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REVIEW

Are Work Disability Prevention Interventions Effective for the Management of Neck Pain or Upper Extremity Disorders? A Systematic Review by the Ontario Protocol for Traffic Injury Management (OPTIMa) Collaboration

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Abstract *Purpose* We conducted a systematic review to critically appraise and synthesize literature on the effectiveness of work disability prevention (WDP) interventions in workers with neck pain, whiplash-associated disorders (WAD), or upper extremity disorders. *Methods* We searched electronic databases from 1990 to 2012. Random pairs of independent reviewers critically appraised eligible studies using the Scottish Intercollegiate Guidelines Network criteria. Scientifically admissible studies were summarized and synthesized following best-evidence synthesis methodology. *Results* Of the 6,359 articles retrieved, 16 randomized controlled trials were eligible for critical appraisal and five were admissible. We found that a return-to-work coordination program (including workplace-based work hardening) was superior to clinic-based work hardening for persistent rotator cuff tendinitis. Workplace high-intensity strength training and workplace advice had similar outcomes for neck and shoulder pain. Mensendieck/Cesar postural exercises and strength and fitness exercises had similar outcomes for non-specific work-related upper limb complaints. Adding a brief job stress education program to a workplace ergonomic intervention was not beneficial for persistent upper extremity symptoms. Adding computer-prompted work breaks to ergonomic adjustments and workplace education benefited workers' recovery from recent work-related neck and upper extremity complaints. *Conclusions* At present, no firm conclusions can be drawn regarding the effectiveness of WDP interventions for managing neck pain, WAD, and upper extremity disorders.

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Our review suggests a return-to-work coordination program is more effective than clinic-based work hardening. Also, adding computer-prompted breaks to ergonomic and workplace interventions benefits workers' recovery. The current quality of evidence does not allow for a definitive evaluation of the effectiveness of ergonomic interventions.

Keywords Neck pain and associated disorders · Whiplash-associated disorders · Upper extremity disorders · Work disability prevention interventions · Treatment · Systematic review

Introduction

Neck pain and upper extremity disorders from traffic collisions, normal activities, or work injuries are among the most common sources of work disability in society. In Ontario, the incidence of work absenteeism related to neck pain is 23 per 100,000 full-time equivalents (FTE) [1]. In Washington state, the incidence of work absenteeism is 11.9 per 100,000 FTE for elbow injuries and 98.3 per 100,000 FTE for hand/wrist disorders [2]. Workers with these disorders can develop long-term disability which is associated with high health care utilization, lost productivity and costs to workers and employers [3–8]. Therefore, it is important to prevent work disability related to neck pain and upper extremity disorders.

Research in the past 20 years suggest that work disability is a complex condition resulting from interactions between workers, healthcare providers, the workplace and the compensation system. Although work disability is triggered by a health problem (e.g., neck pain), its prognosis is influenced by contextual determinants such as the workplace psychosocial environment, legal and regulatory frameworks and workers' beliefs and expectations [9, 10]. Thus to be effective, interventions should consider these determinants with the goal of rehabilitating workers to prevent or decrease absenteeism at work and increase wellbeing [10].

Several systematic reviews of ergonomic interventions in the workplace have found conflicting evidence regarding their effectiveness [4, 11, 12]. Boocock et al. [4] found evidence supporting work environment/workstation adjustments for visual display unit workers with neck and upper extremity conditions. However, Brewer et al. reported that workstation adjustments had no effect on musculoskeletal outcomes in workers [11]. In 2008, the Bone and Joint Decade 2000–2010 Task Force on Neck Pain and Its Associated Disorders (NPTF) concluded that multiple ergonomic interventions were not effective in reducing neck pain [12–14]. This was based on a study that compared no intervention to improved lighting, whole forearm support, and optometric corrections in video display unit workers. They also found that combining computer-prompted work breaks with ergonomic and workplace interventions did not decrease symptoms or sick leave in workers with work-related neck disorders [12, 15].

Similar conflicting results were reported in systematic reviews exploring the efficacy of exercise at the workplace for managing neck and upper extremity disorders [4, 11, 12, 16]. Boocock et al. [4] reported that workplace exercise interventions (i.e. strength training, coordination and flexibility) had positive effects in workers with neck and upper extremity conditions. Reviews by Brewer et al. and the NPTF found that computer-prompted exercises added to rest breaks provide no additional benefit to workers [11, 12, 15]. Furthermore, Williams et al. [16] found that arm strengthening exercises in the workplace were less effective than a clinic-based multimodal intervention (i.e. massage, strength and flexibility exercises, stretching, and weight training with passive mobilization) in workers with work-related upper extremity disorders.

