Workplace-based rehabilitation of upper limb conditions: A Systematic Review

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Declaration

By submitting this thesis electronically, I declare that the entirety of the work contained therein is my own, original work, that I am the sole author thereof (save to the extent explicitly otherwise stated), that reproduction and publication thereof by Stellenbosch University will not infringe any third party rights and that I have not previously in its entirety or in part submitted it for obtaining any qualification.

Abstract

Background: Upper limb conditions are a common and growing cause of work related ill health and disability. International and South African legislation support work rehabilitation and specifically workplace-based rehabilitation, but the availability of workplace-based rehabilitation services appears to be limited in South Africa, with more focus on once-off work evaluations. Evidence is needed on the effectiveness of workplace-based rehabilitation services, in order to inform future service delivery.

Objective: The objective of this systematic review was to identify, collate and analyse the current available evidence on the effectiveness of workplace-based rehabilitative interventions in workers with upper limb conditions on work performance, pain, absenteeism, productivity and other outcomes such as ergonomic risk and mental health.

Methods: This systematic review was designed in accordance with PRISMA guidelines and registered with PROSPERO as number: PROSPERO CRD42017059708. We searched Medline (PubMed), Cochrane Library, Scopus, Web of Science, EBSCOhost (Academic Search Premier, Africa-Wide, CINAHL), OTSeeker and PEDro with search terms in four broad areas: upper limb, intervention, workplace and clinical trial (no date limits). Studies including neck pain only or musculoskeletal pain in other areas were not included. Risk of bias in included studies was assessed using a question and rating system developed by the Institute for Work and Health (IWH). As meta-analysis was not possible, study results were analysed through a narrative synthesis.

Results: The initial literature search located 1071 articles, of which 80 were full text reviewed. Seventeen studies were included, across 28 articles, reporting on various outcomes. Nine studies were of high methodological quality, seven of medium quality, and one of low quality. Studies were sorted into intervention categories: Ergonomic controls (n=3), ergonomic training and workstation adjustments (n=4), exercise and resistance training (n=6), clinic-based versus

workplace-based work hardening (n=1), nurse case manager training (n=1), physiotherapy versus Feldenkrais (n=1), and ambulant myofeedback training (n=1). The largest body of evidence supported workplace exercise programs, with positive effects for ergonomic training and workstation adjustments, and mixed effects for ergonomic controls. Ambulant myofeedback training had no effect. The remaining three categories had positive effects in the single study on each intervention.

Conclusion and Recommendations: There is substantial evidence supporting workplace exercise programs. Further research needs to be conducted on the remaining intervention categories. Researchers are encouraged to collaborate with clinicians to enable more high quality research in “real-life” rehabilitation contexts, including individualised work rehabilitation. Clinicians should build partnerships with the Department of Labour and stakeholders at workplaces, in order to develop rehabilitation resources in work environments.

Opsomming

Agtergrond: Boonste ledemaat toestande is 'n algemene en toenemende oorsaak van werkverwante siektes en gestremdheid. Internasionale en Suid-Afrikaanse wetgewing ondersteun werkrehabilitasie, veral rehabilitasie wat by die werkplek plaasvind. In Suid-Afrika is rehabilitasie by die werkplek nog beperk, met meer fokus op eenmalige werk evaluerings. Inligting oor die doeltreffendheid van werkplek gebaseerde rehabilitasie dienste is nodig ten leiding aangaande toekomstige dienslewering.

Doelwit: Die doelwit van hierdie sistematiese oorsig was om die huidige beskikbare navorsing oor die effektiwiteit van werkplek gebaseerde rehabilitasie dienste in werkers met boonste ledemaatstoestande op werkverrigting, pyn, afwesigheid, produktiwiteit en ander uitkomste soos ergonomiese risiko en geestesgesondheid, te identifiseer, saam te voeg en te analiseer.

Metode: Hierdie sistematiese oorsig is volgens PRISMA riglyne ontwerp en by PROSPERO geregistreer: PROSPERO CRD42017059708. Ons het gesoek in Medline (PubMed), Cochrane Biblioteek, Scopus, Web of Science, EBSCOhost (Academic Search Premier, Africa-Wide, CINAHL), OTSeeker en PEDro met sleutelwoorde in die volgende vier areas: boonste ledemaat, intervensie, werkplek en kliniese proef (met geen datum limiete). Studies oor slegs nekpyn of muskuloskeletale pyn in ander gebiede, is nie ingesluit nie. Risiko van vooroordeel in ingeslote studies is beoordeel deur 'n vraag- en graderingstelsel wat deur die Instituut vir Werk en Gesondheid (Institute for Work and Health (IWH)) ontwikkel is. Aangesien 'n meta-analise nie moontlik was nie, is studie-uitslae geanaliseer deur middel van 'n narratiewe sintese.

Resultate: Die aanvanklike literatuursoektog het 1071 artikels opgetref, waarvan 80 volledige artikels ge-evalueer is. Sewentien studies is ingesluit, vanuit 28 artikels wat oor verskeie uitkomste verslag lewer. Nege studies was van hoë metodologiese gehalte, sewe van medium gehalte en een van lae gehalte. Studies is gesorteer in intervensie kategorieë: Ergonomiese kontrole (n=3), ergonomiese opleiding en werkstasie aanpassings (n=4), oefening en

weerstandsopleiding (n=6), kliniek gebaseerde teenoor werkplek gebaseerde werkverharding (n=1), verpleegkundige bestuurder opleiding (n=1), fisioterapie teenoor Feldenkrais (n=1), en ambulante myoterugvoer opleiding (n=1). Werkplek oefenprogramme is deur die meeste navorsing ondersteun, met positiewe gevolge vir ergonomiese opleiding en werkstasie aanpassings, en gemengde effekte vir ergonomiese kontrole. Ambulante myoterugvoer opleiding het geen effek getoon nie. Die oorblywende drie kategorieë het positiewe effekte getoon in die enkele studie oor elke intervensie.

Gevolgtrekking en Aanbevelings: Werkplek-oefenprogramme word goed deur navorsing ondersteun. Verdere navorsing moet gedoen word oor die oorblywende intervensie kategorieë. Navorsers word aangemoedig om met terapeute saam te werk, ten einde meer hoë kwaliteit navorsing in rehabilitasie omgewings te doen, insluitende geïndividualiseerde werkrehabilitasie. Terapeute moet met die Departement van Arbeid en belanghebbendes by werksplekke vennootskappe bou, om rehabilitasie hulpbronne in werksplekke te ontwikkel.

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List of Abbreviations

RSI	-	Repetitive strain injury
EBP	-	Evidence based practice
USA	-	United States of America
WRUED	-	Work-related upper extremity disorders
RCT	-	Randomised controlled trial
EMG	-	Electromyograph
DASH	-	Disabilities of the arm, shoulder and hand questionnaire
SF-36	-	Short form (36) health survey
WHODAS	-	World Health Organisation Disability Assessment Schedule
MeSH	-	Medical subject headings
IWH	-	Institute for Work and Health
I	-	Intervention
C	-	Control
P	-	Protocol
BG	-	Between group
MS	-	Musculoskeletal
RULA	-	Rapid Upper Limb Assessment
HAL	-	Hand activity level
UE	-	Upper extremity

SSS	-	Symptom severity scale
FSS	-	Functional status scale
SS	-	Statistically significant
APB	-	Abductor pollicis brevis test
NMQ	-	Nordic musculoskeletal questionnaire
VAS	-	Visual analogue scale
UEFS	-	Upper extremity functional scale
UED	-	Upper extremity disorders
PRT	-	Progressive resistance training
RPE	-	Rating of perceived exertion
WAI	-	Work ability index
SPADI	-	Shoulder pain and disability index
QPS NORDIC	-	General Nordic questionnaire for psychological and social factors at work
FCE	-	Functional capacity evaluation
ROM	-	Range of motion
OTOH	-	Occupational Therapy in Occupational Health
WPG	-	Work Practice Group
WFOT	-	World Federation of Occupational Therapy
ILO	-	International Labour Organisation
WHO	-	World Health Organisation

Chapter 1: Introduction

Upper limb conditions are amongst the most common causes of ill-health and disability in the workplace [1,2]. A cross-sectional field survey of South African employees (n=15663) in 2012 found that 47% of employees experienced repetitive strain injury (RSI)-related symptoms in their neck, shoulder and upper back [3]. While all provinces and races were represented, the sample consisted of educated participants, ranging from Grade 8 to doctoral degree. This is unlikely to be fully representative of the South African workforce. The incidence of upper limb pain amongst South African workers with lower educational levels could possibly be higher, particularly in those involved with manual labour or highly repetitive unskilled or semi-skilled work. The impact of upper limb dysfunction on the South African workforce includes direct costs of compensation for work-related injuries by the Compensation Fund, loss of productivity and work quality, absenteeism, worker retraining and replacement [4].

International and South African legislation are clearly supportive of work rehabilitation, specifically workplace-based rehabilitation (interventions offered directly at the workplace, rather than at hospitals or rehabilitation centres). Articles 26 and 27 of the United Nations Convention on the Rights of Persons with Disabilities recognises the rights of persons with disabilities to work on an equal basis with others [5]. To this end, the policy promotes work rehabilitation and return-to-work programmes for persons with disabilities. The International Labour Office Vocational Rehabilitation and Employment (Disabled Persons) Recommendation states that work rehabilitation should be started as early as possible [6]. This policy also advocates for the contribution of employers' and workers' organisations to the development of work rehabilitation services. The Integrated National Disability Strategy stresses the importance of work rehabilitation in enabling people with disabilities to retain employment and becoming fully participating members of society [7]. The South African Compensation Fund's 2014-2019 Strategic Plan identifies the development of a Rehabilitation, Reintegration and Return-to-Work Policy Framework as a key priority [8].

Despite the need and legislative support for work rehabilitation services, a recent descriptive cross-sectional study (n=109) [9] found that 72% of South African occupational therapists in the field of work practice offered no treatment or rehabilitation services, instead focussing on once-off evaluations. Furthermore, only 1% of practitioners were based at industrial settings, with the overwhelming majority practicing at hospitals, work assessment units or work rehabilitation units. However, it was found that a small percentage of practitioners (35% or less) occasionally offered some services at workplaces. These included supported employment, job coaching and support, wellness/fitness programs and symptom/discomfort screenings. When offered, work rehabilitation services were more commonly situated at clinics or therapists' practices – these included work conditioning and job modification, joint protection and energy conservation programs, and re-integration programs [9].

Evidence based practice (EBP) challenges health professionals to practice ethically and to consider clinical efficacy [10], using research results in everyday clinical practice. While challenges persist in practical implementation of EBP amongst health professionals in high income [11], as well as middle and lower income countries [12], the EBP process is supported by access to pre-appraised evidence, which is facilitated by high quality systematic reviews [10].

An up-to-date systematic review on effective rehabilitative workplace interventions for upper limb conditions would assist in guiding practitioners in the selection and structuring of suitable workplace-based programs. Such a review would take account of what type of interventions are available internationally, which practitioners they are offered by and what outcomes are successfully improved by these interventions. This would guide the development of evidence-based workplace interventions in South Africa, in order to address the growing problem of upper limb conditions in the workplace, and bridge the current gap between legislation and practice.

The aim of this study was therefore to determine the effectiveness of workplace-based rehabilitative interventions in workers with upper limb conditions on work performance, pain, absenteeism, productivity and other outcomes, including ergonomic risk and mental health.

Chapter 2: The Manuscript

This manuscript is to be submitted to the Journal of Occupational Rehabilitation.

The Journal Guidelines for Authors are included as Addendum A.

Please note that referencing in the manuscript is independent of the rest of the research report.

Title:

Workplace-based rehabilitation of upper limb conditions: A Systematic Review

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Disclosures:

The authors declare that they have no conflict of interest. No funding was obtained for this study.

