made to detect these studies, mostly because defining which disorders are work-related appeared to be rather difficult. There is no clear definition of the work-relatedness of complaints. In the included trials we noticed that defining the study population with this regard appeared to be difficult and subjective. Therefore, it is possible we have missed studies that could be included in this review.

Heterogeneity is another problem. Five main groups of interventions were included, of which the 'exercises' was the largest one. Within each group a large variety of interventions (and outcome measures) were reported which made it impossible to combine study results in a pooled analysis. Although we were able to include 22 trials, it is disappointing that so little evidence of interventions in CANS could be provided. This is partly caused by the many different interventions and partly by the overall low methodological quality of the trials.

Only seven trials were considered of high quality based on an overall quality score of over 50% of the maximum attainable score. Only one trial [23] was also considered of high quality when defined as "having a concealed randomisation procedure and a form of blinding".

Assessing quality and incorporating quality in the analysis is under debate. Broadly there are two ways of assessing quality: the quality component approach or assigning a quality summary score. A summary score can be incorporated into the analysis in various different ways. We used both approaches, but chose to use a threshold to incorporate the quality results into the conclusion. Whether 'high' quality was based on quality components or a summary score has no influence on the conclusions in this review. Because of the heterogeneity, the more frequently used sensitivity analysis was not possible here. Therefore drawing firm conclusions about the efficacy of treatments becomes difficult. Furthermore 17 out of 22 studies had small sample sizes (less than 25 participants in the smallest treatment arm). Although not a quality item, it shows that most studies were underpowered to provide clear answers.

Hardly any clinical heterogeneity was found in the study populations selected for inclusion in the original trials. In most studies participants with chronic nonspecific neck/shoulder complaints were included. CANS are mostly divided in specific and nonspecific disorders, and the latter appeared to be the largest group. This review contributed especially to the body of knowledge of nonspecific work-related disorders.

Although this version of the review includes seven additional trials, the main conclusion that no strong evidence was found for the effectiveness of any treatment still holds. Some results of this updated review are slightly different compared the previous one. Most recent trials evaluated exercises and, therefore, contrary to the previous version, we now conclude that there is conflicting instead of limited evidence of exercises over no treatment. This conclusion is different from large systematic reviews concerning the effectiveness of exercises in for example low back pain where a clear benefit of exercises is established.[35, 36] On the other hand, the benefit of exercises in people with neck pain is not yet clear, mainly because of the low number of studies found.[36]

The relevance of this systematic review in contributing to the body of knowledge concerning the efficacy of interventions in nonspecific work-related CANS lies mainly in the fact that it points out a clear lack of evidence regarding the effectiveness of most often prescribed interventions. Most important difficulties found here are: lack of a definition of 'work-relatedness', the wide variety of interventions used

to treat people with possible CANS, and the overall poor methodological quality.

The main advantage of this review is that it is one of the first systematic summaries of the current knowledge about CANS. This review clearly shows a need for a definition of what can be considered as a "work-related disorder" and that better targeted, higher quality research is needed.

Reviewers' conclusions

Implications for practice

In conclusion, this review shows limited evidence for the efficacy of specific keyboards with an alternative force-displacement or geometry only for participants labelled with carpal tunnel syndrome. There is limited evidence for the efficacy of exercises when compared to massage; adding breaks during computer work; massage as an add-on treatment on manual therapy, and manual therapy as an add-on treatment on exercises in participants with nonspecific work-related complaints. The benefit of (expensive) ergonomic interventions in the workplace is not clearly demonstrated.

Implications for research

1. There is a need for an agreed definition of what can be considered as a 'work-related disorder'. This way a clear patient population can be selected for future studies.

2. Future research should examine clear and well defined interventions not only in pragmatic trials comparing various conservative interventions with each other, but also in more explanatory trials comparing the intervention with a no treatment control group.

3. Large, adequately powered trials are needed that focus on appropriate allocation concealment, blinding of at least outcome assessment and, if possible, patient and therapist and an adequate data presentation and analysis.

4. The design and reporting of future trials should conform to the CONSORT statement.

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