Such divergent conclusions noted in these systematic reviews can be attributed to methodological differences. For example, several systematic reviews combined evidence from high and low quality randomized controlled trials (RCTs) [4, 11, 16]. In addition, some reviews included studies that examined both preventative and rehabilitative effects of interventions [4, 11, 12]. Therefore, the effectiveness of workplace exercise and ergonomic interventions for the management of neck and upper extremity disorders remains unclear. We conducted a systematic review of the literature from 1990 onwards to critically appraise and synthesize the evidence on the effectiveness of work disability prevention (WDP) interventions (i.e. clinical rehabilitation at the workplace, work hardening/conditioning and graded activity, return-to-work

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coordination, ergonomic interventions, and combined WDP approaches) on self-rated recovery, functional recovery, pain intensity, health-related quality of life, psychological outcomes, and adverse events of workers with neck pain, whiplash-associated disorders (WAD), or upper extremity disorders.

Methods

Registration

This review protocol was registered with the International Prospective Register of Systematic Reviews (PROSPERO) on December 4th, 2012 (CRD42012003390).

Eligibility Criteria

Population

We included studies of adults (i.e. 18 years of age and older) with neck pain and associated disorders (grades I–III), WAD grades I–III and/or upper extremity disorders. We excluded studies of patients with neck pain or upper extremity disorders due to major pathologies (e.g. fractures, dislocations, spinal cord injury, infection, neoplasms, systemic disease).

We defined neck pain and associated disorders according to the definition proposed by the NPTF [17]:

- Grade I neck pain: No signs or symptoms suggestive of major structural pathology, and no or minor interference with activities of daily living
- Grade II neck pain: No signs or symptoms suggestive of major structural pathology, but major interference with activities of daily living
- Grade III neck pain: No signs or symptoms suggestive of major structural pathology, but presence of neurologic signs such as decreased deep tendon reflexes, weakness or sensory deficits

The Quebec Task Force classification was used to define WAD [18]:

- Grade I WAD: Subjects with neck pain and associated symptoms in the absence of objective physical signs
- Grade II WAD: Subjects with neck pain and associated symptoms in the presence of objective physical signs and without evidence of neurological involvement
- Grade III WAD: Subjects with neck pain and associated symptoms with evidence of neurological involvement including decreased or absent reflexes, decreased or limited sensation, or muscular weakness

We included upper extremity disorders involving grades I and II sprains or strains of the shoulder, arm, elbow, forearm, wrist, and hand, as well as nerve entrapment syndromes such as carpal tunnel syndrome [19, 20].

A sprain involves a stretch and/or tear of a ligament that occurs when a ligament and/or joint is placed under excessive load [21–23]. The severity of the sprain is graded according to the extent of ligamentous damage:

- Grade 1 sprain: Occurs when ligamentous fibres are stretched but remain structurally intact
- Grade 2 sprain: Occurs when ligamentous fibres become partially torn. Physical stress reveals increased laxity with a definite end point

In the shoulder, sprains can occur in the supporting ligaments and capsule of the glenohumeral or acromioclavicular joints. In the elbow, sprains can occur in the supporting ligaments and capsule of the humeroulnar, humeroradial, and proximal radioulnar joints. In the wrist, sprains can occur in the distal radioulnar, radiocarpal, intercarpal, midcarpal, carpometacarpal, and intermetacarpal joints, and may involve the triangular fibrocartilage complex. In the hand, sprains can occur in the intercarpal, metacarpophalangeal, and interphalangeal joints.

A strain involves injury to a muscle and/or tendon that occurs when the muscle is placed under a forcible stretch, either passively or during muscle contraction [24]. The severity of the strain is graded according to the severity of muscle fibre damage [25, 26]:

- Grade 1 strain: Occurs when less than 5 % of muscle/tendon fibres are disrupted, with fascia remaining intact
- Grade 2 strain: Occurs when muscle fibre/tendon discontinuity involves a moderate number of muscle fibres

In the shoulder, strains may involve the rotator cuff and supporting muscles of the glenohumeral and scapulothoracic articulation. Tendon strains involving the rotator cuff are often referred to as partial thickness tears (grade 1 and 2 strains) [27]. Shoulder impingement is commonly associated with sprain/strain injuries of the shoulder and occurs when the tendons of the rotator cuff become irritated as they pass beneath the acromion [28]. In the elbow, forearm, wrist, and hand, strains may involve the distal portion of the arm (e.g., biceps, brachialis, triceps, and brachioradialis), muscles of the forearm (e.g., flexors, extensors, supinator, and pronator muscles), thenar, hypothenar, intrinsic and extrinsic muscles of the hand.

Interventions

We classified WDP interventions into five categories. Each category had a different focus for managing work disability.