Abstract:

Purpose: The objective of this systematic review was to identify, collate and analyse the current available evidence on the effectiveness of workplace-based rehabilitative interventions in workers with upper limb conditions on work performance, pain, absenteeism, productivity and other outcomes.

Methods: We searched Medline (PubMed), Cochrane Library, Scopus, Web of Science, Academic Search Premier, Africa-Wide Information, CINAHL, OTSeeker and PEDro with search terms in four broad areas: upper limb, intervention, workplace and clinical trial (no date limits). Studies including neck pain only or musculoskeletal pain in other areas were not included.

Results: Initial search located 1071 articles, of which 80 were full text reviewed. Seventeen studies were included, on which 28 articles reporting on various outcomes were found. Nine studies were of high methodological quality, seven of medium quality, and one of low quality. Studies were sorted into intervention categories: Ergonomic controls (n=3), ergonomic training and workstation adjustments (n=4), exercise and resistance training (n=6), clinic-based versus workplace-based work hardening (n=1), nurse case manager training (n=1), physiotherapy versus Feldenkrais (n=1), and ambulant myofeedback training (n=1). The largest body of evidence supported workplace exercise programs, with positive effects for ergonomic training and workstation adjustments, and mixed effects for ergonomic controls. Ambulant myofeedback training had no effect. The remaining three categories had positive effects in the single study on each intervention.

Conclusion: While there is substantial evidence for workplace exercise programs, other workplace-based interventions require further high quality research.

Systematic review registration: PROSPERO CRD42017059708

Keywords: Workplace, Rehabilitation, Upper extremity, Occupational health

Background:

Upper limb conditions, whether work related or not, continue to pose significant challenges in the workplace. Repetitive strain injury (RSI) is the most common cause of work-related ill health internationally [1]. In high income economies such as the United States of America (USA), Canada and West Europe, upper limb and lower back disorders are among the leading occupational injuries and diseases, and considered a growing problem [2]. Similarly, in middle and lower income economies, musculoskeletal disorders are among the most commonly reported work-related diseases [3].

Workplace-based rehabilitation services may be offered by a variety of healthcare providers, including occupational therapists, physiotherapists and ergonomists. Services may include workplace-based exercise programs [4,5], education of workers [6], modifications to work stations or work process [4], rest breaks [4], and training of supervisors or case managers [4].

Rehabilitation services based at the workplace may have specific advantages over traditional rehabilitation, based at hospitals and rehabilitation centres. Some of these advantages include reduced time off work, earlier return to work, improved quality of life and reduced cost of injuries [4]. Situating rehabilitation services onsite allows injured workers earlier access to rehabilitation, with the potential for better outcomes [7,8]. The role of workplace supervisors in work rehabilitation is well recognised. Early contact between healthcare workers and the workplace has been found to facilitate a reduction in the duration of work disability [6,8]. Healthcare workers based at the workplace may be better placed to train supervisors and negotiate work accommodations; factors which are associated with improved rehabilitation outcomes [8].

A systematic review investigating the effectiveness of workplace-based rehabilitation interventions in the treatment of work-related upper extremity disorders (WRUEDs) was conducted in 2004 (n=8) [4]. Eight studies met the review's inclusion criteria. These included four randomised controlled trials (RCTs), three cohort studies and one case series. Interventions included individual physiotherapy at a local clinic, group exercise at the workplace, physiotherapy based at the workplace, worksite analysis, a training program for nursing case managers on workplace accommodations, ergonomic modifications, as well as rest and exercise breaks. The review concluded that although some positive findings supported the effectiveness of workplace-based interventions in rehabilitating WRUEDs, poor study design affected the reliability of these findings. The flaws in design of individual studies included small sample sizes, lack of standardised outcome measures and statistical analyses, poor reporting of interventions and results, and failure to include control groups. The researchers acknowledged the difficulty in performing workplace-based interventions, and considering this, felt that the risk of bias assessments utilised in the review (Sackett's levels of evidence [9] and the Evaluation Guidelines for Rating the Quality of an Intervention Study Form [10]) may have been overly rigorous. Recommendations included the development of a set of core outcome measures with tested psychometric properties, development of sound methodology for conducting workplace studies, and improved reporting of interventions and study designs [4]. A more recent systematic review was published in 2010, with an update in 2016, on the effectiveness of workplace-based interventions in the prevention of upper limb conditions [2,11]. The initial review included 36 studies of medium to high quality; of which 23 were RCTs, eight were non-randomised trials, and five were cross-over designs [11]. The 2016 update identified an additional 26 medium to high quality studies, of which nine were RCTs, 12 were cluster RCTs and five were non-randomised trials with a control group [2]. Data from the two reviews were combined and grouped into intervention categories. Meta-analysis was not conducted due to differences between comparison/control groups, varied outcome measures and insufficient data reported. Strong evidence was found to support workplace-based resistance training exercise programs; while moderate evidence of positive effect was found for forearm supports, vibration feedback on static mouse use and stretching exercise programs. There was moderate evidence of no effect for EMG biofeedback, job stress management training and office workstation adjustment. Insufficient or conflicting evidence was found for the remaining 23 intervention groups. The updated review found a large number of studies over a shorter period of time than the initial review, and a larger proportion of the more recent studies (from 2008 onward) were of higher quality. Limitations of the review include the inability to include a meta-analysis and the risk of publication bias, as grey literature was not included [2].

While legislation supports workplace-based rehabilitation, a systematic review of existing research on the topic would be beneficial in determining effectiveness of this type of intervention. An up to date systematic review of workplace-based rehabilitative interventions for upper limb conditions would be valuable in accounting for all subsequent literature in this field, particularly considering the value of the 2016 updated review on preventative interventions for upper limb conditions. This review would serve to guide evidence based practice amongst occupational therapists and other rehabilitation professionals working with upper limb conditions in the workplace.

The objective of this review was to determine the effectiveness of workplace-based rehabilitative interventions in workers with upper limb conditions on work performance, pain, absenteeism, productivity and other outcomes, including ergonomic risk and mental health.

Methods / Design:

Study design

This review adheres to the Preferred Reporting Items for Systematic Review and Meta-analysis (PRISMA-P) [12,13]. The review protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO: CRD42017059708).

Eligibility criteria

Type of studies

All clinical intervention studies were considered, including randomised and non-randomised clinical trials published from inception of the databases until April 2017.

Type of participants

Adults aged 18 years or older who are actively employed, with any upper limb condition, including WRUEDs, traumatic injury, degenerative conditions and non-specific or undiagnosed upper limb pain.

Type of interventions

Rehabilitation programs that included any workplace-based interventions were included in the review. Interventions were all at least partly based at the workplace. Interventions based at occupational health clinics were included. Studies on off-site work rehabilitation interventions only (e.g. based at rehabilitation centres, hospitals, therapy clinics, work hardening programs) were excluded.

Examples of workplace-based interventions included job task adaptations, job rotation or alternate placement, work environment/work station or alternate ergonomic modifications, stretching/exercise programs, implementation of rest breaks at work, work hardening, negotiation with supervisors or managers, splint application at work, worker education and supervisor or manager education. Interventions with or without controls were included.

Types of outcome measures

Primary outcomes

The primary outcome of interest was work performance, as measured by productivity, absenteeism, pain or comfort at work, satisfaction or motivation at work.

Secondary outcomes

Outcomes related to upper limb function which are not necessarily related to work, including but not confined to the Disabilities of the Arm, Shoulder and Hand (DASH) questionnaire, grip strength, range of motion; health-related quality of life measures, e.g. SF-36, WHODAS 2.0; or standardised measures of participation in activities of daily living, e.g. Barthel Index.

Information sources and search strategy

With the help of an expert librarian we designed and conducted a search strategy through Stellenbosch University Library and Information Service to find eligible articles in a combination of generalist and specialist electronic databases from March to April 2017, including: Cochrane Central Register of Controlled Trials (CENTRAL) in the Cochrane Library; Medline (PubMed); Scopus; Web of Science; EBSCOhost (Academic Search Premier, Africa-Wide, CINAHL); OTSeeker and PEDro. No language exclusions or date limits were applied. Search strings were adapted by database, and included: exploded MeSH terms, free text, subheadings, synonyms and variant spellings, lay and medical terminology, truncation, Boolean operators, AND and OR. The complete list of terms and detailed search strategy are included as Addendum B. The reference lists of included studies were hand searched for further studies. Full text articles were obtained for all potentially eligible titles. The search results were uploaded into the online software package, Covidence (www.covidence.org), for removal of duplicates (April 2017). Covidence was used for both abstract (April to May 2017) and full-text screening (June 2017).

The total number of results before and after removal of duplicates were documented in a PRISMA flow diagram (See Figure 1).

Selection process

Articles were initially screened for relevance by title and abstract. Thereafter, the full text of potentially suitable studies were retrieved, and inclusion criteria applied. Inclusion criteria comprised articles based on primary empirical research, i.e. not a review, letter to a journal editor, opinion piece or editorial; clinical trials; articles reporting work rehabilitation interventions that were workplace-based, aimed at adult workers with pre-existing upper limb symptoms. Exclusion criteria comprised samples of workers with neck symptoms only; no clear evidence of pre-existing upper limb pain in the sample; other musculoskeletal conditions included in the sample. The reference lists of included articles were screened for additional titles. Title and abstract screening was conducted by the principal investigator (MH). Full text article screening was conducted independently by both MH and a second reviewer (SdK), in order to limit bias in the review (June to July 2017). Disagreements were resolved through discussion. Search dates were recorded. The process followed in screening and selection of studies was reported in a PRISMA flow diagram (Figure 1) [14,15].

Assessment of risk of bias in included studies

Included studies were assessed for risk of bias by the principal investigator (and first reviewer) (MH) and second reviewer (SdK), independently. Results of the independent reviews were correlated, with discussion to reach consensus on any differences. A third reviewer (MB) was available to resolve conflicts in case consensus could not be reached, but this was not needed.

Risk of bias was assessed using the question and rating system developed by the Institute for Work and Health (IWH) and used in their systematic review on occupational health and safety interventions preventing upper limb symptoms [2,11] (Table 1). As in the above review, a 3-

point rating system was used to qualify the questions, ranging from *“somewhat important”* (1), to *“very important”* (3) (See Table 1).

Table 1: Assessing Risk of Bias

Question	Rating
1. Is the research question clearly stated?	2
2. Were comparison group(s) used?	3
3. Was an intervention allocation described adequately?	3
4. Was recruitment/participation rate reported?	2
5. Were pre-intervention characteristics described?	2
6. Was attrition less than 35%?	2
7. Did the author examine for important differences between the remaining and drop-out participants after the intervention?	2
8. Was the intervention process adequately described to allow for replication?	3
9. Were the effects of the intervention on some exposure parameters documented?	1
10. Was the participation in the intervention documented?	2
11. Were the upper extremity musculoskeletal symptoms, signs, disorders, injuries, claims and/or lost time outcomes described at baseline and at follow-up?	3
12. Was the length of follow-up three months or greater?	2
13. Was there adjustment for pre-intervention differences (minimum threshold of three important covariates include age, gender and primary outcome at baseline)?	3
14. Were the statistical analyses optimized for the best results?	3
15. Were all participants’ outcomes analysed by the groups to which they were originally allocated (intention-to-treat analysis)?	2
16. Was there a direct between-group comparison?	3

1=somewhat important, 2=moderately important, 3=very important

A maximum score of 41 is possible, using these 16 criteria. As in the above IWH review, studies were grouped into three categories based on their quality ranking score: High quality (>85%), Medium quality (50-85%) and low quality (<50%) [2,11].

Data extraction and management

Information was extracted from each study (including low quality studies) by the principal investigator and entered into electronic data collection tables on Microsoft Excel. Data was extracted on items including study methods; demographic information of participants; interventions in terms of type, provider, duration, amount of treatment sessions, location and controls; outcomes; conflicts of interest and funding sources. Data entry was double checked for accuracy by the principal investigator on two separate dates. Spot accuracy checks were conducted by the second reviewer (SdK) and third reviewer (MB) on 50% of included studies.

Data synthesis

Results were stratified by intervention type, and further by frequency/duration of intervention, intervention provider and outcome measure.

Due to the heterogeneity of the interventions, comparisons used, reporting of outcome measures and statistical analyses in the included studies, statistical pooling of data in the form of a meta-analysis was not appropriate for this review. Results were subsequently summarized and tabulated in the narrative form.

Results

Study selection

A total of 1071 titles were found on the initial search, including 272 titles from Medline, 172 from OTSeeker, 97 from EBSCOhost, 50 from the Cochrane library, 50 from Web of Science, 420 from Scopus and 11 from PEDro (see Figure 1). Of these, 155 were duplicates, leaving 916 titles for screening. The initial screening of titles and abstracts excluded 808 irrelevant titles. Three of these titles were not available in English (one Norwegian, one Lithuanian and one Afrikaans). Google Translate was used to translate the titles and abstracts. A second title and abstract screening step was conducted jointly by the principal investigator and second reviewer, through discussion. Inclusion criteria were discussed and clarified, and an additional 28 titles excluded.

Full text review was then conducted independently by the principal investigator and second reviewer on 80 studies, resulting in the exclusion of 55 studies. The main reason for exclusion was that participants were not exclusively workers with pre-existing upper limb conditions or pain - studies included asymptomatic workers, or workers with musculoskeletal pain in other regions. One study was excluded as the article was available in Polish only, and could not be translated. Twenty-five articles proceeded to inclusion, and an additional three articles were identified through scanning of reference lists. Several of these 28 articles related to the same research and authors, reporting on different outcomes for the same intervention and control groups, and were thus grouped into 17 studies for inclusion in this review. Protocols of included studies that were published separately were included, to ensure that all available information was used for the quality appraisal.

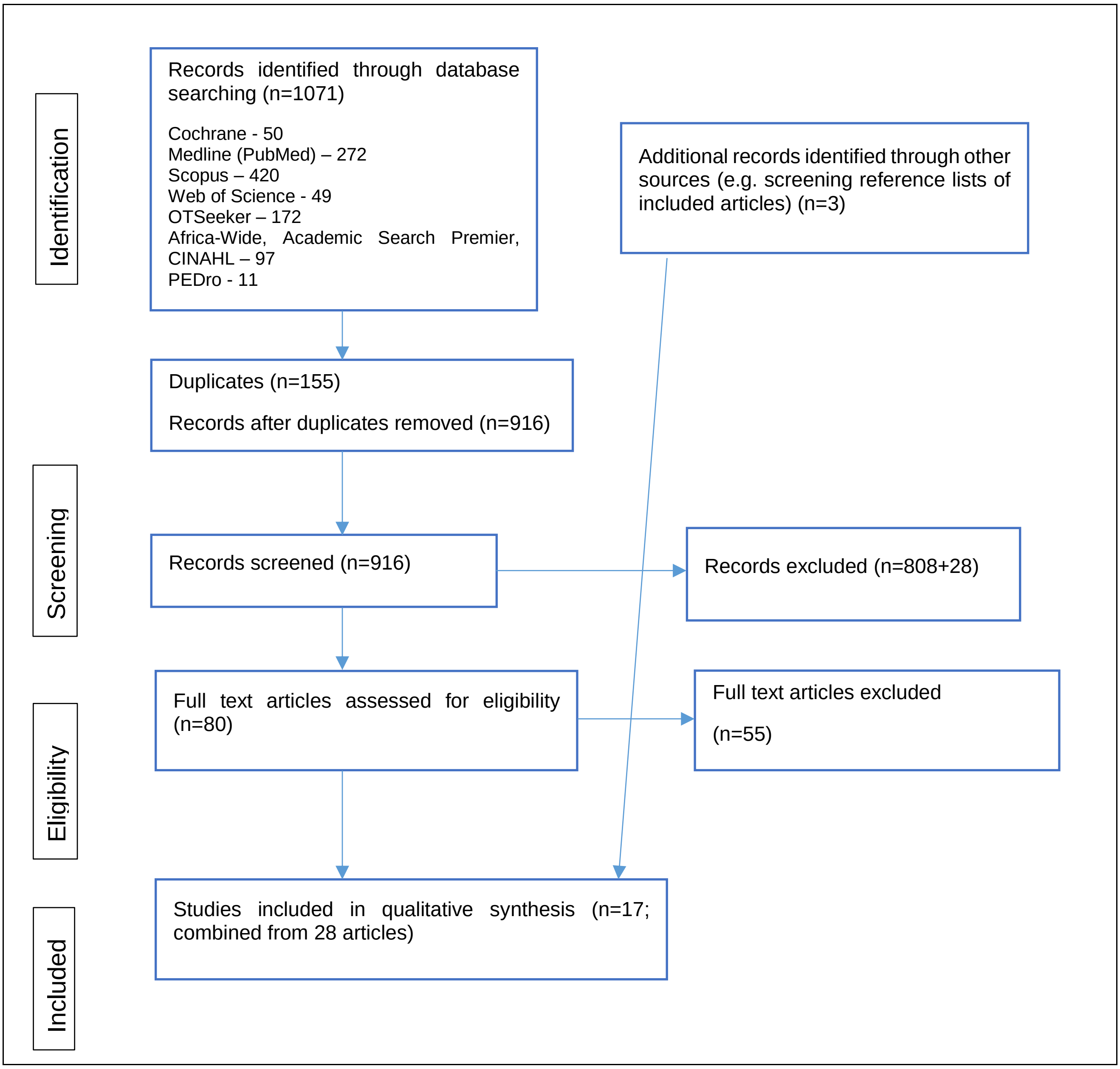

Fig. 1 PRISMA flow diagram

Quality appraisal

Table 2 depicts the list of included studies, their quality appraisal and characteristics. Nine studies were classified as high quality (meeting >85% of criteria) [16-32], seven studies were classified as medium quality (meeting 50-85% of criteria) [32-42], and one study was classified as low quality (<50% of criteria met) [43]. Medium quality studies did not perform intention-to-treat analysis (n=7) [32,36-38,40,42,43], did not document participation in the intervention adequately (n=6) [33-37,39-42], had a follow-up length that was less than 3 months or unclear (n=5) [32,36,39-42], and did not report on important differences between dropouts and remaining participants after the intervention (n=4) [36-38,42]. The one low quality study [43] had no comparison group, pre-intervention characteristics were not adequately described, and statistical analyses were not optimised.

Table 2: Quality Appraisal and Characteristics of Studies

Author: year	Study design	Country	Industry/sector	Sample size	Methodological quality
Aaras: 1999, 2001, 2002	Non-randomised prospective parallel group	Norway	Computer workers	I=32 C=35	Medium
Andersen, L: 2011, 2014; Lidegaard: 2013	RCT	Denmark	Office workers	I1=66 I2=66 C=66	High
Andersen, C: 2011(P), 2014	RCT	Denmark	Office workers	I=24 C=23	High
Bernaards: 2006(P), 2008	RCT	The Netherlands	Computer workers	I1=152 I2=156 C=158	High
Camargo: 2009	Single group	Brazil	Assembly line workers	I=17	Low
Cheng: 2007	RCT	Hong Kong	Varied, Medium physical demand level of work	I=51 C=52	Medium
Dropkin: 2015	RCT	USA	Computer workers	I=56 C=57	High
Esmaeilzadeh: 2014	RCT	Turkey	Computer workers	I=47 C=47	Medium
Feuerstein: 2004	RCT	USA	Professional office workers	I1=47 I2=46	High
Hagberg: 2000	RCT	Sweden	Industrial workers	I1==43 I2=34	Medium
Jay: 2014	RCT	Denmark	Laboratory technicians and office workers	I1=19 I2=19	High
Lincoln: 2002	RCT	USA	Varied: Managers, clerks, postal carriers, mechanical/electrical workers	I=53 C=48	Medium
Lundblad: 1999	RCT	Sweden	Industrial workers	I1=32 I2=33 C=32	High
Martimo: 2010; Shiri: 2011	RCT	Finland	Varied: Nurses and other healthcare workers, clerical workers and secretaries, warehouse workers	I=91 C=86	Medium
Ripat; 2006	RCT	Canada	Computer workers	I=43 C=25	Medium
Sundstrup: 2013(P2006), 2014, 2014, 2016; Andersen: 2017	RCT	Denmark	Slaughterhouse workers	I=33 C=33	High
Voerman: 2007	RCT	Sweden & The Netherlands	Computer workers	I=42 C=37	High

P=Protocol, I=Intervention group, C=Control group, RCT=Randomised controlled trial

Data extraction

Characteristics of included studies

The majority of the included studies were randomised controlled trials (n=15), reported across 23 articles [16-23,23-33,35-42,42]. The remaining two studies were: one of non-randomised prospective parallel group design, reported across three articles [33-35] and one of single group design [43] (see Table 2).

Studies originated in Denmark (n=4) [16-25,31], Sweden (n=2) [32,38], USA (n=3) [29,30,42], Norway (n=1) [33-35], the Netherlands (n=1) [27,28], both Sweden and the Netherlands (n=1) [26], Finland (n=1) [39,41], Hong Kong (n=1) [36], Canada (n=1) [40], Turkey (n=1) [37] and Brazil (n=1) [43].

Study participants included office/computer workers (n=9) [16-20,26-30,33-35,37,40], assembly line workers in the school supply industry (n=1) [43], industrial workers (n=2) [32,38], slaughterhouse workers (n=1) [21-25], and a combination of laboratory technicians and office workers (n=1) [31]. The remaining three studies had participants with varied occupations; one of these had participants working in the medium category of physical demand [36], the second included managers, clerks, postal carriers and mechanical/electrical workers [42], and the third involved healthcare workers, clerical and warehouse workers [39,41].

Sample sizes varied between 17 and 466. Attrition also varied greatly, from 0,04% to 40%. Only two of the studies had attrition rates above 35% [32,39,41].

Interventions

Interventions were grouped as far as possible into the following categories: 1) Ergonomic controls (n=3) [29,33-35,40], 2) Ergonomic training and workstation adjustments (n=4) [27,28,30,37,39,41], 3) Exercise/resistance training (n=6) [16-25,31,38,43]. Four studies did not match any of these categories and thus will be discussed separately [26,32,36,42] (see Table 3). Outcomes varied across studies, but mostly included symptom severity (notably pain), sick leave, postural/ergonomic changes, strength and general measures of health and upper limb-related disability.