1. Clinical rehabilitation at the workplace: any clinical/rehabilitation treatment intended to facilitate return to work and provided within the workplace [3];
2. Work hardening/conditioning and graded activity: programs simulating work and/or functional tasks through progressive training and physical activity graded within a supervised environment in a clinical setting, to address the physical, functional, and/or occupational needs of patients [29, 30];
3. Return-to-work coordination: collaboration between workers, employers, and healthcare providers for the provision of services intended to rehabilitate and return injured workers to the workplace, under the supervision of a coordinator independent from one of the stakeholders [31, 32];
4. Ergonomic interventions: interventions aimed at modifying biomechanical physical exposure(s) and organizational factors within a workplace [33];
5. Combined WDP approaches: a combination of two or more interventions from two or more WDP intervention categories.

Comparison Groups

We considered studies that compared WDP interventions to other non-invasive interventions, or no intervention.

Outcomes

The outcomes of interest included: (1) self-rated recovery; (2) functional recovery (e.g. disability, return to work); (3) pain intensity; (4) health-related quality of life; (5) psychological outcomes such as depression; and (6) adverse events.

Study Characteristics

Eligible studies met the following criteria: (1) English language; (2) Published between January 1st, 1990 to December 6th, 2012; (3) Study designs including: RCTs, cohort studies, and case–control studies; (4) An inception cohort of at least 30 subjects per treatment arm with the specified conditions for RCTs or 100 subjects per group with the specified condition in cohort studies or case–control studies. Studies were excluded if they were: (1) letters, editorials, commentaries, unpublished manuscripts, dissertations, government reports, books and book chapters, conference proceedings, meeting abstracts, lectures and addresses, consensus development statements, guideline statements; (2) cross-sectional studies, case reports, case series, qualitative studies, narrative reviews, systematic reviews (with or without meta-analyses), clinical practice guidelines, biomechanical studies, laboratory studies, studies not reporting on methodology; or (3) cadaveric or animal studies.

Information Sources

We worked with a health sciences librarian to develop a MEDLINE search strategy to retrieve studies on neck pain and associated disorders, WAD, and upper extremity disorders (Online Resource 1). The librarian modified the MeSH terms used in the MEDLINE search strategy to conform with the controlled vocabulary (thesauri) used by other bibliographic databases. The strategies also included free text words relevant to WDP interventions, neck pain and associated disorders (grades I–III), WAD grades I-III, and upper extremity disorders. A second librarian reviewed the search strategy for completeness and accuracy using the Peer Review of Electronic Search Strategies (PRESS) checklist [34, 35]. We searched the following electronic databases, from January 1st, 1990 to December 6th, 2012: MEDLINE, EMBASE, CINAHL, PsycINFO, Cochrane Central Register of Controlled Trials, Database of Abstracts of Reviews of Effects (DARE), National Guideline Clearinghouse, Index to Chiropractic Literature, and ABI Inform. We imported all search results into databases using bibliographic management software (EndNote X6; Thomas Reuters, New York, 2012).

Study Selection

We used a two-phase screening process to select eligible studies. In phase one, two randomly paired, trained reviewers independently screened titles and abstracts to determine the eligibility of studies. In phase two, the same reviewers independently screened the manuscripts of possibly relevant studies to make a final determination of eligibility. Reviewers met to resolve disagreements and reach consensus on the eligibility of studies in both phases. An independent third reviewer was used if consensus could not be reached.

Assessment of Risk of Bias

Random pairs of independent reviewers critically appraised the internal validity of eligible studies using the Scottish Intercollegiate Guidelines Network (SIGN) criteria (Table 1) [36]. The SIGN criteria were used to qualitatively evaluate the presence and impact of selection bias,

Table 1 Risk of bias for accepted randomized controlled trials based on the Scottish Intercollegiate Guidelines Network (SIGN) criteria [28]

Author	Research question	Method of randomization	Concealment of treatment allocation	Blinding of treatment and outcomes	Similarity of baseline characteristics	Cointervention contamination	Outcome measurement	Lost to follow-up[a]	Intention-to-treat	Multiple sites
Cheng and Hung [41]	AA	AA[b]	NR[b]	AA[b]	AA	AA	AA	CWH: 8 % WWH: 10 %	AA	NAd
Feuerstein et al. [42]	AA	AA[b]	AA[b]	AA	AA	NR	AA	EO: 23 % EJSM: 26 %	WC	NAp
van den Heuvel et al. [15]	WC	WC	NAd	NAp	AA	AA	AA[b]	EAGE + CB: 19 % EAGE + CB + Ex: 19 % EAGE:18 %	AA[b]	NAd
van Eijsden-Besseling et al. [40]	WC	WC	NR	WC	WC	AA	AA	PE: 9.1 % SFE: 4.5 %	WC	NR
Zebis et al. [43]	AA	WC	AA	AA	AA	AA	AA	WST: 25 % ASA: 7 %	AA	AA

WC well covered, *AA* adequately addressed, *PA* poorly addressed, *NR* not reported, *NAp* not applicable; *NAd* not addressed, *ASA* advice to stay active, *CB* computer break, *CWH* clinic-based work hardening, *EAGE* ergonomic adjustment and general education, *EO* ergonomic only, *EJSM* ergonomic and job stress management, *Ex* exercise, *PE* postural exercises, *SFE* strength and fitness exercises, *WST* workplace strength training, *WWH* workplace-based work hardening

[a] Includes participant withdrawal and loss-to-follow up

[b] Rating determined using additional information from authors

information bias, and confounding on the results of a study. We did not use a quantitative score or a cutoff point to determine the internal validity of studies [37]. Rather, the SIGN criteria were used to assist reviewers in making an informed overall judgment on the internal validity of studies. This methodology has been previously described [18, 38–42].

Specifically, we critically appraised the following methodological aspects of a study: (1) clarity of the research question; (2) randomization method; (3) concealment of treatment allocation; (4) blinding of treatment and outcomes; (5) similarity of baseline characteristics between/among treatment arms; (6) co-intervention contamination; (7) validity and reliability of outcome measures; (8) follow-up rates; (9) analysis according to intention to treat principles; and (10) comparability of results across study sites (where applicable). Reviewers reached consensus through discussion. An independent third reviewer was used to resolve disagreements if consensus could not be reached. We contacted authors when additional information was needed to complete the critical appraisal. Studies with adequate internal validity had a low risk of bias and were included in our evidence synthesis [43].

Data Extraction and Synthesis of Results

The lead author extracted data from scientifically admissible studies and built evidence tables (Table 2). A second reviewer independently checked the extracted data. We did not perform a meta-analysis due to the heterogeneity of scientifically admissible studies. Instead, we qualitatively synthesized the evidence and developed evidence statements according to principles of best evidence synthesis [43]. We stratified results based on the type and duration of the disorder [i.e. recent (symptoms lasting <3 months) versus persistent (symptoms lasting ≥3 months)].

Statistical Analyses

The inter-rater agreement for the screening of articles was computed using the kappa coefficient and 95 % confidence intervals (CI) [44]. The percentage agreement for the critical appraisal of articles was also calculated for admissible/inadmissible results. When available, we used data provided in the admissible articles to measure the association between the tested interventions and the outcomes by computing the relative risk and its 95 % CI. Similarly, we computed the difference in mean change between groups and its 95 % CI to quantify the effectiveness of interventions. The computation of the 95 % CI for the difference in mean change was based on the assumption that the pre- and post-intervention outcomes were highly correlated (r = 0.8) [45, 46].

Table 2 Evidence table for accepted randomized controlled trials on work disability prevention interventions for neck pain and associated disorders, whiplash-associated disorders, and upper extremity disorders

Author(s)	Subjects and Setting; number (n) enrolled	Interventions; number (n) of subjects	Comparisons; number (n) of subjects	Follow-up	Outcomes	Key findings
Cheng and Hung [41]	Workers' compensation claimants in Hong Kong with rotator cuff tendinitis >90 days duration. (n = 103)	Workplace-based work hardening with job coach (WWH): biomechanics and ergonomic education, shoulder stretch, scapular control exercises, shoulder strengthening exercises, job specific activities (overhead activities, manual handling of load, static posture, repetitive work). (n = 51)	Clinic-based work hardening (CWH): mobilization activities for upper limb, strength and endurance training, and work simulation (simulated work stations, computerized work simulators, Valpar work samples). (n = 52)	Immediately after 4 week intervention	Primary Outcomes: Workers' perceived shoulder pain and disability (SPADI); functional capacity (ARCON and VCWS); return to work (normal duties, modified normal duties or alternative duties)	Primary Outcomes: Difference in mean change (WWH − CWH)[b]: Reduction in shoulder pain and disability: 8.96 (95 % CI 3.13;14.79) Active shoulder flexion: 5.1 degrees (95 % CI 1.72;8.48) Arm lifting strength: 7.75 lbs. (95 % CI 2.17;13.33) High-near lifting strength: 10.71 lbs. (95 % CI 6.17;15.25) Carrying strength: 5.39 lbs. (95 % CI 1.66;9.12) Overhead tolerance: 10.52 % Industrial Standard (95 % CI 1.35;19.69) After controlling for psychological workplace factors, the difference between groups remained statistically significant for all outcomes except reduction in shoulder pain and disability and overhead tolerance. RR of individuals returning to normal or modified duties (WWH versus CWH)[c]: RR = 1.91 (95 % CI 1.27;2.88)
Feuerstein et al. [42]	Full time World Bank (Washington, DC) employees working on computers (3–4 h/day) experiencing upper extremity symptoms in the past 12 months. (n = 93)	Ergonomic intervention (same as comparison) and job stress management education and training (ergo-stress): two 70-min workshops on education and application of psychological stress management, stress diary, relaxation, education on problem solving and effective communication within the workplace. (n = 46)	Ergonomic intervention (ergo-only): workstation assessment, adjustments to workstation, instruction on ergonomic risk prevention, workstation stretches. (n = 47)	3 and 12 months	Primary Outcomes: Pain (VAS); symptoms (symptom severity subscale of the DASH); upper extremity functional impairment (UEFS, physical function impairment, interference with social activities, interference with work and daily activities and the sleep impairment subscales of the DASH); perceived overall physical and mental health (SF-12); external ergonomic risk assessment (Ergonomic Work-site Analysis Form); self-report of ergonomic risk (JRPDS); work stress (job stress subscale of LSRES)	Primary Outcomes: No significant difference between groups for pain, symptoms, upper extremity functional impairment, general function, ergonomic risk, and work stress at 3 and 12 months.