Table 3: Description of Interventions, Main Outcomes and Findings

Authors: year	Intervention description	Intervention provider	Frequency and duration of intervention	Main outcomes	Findings: Intervention group / I1 group	Findings: Control group/ I2 group	Findings: Between group comparisons	Conclusion	Length of observation
Ergonomic controls									
Aaras: 1999, 2001, 2002	I=Adapted mouse (more neutral wrist and forearm position) C=Traditional mouse (pronated forearm)	Not Applicable	Daily use	Pain	I: Significant improvements in wrist/hand, forearm, shoulder and neck pain intensity, frequency and duration at 6 months, maintained at 12 and 36 months.	C: No significant improvement in wrist/hand, forearm, shoulder and neck pain intensity, frequency and duration at 6 months. Control group given the intervention after 6 months.	Significant BG differences in all outcomes, in favour of I group.	Anir mouse use showed overwhelmingly positive outcomes in terms of pain, headache, MS sick leave.	6 months 12 months 36 months
				Headache	I: Significant improvement in headache at 6 months. Maintained at 12 and 36 months.	C: No significant improvement in headache at 6 months.			
				Musculoskeletal sick leave	I: Significant decrease in MS sick leave at 6 months. Maintained at 12 and 36 months.	C: Increase in MS sick leave at 6 months.			
Dropkin: 2015	I=Adjustable keyboard/mouse tray with padded wrist rest and touch pad, training on keyboard shortcuts C=Training on keyboard shortcuts	Unclear	Daily use	Pain	I: Pain severity reduced in all areas, SS in dominant and non-dominant proximal UE.	C: Pain severity reduced in all areas, SS in dominant and non-dominant proximal UE.	No significant BG differences in pain severity, slight protective effect in dominant side and increase in pain on non-dominant side of intervention group (not statistically significant).	Intervention resulted in positive changes to postures on RULA, but negative changes on HAL (non-dominant hand activity).	7 months
				Upper limb postures (modified RULA)	I: Reduced non-neutral postures on modified RULA in 4/5 domains.	C: Increased non-neutral postures on RULA in the same 4/5 domains.	Statistically significant improvement on RULA in 2/5 domains in favour of I group.		
				Hand activity (HAL test)	I: Non-dominant hand activity increased (HAL test).	C: No significant changes in hand activity.	Non-dominant hand activity increased in I group (significant), no other significant BG findings in hand activity level.		
Ripat; 2006	I=Adapted Microsoft Natural keyboards (reduced activation force) C=Unadapted Microsoft Natural keyboards	Not applicable	Daily use	Symptom Severity Scale (SSS)	I: Significant improvement on SSS at 12 weeks, maintained at 24 weeks.	C: Significant improvement on SSS at 12 weeks, maintained at 24 weeks.	Similar patterns of reduction in symptom severity and improvement in functional status in I and C groups. Non-significant trends towards improved function in I group.	Positive results in symptoms and function found with both keyboards. Trend towards improved function with light-touch keyboard (not SS).	24 weeks
				Functional Status Scale (FSS)	I: Significant improvement on FSS at 12 weeks.	C: Significant improvement on FSS at 12 weeks.			
Ergonomic training and workstation adjustments									
Bernaards: 2006, 2008	I1=Work style (ergonomics, stress) behaviour counselling I2=Work style and physical activity counselling C=Usual care	Trained counsellor	I1 and I2=6 group meetings in a 6-month period	Body posture & workstation adjustment	I1: Significant improvements on 5/14 items.	I2: Significant improvements 4/14 items.	Both I1 and I2 groups showed significant improvements in some elements of body posture and workstation adjustment, and use of breaks, over the control/usual care group. Comparisons between I1 and I2 were not reported.	Work style intervention had some positive impact on body posture, WS adjustment and use of rest breaks. No effect on work stress.	12 months
				Use of breaks	I1: Significant improvement in use of breaks software, and taking breaks after every hour of computer work.	I2: Significant improvement in use of breaks software, use of short breaks, and changing position or taking breaks after every hour of computer work.			
				Work stress	I1: No significant change.	I2: No significant change.			

Authors: year	Intervention description	Intervention provider	Frequency and duration of intervention	Main outcomes	Findings: Intervention group / I1 group	Findings: Control group/ I2 group	Findings: Between group comparisons	Conclusion	Length of observation
Esmaeilzadeh: 2014	I=Ergonomic training, ergonomic brochure, workstation adjustment C=No intervention	Physiotherapists with ergonomics training	2 x 90-minute training sessions, training brochure, monthly workstation evaluations and adjustments	Ergonomic exposure (Ergonomic Questionnaire)	I: Self-reported postural abnormalities and improper equipment locations significantly decreased.	C: Self-reported postural abnormalities and improper equipment locations increased (not significant).	Significant BG differences in postural abnormalities and improper equipment locations, in favour of I group.	Multi-component ergonomic intervention had a positive effect on ergonomic risk factors and musculoskeletal symptoms.	6 months
				Musculoskeletal symptoms (Modified NMQ, VAS)	I: Intensity, duration and frequency of symptoms decreased significantly.	C: Intensity of symptoms increased significantly. No significant change in duration and frequency of symptoms.	Statistically significant BG differences in intensity, duration and frequency of symptoms, in favour of I group.		
				Medical care, medication use	I: No significant change, tendency to decrease.	C: No significant change.	No significant BG differences.		
Feuerstein: 2004	I1=Ergonomic workstation assessment and adjustments, stretching exercises. I2=As above + job stress management training	Occupational Health Nurse and Rehabilitation Engineer	I1 & I2: Workstation adjustments at start, 3 months and 12 months. I2: 2 x 70 min stress management meetings	Symptoms (Pain – VAS, DASH symptom severity)	I1: Pain and DASH symptom severity significantly decreased at 3 months, maintained at 12 months.	I2: Pain and DASH symptom severity significantly decreased at 3 months, maintained at 12 months.	No significant BG differences in pain and symptom severity.	Ergonomic workstation adjustments with stretching exercises had a positive effect on pain, ergonomic risk and work stress. The additional job stress management training did not significantly enhance these effects.	12 months
				Ergonomic risk assessment	I1: Significant improvements at 3 months, maintained at 12 months.	I2: Significant improvements at 3 months, maintained at 12 months.	No significant BG differences.		
				Work stress	I1: Significant improvements at 3 months, maintained at 12 months.	I2: Significant improvements at 3 months, maintained at 12 months.	No significant BG differences.		
Martimo: 2010; Shiri: 2011	I=Usual care plus work visit by a physiotherapist (suggested and negotiated ergonomic improvements with employee and supervisor) C=Usual care by an occupational health doctor	I=Physiotherapist C=Occupational health doctor	I=One work visit	Productivity loss at work (self-assessed)	I: Proportion and magnitude of productivity loss lower at 12 weeks.	C: Proportion and magnitude of productivity loss higher at 12 weeks.	Statistically significant BG differences in proportion and magnitude of productivity loss, in favour of I group.	Ergonomic intervention had a positive effect on productivity at 12 weeks No significant effect on pain intensity and pain interference with work as well as sickness absence at 12 weeks and 12 months.	12 weeks 12 months
				Pain intensity and pain interference with work	I: Significant decrease over time (12 weeks and 12 months).	C: Significant decrease over time (12 weeks and 12 months).	No significant BG differences, tendencies in favour of I group at 12 weeks and 12 months, especially for pain interference with work.		
				Sickness absence	I: Similar percentage of participants with sickness absence due to UED at 3 months and 12 months.	C: Higher percentage of participants with sickness absence due to UED at 12 months.	No significant BG differences.		
Exercise / Resistance training									
Andersen, L: 2011, 2014; Lidegaard: 2013	I1=2-minute PRT with elastic tubing I2=12-minute PRT with elastic tubing C=Weekly email with general health information	Physiotherapists	5 sessions per week (total of 10-60 minutes) for 10 weeks	Pain	I1: Significant decrease in neck/shoulder pain intensity.	I2: Significant decrease in neck/shoulder pain intensity.	No significant differences between I1 and I2 in pain intensity, tenderness and muscle strength. Both groups showed significant improvement over control group in all 3 outcomes.	Strength training had a positive effect on pain, tenderness and muscle strength. No significant difference between 2-min and 12-min training.	10 weeks
				Tenderness	I1: Significant decrease in neck/shoulder tenderness.	I2: Significant decrease in neck/shoulder tenderness.			
				Muscle strength	I1: Significant increase in muscle strength.	I2: Significant increase in muscle strength.			
Andersen, C: 2011, 2014	I=Shoulder function exercises C=Advised to stay physically active	Instructors	3 x 20-minute sessions per week for 10 weeks	Pain	I: Pain intensity decreased.	C: Slight increase in pain intensity.	Significant BG difference in pain intensity, in favour of I group.	Shoulder function exercises had a positive effect on pain and shoulder elevation strength.	10 weeks
				Muscle strength	I: Shoulder elevation and scapula protraction strength increased.	C: Unclear - only BG differences reported.	Significant BG difference in shoulder elevation strength, in favour of I group. No significant BG difference in scapula protraction strength, tendency in favour of I group.		

Authors: year	Intervention description	Intervention provider	Frequency and duration of intervention	Main outcomes	Findings: Intervention group / I1 group	Findings: Control group/ I2 group	Findings: Between group comparisons	Conclusion	Length of observation
Camargo: 2009	I=Cryotherapy, stretching and strengthening exercises	Physiotherapist	Twice weekly for 8 weeks	Upper limb function (DASH)	I: Significant improvement in DASH overall and work module scores.	No C group.	Not applicable.	I group (Cryotherapy, stretching and strengthening exercises) showed positive results in terms of pain and upper limb function. No C group in study.	8 weeks
				Pain (McGill Pain Questionnaire)	I: Significant decrease in pain intensity.				
Hagberg: 2000	I1=Isometric shoulder endurance training I2=Isometric shoulder strength training	Physiotherapists and home program	3 times per week for 12 weeks	Pain (VAS)	I1: Decrease in pain intensity.	I2: Decrease in pain intensity.	No significant BG differences.	Isometric shoulder endurance and shoulder strength exercises had a positive effect on pain, muscle strength and endurance. No significant difference between endurance and strength training. No control group.	24 weeks
				Muscle strength	I1: Significant increase in shoulder muscle strength. No significant effect on grip strength.	I2: Significant increase in shoulder muscle strength. No significant effect on grip strength.	No significant BG differences.		
				Endurance	I1: Significant improvement in shoulder forward flexion endurance.	I2: Significant improvement in shoulder forward flexion endurance.	No significant BG differences.		
Jay: 2014	Elastic tubing exercises I1=4 short instructional videos with audio and written instructions with pictures I2=As above + option to attend personalised instruction sessions as needed.	Trainer	I2: Up to 10 minutes, 5 days per week	Errors in exercise execution	Not applicable.	Not applicable.	No significant BG differences in ¾ exercises. Higher error score in I1 for unilateral shoulder external rotation.	Video-based instruction and personalised instruction resulted in similar performance of exercises and similar pain improvement.	2 weeks
				Pain	I1: Decrease in pain intensity at 2 weeks.	I2: Decrease in pain intensity at 2 weeks.	No significant BG differences.		
Sundstrup: 2013, 2014, 2014, 2016; Andersen: 2017	I=Strength training C=Participatory ergonomics	I=Training instructor C=Ergonomists	I=3 x 10 minutes per week	Pain (VAS)	I: Decrease in pain intensity at 10 weeks.	C: Decrease in pain intensity at 10 weeks.	Significant BG difference in pain intensity, in favour of I group.	Strength training was more effective than ergonomic training at reducing pain and work disability, increasing muscle strength and maintaining work ability. No significant impact on mental health, with moderate positive effect on vitality and social climate.	10 weeks
				Work disability (DASH work module)	I: Work disability reduced at 10 weeks.	C: Work disability increased at 10 weeks.	Significant BG difference in work disability, in favour of I group.		
				Muscle strength	I: Shoulder rotation and wrist extension strength increased at 10 weeks.	C: Shoulder rotation and wrist extension strength decreased at 10 weeks.	Significant BG difference in muscle strength, in favour of I group.		
				Work ability index (WAI)	I: No significant change in WAI at 10 weeks.	C: Significant decrease in WAI at 10 weeks.	Significant BG difference in work ability, in favour of I group.		
				Mental health (SF-36)	I: Decline in mental health at 10 weeks.	C: Improvement in mental health at 10 weeks.	No significant BG differences.		
				Social climate (QPS Nordic)	I: Social climate improved at 10 weeks	C: Social climate deteriorated at 10 weeks.	Significant BG difference in favour of I group, moderate effect size.		
				Vitality (SF-36)	I: Vitality improved at 10 weeks	C: Vitality decreased at 10 weeks.	Significant BG difference in favour of I group, moderate effect size.		