Table 2 continued

Author(s)	Subjects and Setting; number (n) enrolled	Interventions; number (n) of subjects	Comparisons; number (n) of subjects	Follow-up	Outcomes	Key findings
van den Heuvel et al. [15]	Computer workers at GAK Nederland (22 locations), working in the office (≥4 days/week) on computers (≥5 h/day) with work-related neck and upper-limb disorders for ≥2 weeks. (n = 268)	Work station ergonomic adjustment and general education (same as control) plus computer-prompted rest break (5 min rest break after 35 min of computer usage and 7 s microbreak after 5 min of computer usage) (n = 97) Work station ergonomic adjustment and general education (same as control) plus exercise during work break (four physical exercises at the start of each rest break). (n = 81)	Work station ergonomic assessment and adjustment and general education booklet (n = 90)	Immediately after 8 week intervention	Primary outcome: Perceived overall recovery [7-point scale on questionnaire trichotimized to improvement (workers reporting complete recovery, much improvement, and little improvement), no change, and deterioration (workers reporting slight deterioration, much deterioration, and worse than ever before)] Secondary outcome: Frequency and severity of symptoms; self-reported sick leave.	Primary Outcomes: Perceived overall recovery: No significant difference between Breaks + Exercise and Breaks groups in workers reporting improvement or deterioration. No difference between all groups for workers reporting no change. RR for workers reporting improvement[c]: Breaks versus Control: RR = 1.6 (95 % CI 1.1;2.3) Breaks + Exercise versus Control: RR = 1.6 (95 % CI 1.1;2.4) RR for workers reporting deterioration[c]: Breaks versus Control: RR = 0.06 (95 % CI 0.00;0.44) Breaks + Exercise versus Control: RR = 0.28 (95 % CI 0.1;0.8) Secondary Outcomes: No difference between groups in symptom frequency, symptom severity or sick leave.
van Eijsden-Besseling et al. [40]	Visual display unit workers (20–45 years of age) who do computer work at least 20 h/week with non-specific work-related upper limb disorders (symptom duration >2 weeks, <3 months). (n = 88)	Postural exercises delivered by Mensendieck/Cesar therapists for 10 weeks (12 sessions): feedback from muscle, joint, tendon, and ligaments through audio visual and proprioceptive signals, verbal instructions and demonstration by therapists, training in patient-specific everyday activities. (n = 44)	Strength and fitness exercises delivered by physiotherapists for 10 weeks (18 sessions): local exercises to address painful areas, active spinal and peripheral muscle training and fitness exercises. (n = 44)	3, 6, and 12 months	Primary outcomes: Pain intensity (10-cm VAS); self-reported disability (DASH); health-related quality of life (SF-36); presence of non-specific work-related upper limb complaints (self-reported).	Primary Outcomes: No significant difference between groups for pain intensity, disability, quality of life, or self-reported upper limb complaints at any follow-up.

Table 2 continued

Author(s)	Subjects and Setting; number (n) enrolled	Interventions; number (n) of subjects	Comparisons; number (n) of subjects	Follow-up	Outcomes	Key findings
Zebis et al. [43]	Industrial workers from Copenhagen, Denmark with neck and/or shoulder pain; (n = 172 neck pain cases, n = 145 right shoulder cases, n = 89 left shoulder cases)[a]	Combined supervised and unsupervised high-intensity strength training at the workplace for 20 weeks (n = 95 neck pain cases, n = 76 right shoulder cases, n = 46 left shoulder cases)[a]	Advice to stay active over 20 weeks with consultation by a supervisor once a week; (n = 77 neck pain cases, n = 69 right shoulder cases, n = 43 left shoulder cases)[a]	Immediately after 20 week intervention	Primary outcomes: Self-reported neck and shoulder pain intensity during the last 7 days (modified Nordic questionnaire for neck and shoulders symptoms) Adverse events	Primary outcomes: Differences in mean changes (training – advice)[b]: Reduction in neck pain: 1.2 (95 % CI 0.82;1.58) Reduction in right shoulder pain: 1.2 (95 % CI 0.76;1.64) Reduction in left shoulder pain: 0.8 (95 % CI 0.26;1.34) Neck pain <3 on 0–9 scale (training versus advice): OR = 2.0 (95 % CI 1.0;4.2) Shoulder pain <3 on 0–9 scale (training versus advice): OR = 3.9 (95 % CI 1.7;9.4) Adverse events: Training: 15.8 % reported minor and transient complaints No reports of adverse events in control group

ARCON applied rehabilitation concepts, *CI* confidence intervals, *DASH* disability arm shoulder hand outcome measure, *JRPDS* job requirements and physical demands survey, *LSRES* Life Stressors and Social Resources Inventory, *OR* odds ratio, *RR* relative risk, *SF-12* short form-12, *SF-36* short form-36, *SPADI* shoulder pain and disability index, *UEFS* upper extremity function scale, *VAS* visual analogue scale, *VCWS* Valpar component work sample 9

[a] Cannot be determined how many subjects had more than one area of complaint

[b] Between group differences in mean change and 95 % CI were calculated by authors; where necessary, standard deviations for pre- and post-intervention data were calculated based on the assumption of a 0.8 correlation

[c] RR and 95 % CI was calculated by authors

Reporting

We organized and reported the systematic review according to Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) [47].

Results

Study Selection

Our search yielded 6,359 articles. After removing 1,642 duplicates, we screened 4,717 articles for eligibility (Fig. 1). There were 4,699 ineligible articles; we critically appraised 16 RCTs reported in 18 articles (no relevant cohort or case–control studies were found). Five of the 16 RCTs were scientifically admissible and included in our synthesis (Table 1). The remaining articles were deemed scientifically inadmissible (Fig. 1).

The inter-rater agreement for the screening of articles was $\kappa = 0.64$ (95 % CI 0.54 to 0.75). The percentage agreement for the critical appraisal of articles was 88 % (14/16 RCTs) based on admissible/inadmissible results. For the two studies where reviewers disagreed, consensus was reached through discussion.

Characteristics of Scientifically Accepted Studies

The five scientifically admissible RCTs studied different disorders including recent work-related neck and upper limb disorders [15], recent nonspecific work-related upper limb disorders [48], persistent work-related rotator cuff tendinitis [49], persistent upper extremity symptoms [50], and neck and shoulder pain [51] (Table 2). None of the admissible studies included patients with WAD. Four of the five RCTs compared different WDP interventions [15, 49–51], and one RCT compared a WDP intervention to an exercise intervention [48] (Table 3). None of the interventions among the five studies were the same. In one RCT, an intervention combining four different WDP approaches was compared to a work hardening intervention [49]. The interventions assessed in two other RCTs comprised multiple WDP approaches [15, 50]. In another RCT, two workplace interventions were compared [51]. One RCT compared a WDP program to an exercise intervention (setting not specified) [48]. The five RCTs studied populations from the Netherlands [15, 48], Hong Kong [49], the United States [50], and Denmark [51]. Two of the five RCTs were conducted on computer workers [15, 50], while the other three studies each examined a different population of workers (i.e. workers' compensation claimants, visual display unit workers, industrial workers) [48, 49, 51].

Risk of Bias within Studies

Although we had 16 relevant RCTs, the majority of these studies (69 %) had poor internal validity (Fig. 1) [52–64]. They had inadequate randomization, concealment or blinding methods [52, 54–58, 60–64], differences between treatment arms at baseline [53–55, 57, 59–61, 63], or they used outcome measures with poor and/or unknown validity and/or reliability [52, 54–59, 63, 64].

The methodological quality of scientifically admissible studies is presented in Table 1. All studies had clear research questions, appropriate randomization methods, adequately addressed baseline characteristics between treatment arms, suitable outcome measures and performed intention-to-treat analyses. Allocation concealment was adequately addressed in two of the five studies [50, 51]. In the other three studies the allocation concealment was described poorly. The follow-up rate was above 80 % in three studies and above 70 % in two other studies [50, 51].