Authors: year	Intervention description	Intervention provider	Frequency and duration of intervention	Main outcomes	Findings: Intervention group / I1 group	Findings: Control group/ I2 group	Findings: Between group comparisons	Conclusion	Length of observation
Clinic-based VS Workplace-based Work hardening									
Cheng: 2007	I=Workplace-based work hardening training C=Clinic-based work hardening training	Unclear	3 sessions per week for 4 weeks	Self-perceived shoulder pain and disability (SPADI)	I: Decrease in SPADI at 4 weeks.	C: Decrease in SPADI at 4 weeks.	Significant BG difference in SPADI, in favour of I group.	Workplace-based work hardening had a significantly higher positive effect on shoulder pain and disability, FCE and return to work.	4 weeks
				FCE	I: Improvement in FCE at 4 weeks.	C: Improvement in FCE at 4 weeks	Significant BG differences in shoulder flexion, arm lifting force, high-near lifting force, carrying force, overhead tolerance; in favour of I group.		
				Return to work	I: 72% of workers returned to normal or modified duties.	C: 38% of workers returned to normal or modified duties.	Significant BG difference in favour of I group.		
Nurse case manager training									
Lincoln: 2002	I=Training program for nurse case managers on ergonomic assessment, worksite accommodations and problem-solving. C=Usual care – Nurse case managers without the additional ergonomic training	Unclear	I=Once-off training for 2 days, training manual, option to contact instructors for further support	Recommended accommodations	I: Variety in type of accommodations recommended (workstation layout, computer -related improvements, furnishings, accessories, lifting/carrying aids).	C: Mostly administrative accommodations recommended (lifting restrictions, modified or light duty, increased work breaks).	Significant BG differences number and type of accommodations recommended and implemented, in favour of I group. Implementation rates similar between groups.	Trained nurses had more accommodations recommended and implemented.	Observed until completion of case management (varying time periods)
Physiotherapy VS Feldenkrais									
Lundblad: 1999	I1=Group-based physiotherapy I2=Group-based and individual Feldenkrais C=No intervention	I1=Physiotherapists I2=Unclear	I1=50 minutes twice weekly for 16 weeks. I2=50 minutes per week: 4 individual and 12 group sessions	Symptoms: Neck complaints Shoulder complaints Neck Index Shoulder Index Neck-Shoulder Index Usual pain Worst pain	I1: No significant changes in any symptom-outcomes.	I2: Significant improvements in neck complaints, shoulder complaints, Neck-Shoulder Index and usual pain intensity. No significant change in Neck Index, shoulder index and worst pain.	Significant differences between I1 and I2 in Neck Index, Neck-Shoulder Index, in favour of I2. Significant decrease in usual pain in I2 and C groups, most pronounced in I2 group.	Feldenkrais had a positive effect on neck complaints, neck-shoulder complaints and usual pain intensity. Physiotherapy had no significant effect.	12 months
				Disability	I1: No significant changes in sick leave (tendency to decrease) or disability during work.	I2: No significant changes in sick leave of disability during work (both showed tendency to decrease).	No significant BG differences. I2 showed a tendency to decrease and C showed a tendency to increase sick leave.		
Ambulant Myofeedback Training									
Voerman: 2007	I=Ambulant myofeedback training and ergonomic training C=Ergonomic training only	Physiotherapist and health scientists	I=8 hours per week for 4 weeks, plus weekly visits by therapist C=4 weekly visits by therapist	Pain (VAS)	I: Significant decrease in neck/shoulder pain intensity.	C: Significant decrease in neck/shoulder pain intensity.	No significant BG differences.	Both ergonomic counselling and ambulant myofeedback had positive effects on pain and disability. No significant differences in effects between the interventions.	6 months
				Pain disability index	I: Significant decrease in disability levels.	C: Significant decrease in disability levels.	No significant BG differences.		

I=Intervention group, C=Control group, BG=Between Group, MS=Musculoskeletal, RULA=Rapid Upper Limb Assessment, HAL=Hand Activity Level, UE=Upper extremity, SSS=Symptom Severity Scale, FSS=Functional Status Scale, SS=Statistically significant, APB=Abductor Pollicis Brevis, NMQ=Nordic Musculoskeletal Questionnaire, VAS=Visual Analogue Scale, UEFS=Upper Extremity Functional Scale, UED=Upper extremity disorders. DASH=Disabilities of the Arm, Shoulder and Hand questionnaire, PRT=Progressive Resistance Training, RPE=Rating of Perceived Exertion, WAI=Work Ability Index, SPADI=Shoulder Pain and Disability Index, QPS Nordic – General Nordic Questionnaire for psychological and social factors at work, FCE=Functional Capacity Evaluation, ROM=Range Of Motion

Ergonomic controls

The ergonomic controls investigated included a non-traditional mouse, which uses a more neutral wrist and forearm position [33-35]; an adjustable keyboard-mouse tray with a touch pad in the non-dominant hand [29]; and reduced-force keyboards [40]. One of these studies was rated as high quality [29], and the remaining two studies were of medium methodological quality [33-35,40]. Results of the Aaras study [33-35], which assessed outcomes at 6 months, 12 months and 36 months, suggest that use of a mouse enabling more neutral forearm and wrist position compared with a standard mouse may reduce pain, headache and musculoskeletal-related sick leave. The Dropkin study [29], which was of high quality, found that while some ergonomic postures improved with the intervention, hand activity in the distal non-dominant arm increased, possibly due to the 11 functions of the touch pad. The Ripat study [40] results were complicated by the use of a Microsoft Naturals keyboard in both intervention and control groups, while the intervention group's keyboards were adapted to also reduce activation force. Improvements were seen in symptom severity and functional status of both groups, with no significant between-group differences.

Ergonomic training and Workstation adjustments

Four studies were included in this category, of which two were high quality [27,28,30] and two medium quality [37,39,41]. Workstation adjustments were conducted by physiotherapists in two of the studies [37,39,41]. Alternately, interventions were offered by occupational health nurses, rehabilitation engineers and counsellors [27,28,30]. The Feuerstein study [30], which was of high quality, offered workstation adjustment to the control group as well, and found that improvement in outcomes were seen in both groups, with no significant between-group differences. Similarly, the high quality Bernaards [27,28] study offered the same work style behaviour counselling to two intervention groups, while the second intervention group also received physical activity counselling. Both intervention groups showed significant improvements over a control group, which received usual care, but direct comparisons between the two intervention groups were not reported. The Esmaeilzadeh study [37], which offered no control intervention, found that ergonomic postures and musculoskeletal symptoms improved significantly more in the intervention group than the control group. The Martimo/Shiri study found that productivity loss was significantly lower in the intervention compared to the control group [39,41].

Exercise / Resistance training

This was the largest intervention category, with six studies included across 13 articles. Four of these studies were high quality [16-25,31], with one medium quality study [38] and one low quality study (no control group) [43]. Three of the studies offered the intervention through physiotherapists [18-20,38,43], and in the remaining three studies the intervention providers were described as trainers or instructors [16,17,21-25,31]. Results of all studies were positive, with improvements seen in pain [16-25,31,38,43], strength [16-25,38], functional ability [21-25,43], work ability [21-25,43], absenteeism [38] and medication use [38] in intervention groups. The Andersen/Lidegaard study [16-18] found that as little as two minutes of resistance training five times per week had a marked positive impact on pain, tenderness and muscle strength. Jay et al [31] assessed errors in exercise execution between an intervention group using video-based training and a control group using personalised instruction, and found that the two groups had similar error scores, training frequency and pain improvements.

Clinic-based Vs Workplace-based Work hardening

The Cheng study [36], based in Hong Kong, investigated the effect of a workplace-based work hardening program on workers with work-related rotator cuff tendonitis. This was a medium quality study. A job coach contacted the worksites to arrange for the workers' actual work tasks to be used as treatment media. A control group of conventional clinic-based work hardening was used. It was found that the intervention group had significantly higher improvements on the functional capacity evaluation, lower Shoulder Pain and Disability Index (SPADI) scores, and a higher percentage of the group successfully returned to work.

Nurse case manager training

An RCT of medium quality, based in the USA, involved training randomly selected nurse case managers in Integrated Case Management for two days [42]. The training program included ergonomic assessment, worksite accommodations and problem-solving. The nurses' approach to case managing workers with WRUEDs was then compared with usual care (nurses who had not undergone the specialised training) in the same population. The intervention group was found to make more recommendations, with more variety in the types of accommodations recommended, compared with the control group. Trained nurses also had a higher number of accommodations implemented, although implementation rates were the same between intervention and control groups.

Physiotherapy Vs Feldenkrais

One high quality study investigated the difference between group-based physiotherapy and Feldenkrais interventions amongst female industrial workers at an automotive factory with neck/shoulder complaints [32]. Interventions took the form of 50-minute weekly sessions for 16 weeks. Feldenkrais interventions aimed to increase sensory awareness, investigate common movement and postural patterns, break stereotyped movement patterns, and enable self-care for neck, shoulder and back complaints through guided movement sequences [32]. Physiotherapy sessions aimed to increase knowledge of body and pain, learn back stabilising exercises and improve postural awareness by practicing work-related lift and movement techniques in a group exercise program. The Feldenkrais group showed a significant decrease in neck/shoulder complaints, compared with the physiotherapy and control groups, while no significant changes were found in any outcomes in the physiotherapy group.

Ambulant Myofeedback training

Voerman et al [26], in a high quality study, investigated the effect of a myofeedback system with harness worn by participants for 4 weeks. The device assessed and recorded muscle activity in the upper trapezius, and provided sound and vibration feedback to participants at intervals, prompting them to relax. Both intervention and control groups also received ergonomic counselling, with weekly visits from their therapists. Both groups experienced significant improvements in pain and disability, with no significant difference between groups.

Discussion

This systematic review aimed to determine the effectiveness of workplace-based rehabilitative interventions in workers with upper limb conditions on work performance, pain, absenteeism, productivity and other outcomes. Twenty-eight suitable articles were found, which were grouped into 17 studies and seven intervention categories (see Table 3). The largest body of evidence was found to support workplace exercise programs, of which four out of six were high quality studies. Positive effects were also found for use of ergonomic controls, ergonomic training and workstation adjustments, although these intervention categories had fewer high quality studies. The remaining intervention categories (work hardening, myofeedback training, Feldenkrais, nurse case manager training) only had one study each. While results of three of these studies were encouraging, with interventions showing significant positive effects, recommendations for practice should be made with caution as there are only one medium or high quality study per intervention.

Four high quality studies [16-25,31], one medium quality study [38] and one low quality study [43] supported workplace exercise programs. The research suggests that these programs may be effective whether including strength or endurance training programs [38], using as little as two minutes of regular exercise [16-18], or basing them on high quality video instruction rather than a personalised trainer [31]. In the case of ergonomic controls, it is difficult to draw conclusions. Studies finding that an adapted mouse (Anir mouse) significantly reduced pain, headaches and musculoskeletal sick leave at 6 months and were maintained at 12 and 36 months, were of medium quality [33-35]; while keyboard adjustments and shortcuts had mixed results [29,40]. The two high quality studies on workstation adjustments [27,28,30] offered ergonomic training or workstation adjustment to both intervention groups, although the Bernaards study [27,28] also included a control group which received usual care. In the Feuerstein study [30], both intervention groups showed significant improvements, but there were no significant between group differences. Inclusion of a third (control) group that did not receive any workstation adjustment or ergonomic training, as in the Bernaards study [27,28], may have more clearly highlighted the effects of the intervention. The remaining two studies on workstation adjustment and ergonomic training [37,39,41] found statistically significant improvements in use of breaks and some elements of body posture, as well as productivity loss at work.

The Cheng study [36] supports work hardening that has a workplace-based component, rather than clinic-based work hardening. While the workplace-based group showed significantly better outcomes than the clinic-based group, the authors cautioned that the process of change is not well understood: the improvements in intervention group could be due to a number of factors, including the presence of the job coach or the provision of modified work duties. Further study in smaller organisations and considering longer term effects was recommended.

Feldenkrais was found to be more effective than physiotherapy in the Lundblad study [32]. The authors postulated that this could be because Feldenkrais has a stronger focus on participants' perceptions and experiences than physiotherapy, and that Feldenkrais has some features in common with relaxation and biofeedback techniques, which have been found to be effective at reducing pain [32].

In the Voerman study [26], the ambulant myofeedback training group did not have significantly different outcomes to the control group. The researchers attributed this to the presence of subgroups in which the intervention was more beneficial (e.g. workers with certain cognitive-behavioural characteristics), the use of too generic outcomes (pain and disability were used instead of outcomes related to the specific working mechanisms of the intervention), and the low initial pain and disability levels, resulting in a smaller potential for improvement.

As expected, the present review identified more relevant studies than the 2004 review on workplace-based rehabilitative interventions with work related upper extremity disorders [4], which included eight studies. Intervention categories were similar across the two reviews. The Williams review [4] concluded that there was insufficient evidence to identify and make recommendations regarding effective workplace-based rehabilitative interventions for upper limb conditions. Our conclusions regarding the one study common to both reviews [42] are similar, but we are able to make more recommendations regarding workplace exercise, ergonomic controls and adjustments due to research published subsequent to the 2004 review.

Six studies [26,30,32,34,40,41] included in our review were also included in the reviews on preventative workplace interventions with upper limb conditions [2,11], as these reviews included secondary and tertiary preventative interventions which also qualify as rehabilitative interventions. Quality assessment and data extraction matched between the reviews. One more study [36] was also included in a recent IWH review on workplace-based return-to-work interventions for musculoskeletal, pain-related and mental health conditions [44]. The authors of this review similarly concluded that there was insufficient evidence to draw conclusions and make recommendations regarding the effectiveness of work hardening programs, as too few high and medium quality studies with positive results were available.

Strengths and Limitations of this review

A meta-analysis could not be conducted in this review, due to the heterogeneity of outcomes. This is consistent with other reviews in the field [2,4,11,44]. Instead, a critical analysis and narrative synthesis was provided, in order to provide practitioners with the opportunity to draw from studies most relevant to their needs, at varying levels of evidence.

The quality appraisal of studies was optimised through inclusion of all articles related to the studies, e.g. study protocols. This enabled access to all published information on the study methodology, which is not always available in articles reporting primary outcomes.

Publication bias was not addressed, as grey literature was not included. This means that studies with positive results were more likely to be included in our review. We attempted to be as inclusive as possible by seeking expert advice, utilising a wide range of search terms and including multiple databases in our literature search. We also included all languages in our initial search, only excluding one article at full text review stage due to difficulty translating. In spite of this, our search did not yield all of the studies expected. Notably, seven of the eight studies included in the Williams review [4] were not retrieved in our literature search, despite using more databases, a wider inclusion criteria (all upper limb conditions were included, rather than only WRUEDs) and searching the reference lists of included articles for further studies. One of the databases used in the Williams review (EMBASE) could not be included in our review, as we did not have access to this database through the library service of Stellenbosch University. It may also be related to changes in database content and MeSH terms over time, differences in use of Boolean operators between the two reviews or the structure of our search strategy. It is thus possible that not all relevant studies were found in our review.

Recommendations for future research

Several of the included studies showed positive effects with no significant between-group results, likely due to insufficient difference between intervention and control group. It is recommended that when two differing interventions are studied, an additional control group is included, which may be more likely to highlight intervention effects.

Quality appraisal of included studies was hampered by unclear reporting or inadequate statistical analyses. Future studies should clearly report on the details of and participation in intervention, examine and adjust for pre-intervention differences, examine for differences between dropout and remaining participants, perform intention-to-treat analyses, and always perform direct between-group comparisons. It is also recommended that a follow-up assessment after 3 months or more is included in the study, to assess long term effects of the intervention. These factors will reduce the risk of bias in individual studies and enable clearer interpretation of results.

Most studies included pain as an outcome, assessed through the Visual Analogue Scale (VAS). More standardised reporting may have enabled meta-analyses in different categories of intervention. The continued use of outcome measures such as the VAS, DASH, UEFS and RULA is encouraged, to ensure valid and reliable data and improve the potential for homogeneity between studies.

In future studies, researchers should pre-determine the minimum effect size that would demonstrate clinical significance for participants, as statistical significance is not necessarily indicative of clinical significance [45].

Recommendations for practice

The use of workplace exercise programs in rehabilitation of upper limb conditions is well supported by the evidence. Clinicians may consider implementing strength or endurance training programs of regular, short duration. Larger populations of workers may be reached through use of high quality instructional videos. Group programs appear to be effective at reducing upper limb symptoms and improving function.

Workstation adjustment and ergonomic training appear to be beneficial in reducing ergonomic risk, improving musculoskeletal symptoms and productivity. Job stress management training had no significant effect and is therefore not recommended.

Ergonomic controls vary significantly and should therefore be evaluated by their individual merit. An adapted computer mouse enabling more neutral wrist and forearm postures may be beneficial in reducing upper limb pain, headaches and musculoskeletal sick leave, with the effect maintained at 12 and 36 months. Adjustable keyboard/mouse trays and ergonomically adapted keyboards may be beneficial, but care should be taken to assess whether these adaptations shift hand activity or non-neutral postures to the non-dominant hand.

Workplace-based work hardening, case manager training and Feldenkrais should be implemented with caution, as only one study supported each of these interventions. Ambulant myofeedback training is not recommended.

Conclusions

High quality evidence was found in favour of workplace exercise programs in a variety of employment settings. Positive effects included reduced pain, increased muscle strength and endurance, maintenance of work ability, improved upper limb function and reduction in work disability. Mixed evidence was found for ergonomic controls: medium quality evidence with strong positive results for an adapted mouse using more neutral forearm and wrist positions; mixed results for an adjustable keyboard-mouse tray with touch pad in the non-dominant hand; and positive effects for Microsoft Naturals keyboards, with no significant improvement with use of reduced force keyboards. Workplace adjustments, ergonomic training and work style behaviour counselling also showed positive effects, while job stress management training had no significant additional effect. Positive effects were seen for workplace-based work hardening, Feldenkrais and case manager training, but more research needs to be conducted on these interventions. Ambulant myofeedback training had no significant effect compared with ergonomic training.

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Compliance with Ethical Standards

Funding

No funding was obtained for this study.

Conflict of interest

The authors declare that they have no conflict of interest.

Informed consent

This article does not contain any studies with human participants or animals performed by any of the authors.

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Chapter 3: Conclusion

Several systematic reviews have been conducted on workplace-based interventions for musculoskeletal conditions, but the current review is the first which specifically focuses on workplace-based rehabilitative interventions for all upper limb conditions.

The initial literature search yielded 1071 titles (see Addendum B for search strings and detailed results). After title and abstract screening, full text review, and scanning of included articles' reference lists, 17 studies were included, which were published across 28 articles. Quality appraisal of the studies was conducted using the IWH Risk of Bias tool. Nine studies were rated as high quality, seven as medium quality, and one as low quality (see Addendum C for rating scores). Studies were categorised by intervention, as follows:

1. Ergonomic controls (n=3);
2. Ergonomic training and workstation adjustments (n=4);
3. Exercise and resistance training (n=6);
4. Clinic-based vs workplace-based work hardening (n=1);
5. Nurse case manager training (n=1);
6. Physiotherapy vs Feldenkrais (n=1);
7. Ambulant myofeedback training (n=1).

Positive effects were found for workplace exercise and ergonomic training/workstation adjustments. Results were mixed for ergonomic controls. Ambulant myofeedback training showed no effect. The remaining three categories had positive effects, but only one study per category.

Similarly to other reviews, workplace exercise programs were found to have the largest body of high quality research supporting their value in improving upper limb musculoskeletal symptoms and work ability. It is important to note that this does not mean that workplace exercise programs are more effective than other rehabilitation programs, rather that they have been better researched. Research on group-based exercise programs may be inherently easier to conduct than more individualised workplace interventions, such as reasonable accommodations, workstation and job task adjustments, splinting, job rotation and alternate placement, where participant numbers will be lower. In addition, all four of the high quality studies on workplace exercise programs were conducted by researchers from the National Research Centre for the Working Environment in Copenhagen, Denmark, who are likely to have resources and support aiding them in conducting high quality research.

Interestingly, only one of the included studies was clearly designed by occupational therapists [13], while several of the intervention programs were conducted by physiotherapists [14-22]. Furthermore, 15 of the 17 included studies were conducted in high income countries, while only two studies were conducted in upper middle income countries similar to South Africa (Turkey and Brazil) [18,19]. This raises several questions:

1. Are physiotherapists more likely to be employed in occupational health settings than occupational therapists? One study referred to physiotherapists in the Finnish occupational health services receiving advanced training in occupational health and ergonomics [20].
2. If this is the case, is it prevalent in Northern European or high income countries only? The only study designed by occupational therapists was conducted in Hong Kong [13].
3. Are occupational therapists as active in occupational health care but less likely to conduct and publish research?

Providing answers to these questions is beyond the scope of this study, but certainly does give food for thought, and brings to mind recommendations for future research:

1. Research institutions should endeavour towards diversity in staff, employing rehabilitation professionals with a variety of areas of expertise. This will aid in reducing bias in the types of research conducted and published.

2. Researchers at research institutions and universities should build partnerships with clinicians in practice, to assist in designing and publishing more high quality research in “real-life” rehabilitation contexts.
3. More research needs to be conducted on individualised rehabilitation. Study protocols could potentially be designed by professional interest groups, such as OTOH (Occupational Therapy in Occupational Health) or WPG (Work Practice Group) in South Africa, in order to collate data from several practitioners or institutions.
4. The gap between research in high income and middle to low income countries needs to be addressed, although this is a difficult problem to overcome, as high income countries would inevitably have more resources for conducting and publishing research. Partnerships through international organisations such as the World Federation of Occupational Therapy (WFOT), the International Labour Office (ILO) or the World Health Organisation (WHO) may be beneficial to this end.

Issues were raised in the introduction of this report, related to the development of workplace-based rehabilitation services in South Africa. The results of the current systematic review, while more relevant to high income countries, do suggest the following recommendations for practice:

1. Collaboration with the Department of Labour to build health resources for work environments, such as those described in the Lincoln study [23], is encouraged. It is acknowledged that this is not without challenges in the South African context, but this process is critical to bridging the gap between legislation and practice.
2. Several of the interventions were conducted in partnership with workers or workplace supervisors [20,23]. This aligns with occupational therapy values, and should be included in design of future programs.
3. Workplace-based rehabilitation programs should consider including an exercise / resistance training component, possibly through collaboration with physiotherapists.

4. Programs should be designed with anticipated outcomes in mind. Ergonomic controls or training may be more suitable in work environments or with workers requiring reduction in ergonomic risk, while strengthening programs may be more suitable if considerable muscle strength is an inherent requirement of the job.
5. Practitioners should take care to select and use appropriate outcome measures to document the outcomes of interventions, considering the psychometric properties of these measures, particularly as these apply to the South African context.
6. Long term follow-up should be included in rehabilitation programs, in order to determine lasting effects of intervention. Reassessment of outcomes at three to six months after cessation of intervention is recommended.

Recommendations for education:

1. Undergraduate curricula should include training on international and South African legislation and policies related to work disability and rehabilitation, along with exposure to current practices in workplace-based rehabilitation by occupational therapists and other practitioners.
2. Postgraduate training should include education on the setup and provision of workplace-based rehabilitation services; collaboration with key role players such as managers and supervisors, as well as other occupational health staff; addressing challenges specific to the workplace; selecting workplace-specific, responsive outcomes; development of evidence based intervention programs suitable to the workplace; and collection of suitable data for future research.

Workplace-based rehabilitation is a growing field of practice for occupational therapists and other practitioners. It is well supported by legislation. There is a clear need for intervention specific to upper limb conditions in the workplace. While challenges persist in the provision of work rehabilitation services in South Africa, It is hoped that the findings and recommendations of this study will assist in the application of evidence based practice in this area.

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Addendum A: Journal Guidelines

Journal of Occupational Rehabilitation: Instructions for Authors

TYPES OF PAPERS

Original Paper, Review, Editorial, Introduction, Book review, Brief communication, News, Report, erratum, etc.