Summary of Evidence

Recent Work-Related Neck and Upper Limb Complaints

Evidence from a cluster RCT suggests that adding computer-prompted exercise and work breaks or work breaks

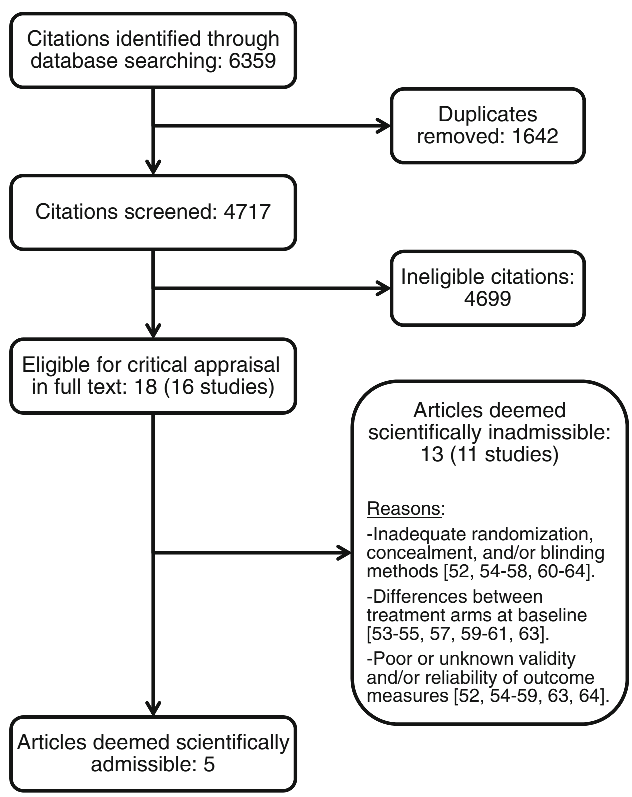

Fig. 1 Selection of studies

alone to a combined WDP approach (i.e. ergonomic adjustment and general education) improves self-perceived recovery and deterioration in computer workers with neck and upper extremity complaints (Table 2) [15]. Exercise breaks provided no additional benefit when added to computer-prompted work breaks. Furthermore, adding computer-prompted breaks (with or without computer-prompted exercise breaks) to ergonomic adjustment and workplace education did not improve symptoms or sick leave in workers. In this study, van den Heuvel et al. randomized computer workers from the Netherlands to three groups: (1) control intervention (i.e. work station ergonomic adjustment and education booklet); (2) control intervention and computer-prompted extra work breaks; and (3) control intervention and computer-prompted extra work breaks with four physical exercises (including stretches). This trial suggests that adding computer-prompted work breaks (with or without computer-prompted exercise breaks) to ergonomic adjustment and workplace education benefits workers' recovery immediately after an 8-week intervention.

Recent Nonspecific Work-Related Upper Limb Disorders

Evidence from one RCT conducted on visual display unit workers suggests that a combined WDP approach (i.e. postural exercises and a graded activity intervention) provided by Mensendieck/Cesar therapists leads to the same outcomes as a fitness and strengthening exercise program provided by physiotherapists [48]. Both interventions were equally effective in reducing the number of workers reporting non-specific work-related upper limb complaints, including pain, self-reported disability, and health-related quality of life. In this study, van Eijsden-Besseling et al. randomized participants from the Netherlands to two groups: (1) Mensendieck/Cesar postural exercises with work hardening (i.e. audiovisual and proprioceptive feedback, verbal instructions and demonstration by therapists, patient-specific everyday activity training); or (2) strength and fitness exercises (i.e. local exercises addressing painful areas, active spinal and peripheral muscle exercises). This trial suggests that two treatment programs, Mensendieck/Cesar postural exercises or strength and fitness exercises lead to similar complaint-reduction outcomes.

Persistent Work-Related Rotator Cuff Tendinitis

Evidence from one RCT suggests that a combined WDP approach at the workplace (including return-to-work coordination and work hardening interventions) is more effective than clinic-based work hardening in improving short-term functional outcomes (e.g., lifting and carrying) and return to work of workers with persistent rotator cuff tendinitis (Table 3) [49]. However, both interventions were equally effective in improving self-perceived shoulder pain and disability for the injured workers. In this study, Cheng and Hung randomized workers' compensation claimants from Hong Kong into two groups. The first group received a return-to-work coordination program that included work-based ergonomic education, stretching and strengthening exercises, and job specific activities monitored by an occupational therapist. The occupational therapist was also responsible for fulfilling the following roles: (1) supervise, train and support workers; (2) advise patients regarding proper body mechanics, safe work practices, and appropriate pacing of work activities; (3) provide on-site monitoring and evaluation of the workers' occupational performance; (4) educate and inform employers about activities to restore the worker's level of functioning; and (5) advocate understanding for the worker and facilitate successful return to work. The second group received clinic-based mobilization activities for the upper limb, strength and endurance exercises, and work simulation. This trial suggests that a return-to-work coordination program, that includes workplace-based work hardening, is superior to clinic-based work hardening in improving functional outcomes and return to work immediately after a 4-week intervention.