EDITORIAL PROCEDURE

Single-blind peer review

This journal follows a single-blind reviewing procedure. Authors are therefore requested to submit a title page, containing title, all author names, affiliations, and the contact information of the corresponding author. Any acknowledgements, disclosures, or funding information should also be included on this page.

MANUSCRIPT SUBMISSION

Manuscript Submission

Submission of a manuscript implies: that the work described has not been published before; that it is not under consideration for publication anywhere else; that its publication has been approved by all co-authors, if any, as well as by the responsible authorities – tacitly or explicitly – at the institute where the work has been carried out. The publisher will not be held legally responsible should there be any claims for compensation.

Permissions

Authors wishing to include figures, tables, or text passages that have already been published elsewhere are required to obtain permission from the copyright owner(s) for both the print and online format and to include evidence that such permission has been granted when submitting their papers. Any material received without such evidence will be assumed to originate from the authors.

Online Submission

Please follow the hyperlink “Submit online” on the right and upload all of your manuscript files following the instructions given on the screen.

TITLE PAGE

The title page should include:

- The name(s) of the author(s)
- A concise and informative title
- The affiliation(s) and address(es) of the author(s)
- The e-mail address, telephone and fax numbers of the corresponding author

Abstract

Please provide a structured abstract of 150 to 250 words which should be divided into the following sections:

- Purpose (stating the main purposes and research question)
- Methods
- Results
- Conclusions

Keywords

Please provide up to 5 key words selected from the National Library of Medicine-Medical Subject Headings (http://www.nlm.nih.gov/MeSH/MBrowser.html).

TEXT

Text Formatting

Manuscripts should be submitted in Word.

- Use a normal, plain font (e.g., 10-point Times Roman) for text.

- Use italics for emphasis.
- Use the automatic page numbering function to number the pages.
- Do not use field functions.
- Use tab stops or other commands for indents, not the space bar.
- Use the table function, not spreadsheets, to make tables.
- Use the equation editor or MathType for equations.
- Save your file in docx format (Word 2007 or higher) or doc format (older Word versions).

Manuscripts with mathematical content can also be submitted in LaTeX.

- LaTeX macro package (zip, 182 kB)

Headings

Please use no more than three levels of displayed headings.

Abbreviations

Abbreviations should be defined at first mention and used consistently thereafter.

Footnotes

Footnotes can be used to give additional information, which may include the citation of a reference included in the reference list. They should not consist solely of a reference citation, and they should never include the bibliographic details of a reference. They should also not contain any figures or tables.

Footnotes to the text are numbered consecutively; those to tables should be indicated by superscript lower-case letters (or asterisks for significance values and other statistical data). Footnotes to the title or the authors of the article are not given reference symbols.

Always use footnotes instead of endnotes.

Acknowledgments

Acknowledgments of people, grants, funds, etc. should be placed in a separate section on the title page. The names of funding organizations should be written in full.

As a guide, manuscripts should not normally exceed 5000 words (excluding references and abstract) or have more than 5 tables or figures or more than 50 references (more references may be allowable for systematic reviews)."

Manuscripts are typically 15-20 double-spaced typed pages. Table and figures should be limited to 3-4 total. If you think your article will be significantly shorter or longer than that average, please include an explanation along with your submission.

SCIENTIFIC STYLE

- Please always use internationally accepted signs and symbols for units (SI units).
- Nomenclature: Insofar as possible, authors should use systematic names similar to those used by Chemical Abstract Service or IUPAC.
- Genus and species names should be in italics.
- Generic names of drugs and pesticides are preferred; if trade names are used, the generic name should be given at first mention.
- Please use the standard mathematical notation for formulae, symbols, etc.:
  - Italic for single letters that denote mathematical constants, variables, and unknown quantities
  - Roman/upright for numerals, operators, and punctuation, and commonly defined functions or abbreviations, e.g., cos, det, e or exp, lim, log, max, min, sin, tan, d (for derivative)
  - Bold for vectors, tensors, and matrices.

Statistical software: Include the name of the manufacturer along with the manufacturer's location after first appearance in text.

REFERENCES

Citation

Reference citations in the text should be identified by numbers in square brackets. Some examples:

1. Negotiation research spans many disciplines [3].

2. This result was later contradicted by Becker and Seligman [5].

3. This effect has been widely studied [1-3, 7].

Reference list

The list of references should only include works that are cited in the text and that have been published or accepted for publication. Personal communications and unpublished works should only be mentioned in the text. Translate all non-English titles into English. Do not use footnotes or endnotes as a substitute for a reference list.

The entries in the list should be numbered consecutively to follow the order of citations in the text.

Journal article

Smith JJ. The world of science. Am J Sci. 1999;36(4):234–235.

Article by DOI

Slifka MK, Whitton JL. Clinical implications of dysregulated cytokine production. J Mol Med. 2000; doi:10.1007/s001090000086

Book

Blenkinsopp A, Paxton P. Symptoms in the pharmacy: a guide to the management of common illness. 3rd ed. Oxford: Blackwell Science; 1998.

Book chapter

Wyllie AH, Kerr JFR, Currie AR. Cell death: the significance of apoptosis. In: Bourne GH, Danielli JF, Jeon KW, editors. International review of cytology. London: Academic; 1980. pp. 251–306.

Online document

Doe J. Title of subordinate document. In: The dictionary of substances and their effects. Royal Society of Chemistry. 1999. http://www.rsc.org/dose/title of subordinate document. Accessed 15 Jan 1999.

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- Name your figure files with "Fig" and the figure number, e.g., Fig1.eps.

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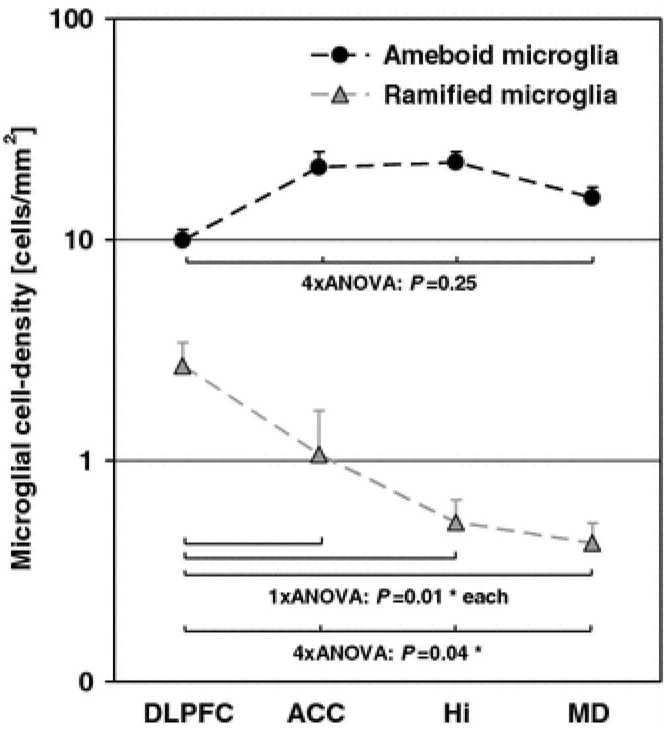

- Definition: Black and white graphic with no shading.
- Do not use faint lines and/or lettering and check that all lines and lettering within the figures are legible at final size.
- All lines should be at least 0.1 mm (0.3 pt) wide.
- Scanned line drawings and line drawings in bitmap format should have a minimum resolution of 1200 dpi.
- Vector graphics containing fonts must have the fonts embedded in the files.

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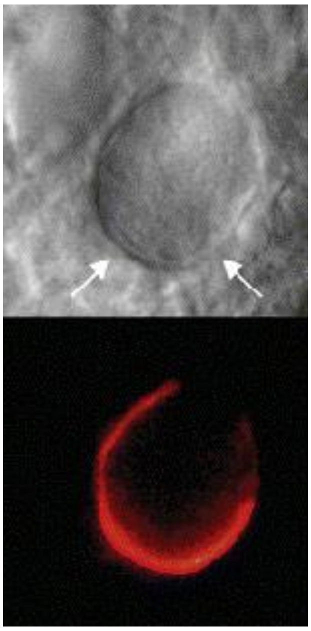

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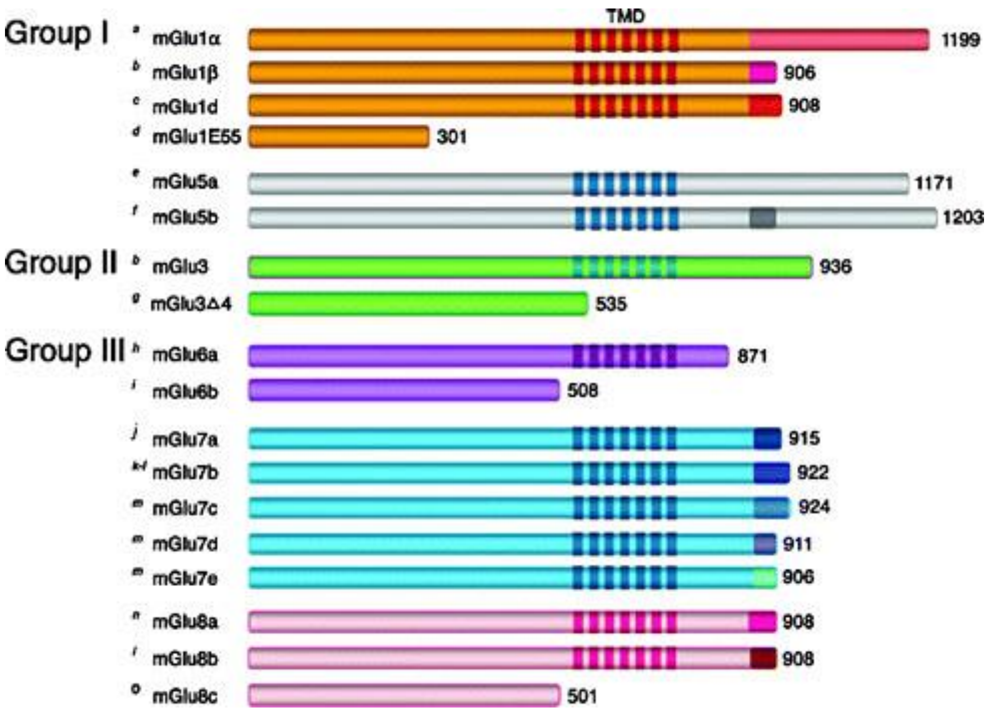

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- Color art is free of charge for online publication.
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Addendum B: Search Strategy

Medline (PubMed)

Date searched: 29 March 2017

Results: 272 titles

Search terms:

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AND

("Occupational Therapy"[MeSH] OR "Physical Therapy Modalities/education"[MeSH] OR "Physical Therapy Modalities/rehabilitation"[MeSH] OR "Physical Therapy Modalities/therapy"[MeSH] OR "Human Engineering/therapeutic use"[MeSH] OR "Exercise Therapy"[MeSH] OR "Employment, Supported"[MeSH] OR "Rehabilitation, Vocational"[MeSH] OR stretching[All Fields] OR "rest break*"[All Fields] OR "workstation adjustment*"[All Fields] OR "reasonable accommodation*"[All Fields] OR "modified work"[All Fields] OR "modified job*"[All Fields]))

AND

("Workplace"[MeSH] OR "Industry"[MeSH] OR "Occupational Health"[MeSH] OR "Employment"[MeSH] OR employer[All Fields] OR factory[All Fields] OR factories[All Fields] OR ("Office"[Journal] OR "office"[All Fields]) OR company[All Fields] OR companies[All Fields] OR onsite[All Fields] OR employee[All Fields] OR worker[All Fields] OR ("manpower"[Subheading] OR "manpower"[All Fields] OR "workers"[All Fields]))

AND

("clinical trial*" OR "randomized controlled trial*" OR "random allocation" OR placebo* OR "random research" OR comparative OR “evaluation stud*” OR "follow up" OR "prospective*" OR "cohort" OR "control*" OR “case series” OR “cross-sectional” OR “experimental stud*” OR "single mask*" OR "double mask*" OR "treble mask*" OR "triple mask*" OR "single-blind*" OR "double-blind*" OR "treble blind*" OR "triple blind*" OR RCT*)

OTSeeker

Date searched: 29 March 2017

Results: 172 titles

Search terms:

(“upper extremity” OR “upper limb” OR arm OR axilla OR forearm OR hand or finger OR wrist OR elbow OR shoulder OR “cumulative trauma disorder*” OR “repetitive strain injur*” OR “compression neuropathy” OR “carpal tunnel” OR “trigger finger” OR “tenosynovitis” OR “tendonitis” OR “tendon injury*” OR “tendinopathy” OR “lateral epicondylitis” OR “tennis elbow” OR “rotator cuff” OR “arthritis” OR “soft tissue injur*” OR “cubital tunnel syndrome” OR ganglion cyst OR neuralgia OR neuritis OR bursitis OR arthralgia OR “musculoskeletal” OR “radiculopathy” OR “synovitis”)

AND

(“vocational rehabilitation” OR rehabilitation” OR “work hardening” OR “intervention*” OR “occupational therapy” OR “physiotherap*” OR “physical therap*” OR “ergonomic*” OR “wellness” OR “exercise” OR “stretching” OR “rest breaks” OR “workstation adjustment*” OR “reasonable accommodation*” OR “education” OR “training” OR “supported employment” OR “job rotation” OR “splint*” OR “modified work” OR “modified job*” OR “arm support” OR “wrist guard*”)

AND

(worksite OR workplace OR employer OR industry OR factory OR factories OR office OR company OR “occupational health” OR employment OR onsite OR employee OR worker OR workers)

EBSCOhost

Date searched: 29 March 2017

Databases included: Africa-Wide, Academic Search Premier, CINAHL

Results: 97 titles

Limiters applied:

- Boolean phrase
- Peer-reviewed journals only
- Human only, all adults (CINAHL only)

Search terms:

(“upper extremity” OR “upper limb” OR arm OR axilla OR forearm OR hand or finger OR wrist OR elbow OR shoulder OR “cumulative trauma disorder*” OR “repetitive strain injur*” OR “compression neuropathy” OR “carpal tunnel” OR “trigger finger” OR “tenosynovitis” OR “tendonitis” OR “tendon injury*” OR “tendinopathy” OR “lateral epicondylitis” OR “tennis elbow” OR “rotator cuff” OR “arthritis” OR “soft tissue injur*” OR “cubital tunnel syndrome” OR ganglion cyst OR neuralgia OR neuritis OR bursitis OR arthralgia OR “musculoskeletal” OR “radiculopathy” OR “synovitis”)

AND

(“vocational rehabilitation” OR rehabilitation OR “work hardening” OR intervention* OR “occupational therapy” OR physiotherap OR “physical therap*” OR ergonomic* OR “wellness” OR “exercise” OR “stretching” OR “rest breaks” OR “workstation adjustment*” OR “reasonable accommodation*” OR “education” OR “training” OR “supported employment” OR “job rotation” OR “splint*” OR “modified work” OR “modified job*” OR “arm support” OR “wrist guard*”)

AND

(worksite OR workplace OR employer OR industry OR factory OR factories OR office OR company OR “occupational health” OR employment OR onsite OR employee OR worker OR workers)

AND

("clinical trial*" OR "randomized controlled trial*" OR "random allocation" OR placebo* OR "random research" OR comparative OR “evaluation stud*” OR "follow up" OR "prospective*" OR "cohort" OR "control*" OR “case series” OR “cross-sectional” OR “experimental stud*” OR "single mask*" OR "double mask*" OR "treble mask*" OR "triple mask*" OR "single-blind*" OR "double-blind*" OR "treble blind*" OR "triple blind*" OR RCT*)

Cochrane Library

Date searched: 31 March 2017

Results: 50 titles

Search terms:

1. MeSH descriptor: [Upper Extremity] explode all trees
2. MeSH descriptor [Cumulative Trauma Disorders] explode all trees
3. MeSH descriptor [Hand Deformities] explode all trees
4. MeSH descriptor: [Joint Diseases] explode all trees
5. MeSH descriptor [Muscular Diseases] 1 tree(s) exploded
6. MeSH descriptor [Tennis Elbow] explode all trees
7. MeSH descriptor: [Rheumatic Diseases] this term only

AND

8. MeSH descriptor [Occupational Therapy] explode all trees
9. MeSH descriptor [Physical Therapy Modalities] explode all trees
10. MeSH descriptor: [Human Engineering] explode all trees
11. MeSH descriptor: [Employment, Supported] explode all trees

AND

12. MeSH descriptor [Workplace] this term only
13. MeSH descriptor [Industry] explode all trees
14. MeSH descriptor: [Occupational Health] explode all trees
15. MeSH descriptor: [Workers' Compensation] this term only

Web of Science

Date searched: 24 April 2017

Results: 50 titles

Limiters applied: Articles only

Search terms:

(TI=("upper extremity" OR "upper limb" OR arm OR axilla OR forearm OR hand or finger OR wrist OR elbow OR shoulder OR "cumulative trauma disorder*" OR "repetitive strain injur*" OR "compression neuropathy" OR "carpal tunnel" OR "trigger finger" OR "tenosynovitis" OR "tendonitis" OR "tendon injury*" OR "tendinopathy" OR "lateral epicondylitis" OR "tennis elbow" OR "rotator cuff" OR "arthritis" OR "soft tissue injur*" OR "cubital tunnel syndrome" OR ganglion cyst OR neuralgia OR neuritis OR bursitis OR arthralgia OR "musculoskeletal" OR "radiculopathy" OR "synovitis")

AND

TI=("vocational rehabilitation" OR rehabilitation OR "work hardening" OR intervention* OR "occupational therapy" OR physiotherap OR "physical therap*" OR ergonomic* OR wellness OR exercise OR stretching OR "rest breaks" OR "workstation adjustment*" OR "reasonable accommodation*" OR education OR training OR "supported employment" OR "job rotation" OR splint* OR "modified work" OR "modified job*" OR "arm support" OR "wrist guard*")

AND

TI=(worksite OR workplace OR employer OR industry OR factory OR factories OR office OR company OR "occupational health" OR employment OR onsite OR employee OR worker OR workers)

AND

TI=("clinical trial*" OR "randomized controlled trial*" OR "random allocation" OR placebo* OR "random research" OR comparative OR “evaluation stud*” OR "follow up" OR "prospective*" OR "cohort" OR "control*" OR “case series” OR “cross-sectional” OR “experimental stud*” OR "single mask*" OR "double mask*" OR "treble mask*" OR "triple mask*" OR "single-blind*" OR "double-blind*" OR "treble blind*" OR "triple blind*" OR RCT*)) *AND* **DOCUMENT TYPES:** (Article)

Scopus

Date searched: 25 April 2017

Results: 420 titles

Limiters applied: Articles only

Search terms:

TITLE-ABS ("upper extremity" OR "upper limb" OR arm OR axilla OR forearm OR hand OR finger OR wrist OR elbow OR shoulder OR "cumulative trauma disorder" OR repetitive strain injur" OR "compression neuropathy" OR "carpal tunnel" OR "trigger finger" OR tenosynovitis OR tendonitis OR "tendon injury*" OR tendinopathy OR "lateral epicondylitis" OR "tennis elbow" OR "rotator cuff" OR "soft tissue injur*" OR "cubital tunnel syndrome" OR ganglion OR cyst OR neuralgia OR neuritis OR bursitis OR musculoskeletal OR radiculopathy OR synovitis)*

AND

TITLE-ABS ("vocational rehabilitation" OR rehabilitation OR "work hardening" OR intervention OR "occupational therapy" OR physiotherapy* OR "physical therap*" OR ergonomic* OR wellness OR exercise OR stretching OR "rest breaks" or "workstation adjustment*" OR "reasonable accommodation*" Or education OR training OR "supported employment" OR "job rotation" OR splint* OR "modified work" OR "modified job*" Or "arm support" OR "wrist guard*")*

AND

TITLE-ABS (worksite OR workplace OR employer OR industry OR factory OR factories OR office OR company or "occupational health" OR employment OR onsite OR employee OR worker OR workers)

AND

TITLE-ABS ("clinical trial" OR "randomized controlled trial*" OR "random allocation” OR placebo* OR “random research” OR comparative OR “evaluation stud*” Or “follow up” OR prospective* OR cohort OR control* Or “case series” Or cross-sectional” OR “experimental stud*” Or “single mask*” OR “double mask*” Or “treble mask*” OR “triple mask*” OR “single-blind*” OR “double-blind*” OR “treble blind*” OR “triple blind*” OR rct*)*

AND (LIMIT-TO (SRCTYPE , "j ")) AND (LIMIT-TO (DOCTYPE , "ar "))

PEDro

Date searched: 28 April 2017

Results: 11 titles

Type of search: Simple search

Search terms:

Workplace (upper limb)

Addendum C: Quality appraisal table

	Research Question	Comparison group	Intervention Allocation	Recruitment rate reported	Pre-intervention characteristics	Loss to follow-up <35%	Differences between remaining & drop out	Intervention described for replication	Intervention on some exposure parameters documented	Participation in intervention	Upper extremity outcomes described at baseline & follow-up	Length of follow-up 3 months or greater	Adjustment for pre-intervention differences	Statistical analyses optimised	Intention-to-treat analysis	Direct between group comparison	Total quality score	Percentage quality score	Ranking
Criteria Code	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**			
Weight	**2**	**3**	**3**	**2**	**2**	**2**	**2**	**3**	**1**	**2**	**3**	**2**	**3**	**3**	**2**	**3**			
Max Score	**1**	**1**	**2**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**1**	**41**		
Main article Author: year																			
Aaras: 1999	1	1	2	1	1	1	1	1	1	0	1	1	1	0	1	0	33	80%	Medium
Andersen, L: 2011	1	1	2	1	1	1	0	1	1	1	1	0	1	1	1	1	37	90%	High
Andersen, C: 2011	1	1	2	1	1	1	0	1	0	1	1	0	1	1	1	1	36	88%	High
Bernaards: 2006	1	1	2	1	1	1	1	1	1	1	1	1	1	1	1	1	41	100%	High
Camargo: 2009	1	0	1	1	0	1	0	1	0	0	1	0	0	0	0	0	15	37%	Low
Cheng: 2007	1	1	2	1	1	1	0	1	1	0	1	0	1	1	0	1	33	80%	Medium
Dropkin: 2015	1	1	2	1	1	1	1	1	1	0	1	1	1	1	1	1	39	95%	High
Esmaeilzadeh: 2014	1	1	2	1	1	1	0	0	1	0	1	1	1	1	0	1	32	78%	Medium
Feuerstein: 2004	1	1	2	1	1	1	1	1	1	0	1	1	0	1	1	1	36	88%	High
Hagberg: 2000	0	1	2	0	1	1	0	1	0	1	1	1	0	1	0	1	29	71%	Medium
Jay: 2014	0	1	2	1	1	1	1	1	1	1	1	0	1	1	1	1	37	90%	High
Lincoln: 2002	1	1	2	1	1	0	0	1	0	0	0	0	0	0	0	1	21	51%	Medium
Lundblad: 1999	1	1	2	1	1	0	1	1	1	1	1	1	0	1	1	1	36	88%	High
Martimo: 2010	1	1	2	1	1	0	1	0	0	0	1	0	1	1	1	1	31	76%	Medium
Ripat: 2006	1	1	2	0	1	1	1	1	1	1	1	1	1	0	0	0	31	76%	Medium
Sundstrup: 2013	1	1	2	1	1	1	0	1	1	1	1	0	1	1	1	1	37	90%	High
Voerman: 2007	1	1	2	0	1	1	1	1	0	0	1	1	1	1	1	1	36	88%	High