Persistent Upper Extremity Symptoms

Evidence from one RCT suggests that adding a brief job stress education program to a combined WDP approach does not improve pain, symptoms, upper extremity functional impairment, general function, ergonomic risk, or work stress in computer workers [50]. In this study, Feuerstein et al. randomized full time World Bank employees from the United States to two groups: (1) ergonomic and workplace exercise intervention (i.e. workstation assessment and adjustments, ergonomic risk prevention instructions, workstation stretches); or (2) ergonomic and workplace exercise intervention and job stress management education and training (i.e. two 70-min workshops on education and application of psychological stress management, stress diary, relaxation, problem solving and effective workplace communication education). This trial suggests that there is no additional benefit to adding a brief job stress education program to an ergonomic and workplace exercise intervention.

Neck and Shoulder Pain

Evidence from one RCT suggests that a workplace exercise program and a workplace education intervention had similar reductions in neck and shoulder pain [51]. In this study, Zebis et al. randomized industrial workers from

Copenhagen, Denmark to two groups: (1) 20 weeks of workplace exercise (i.e. combined supervised and unsupervised high-intensity strength training); or (2) workplace education (i.e. advice to stay active with consultations by a supervisor once a week for 20 weeks). This trial suggests that high-intensity strength training at the workplace and advice to stay active in the workplace lead to similar reductions in neck and shoulder pain immediately after the intervention.

Adverse Events

Only one of the five admissible studies addressed adverse events [51]. In their trial of high-intensity strength training versus advice to stay active at the workplace, Zebis et al. found that no serious adverse events were reported. However, 15.8 % of workers assigned to the workplace exercise group reported minor and transient complaints. The comparison group reported no adverse events.

Discussion

There are few methodologically rigorous studies supporting the use of WDP interventions for the management of neck pain or upper extremity disorders. Only five of the 16 RCTs were methodologically rigorous [15, 48–51]. The inadmissible studies had major limitations due to inadequate randomization [57, 60, 62], concealment [58, 60, 61], or blinding methods [52, 54–57, 60, 63, 64]. Other major limitations included differences between treatment arms at baseline [53–55, 57, 59–61, 63] and poor or unknown validity and/or reliability of outcome measures [52, 54–59, 63, 64]. Nevertheless, our review provides important findings for the management of neck pain and upper extremity disorders in workers. First, in the short-term a return-to-work coordination program (including workplace-based work hardening) is more beneficial than clinical work hardening for the management of workers with persistent rotator cuff tendinitis [49]. Second, adding a brief job stress education program to an ergonomic intervention in the workplace does not provide additional benefits to workers with persistent upper extremity symptoms [50]. Third, both Mensendieck/Cesar postural exercises and strength and fitness exercises lead to similar complaint-reduction outcomes for workers with recent nonspecific work-related upper limb disorders [48]. Fourth, adding computer-prompted work breaks (with or without computer-prompted exercise breaks) to an ergonomic intervention and workplace education is beneficial in improving workers' self-perceived recovery from recent work-related neck and upper extremity complaints [15]. Fifth, combined supervised and unsupervised high-intensity strength training at work and workplace advice lead to similar reductions in neck and shoulder pain [51]. Finally, the effectiveness of WDP interventions for the management of neck pain and upper extremity disorders remains unclear due to the limited evidence available. We found no relevant studies on the effectiveness of WDP interventions for the management of WAD. We found only one study that compared a WDP intervention to a non-WDP intervention [48]. We found no studies that evaluated the effectiveness of WDP interventions compared to no treatment.

A previous systematic review on the effectiveness of clinical rehabilitation in the workplace has concluded that exercise can be effective [4], while another review found that exercise was ineffective [16]. Others have reported that there were no differences between exercises and other non-invasive interventions for improving outcomes [11, 12]. Our review helps provide future directions in research on workplace exercises for the rehabilitation of workers with neck pain and upper extremity disorders. We found that high-intensity strength-training at the workplace and workplace advice had similar reductions in neck and shoulder pain immediately after 20 weeks of the interventions [51]. We also found that such high-intensity exercises can be performed relatively safely with few minor transient complaints [51]. However, we found that computer-prompted workplace exercises provided no additional benefit when combined with computer-prompted work breaks [15]. The exercises performed by the worker were low intensity and very brief in duration (intended to be easily performed while seated and 45 s each) [15]. Further research is needed on the intensity and duration of exercise to better understand the effectiveness of workplace exercise for the management of neck and upper extremity disorders.

Strengths and Limitations

There are many strengths to our review. First, we conducted an exhaustive and rigorous search of the literature. Specifically, we searched nine databases and the search strategy was peer reviewed by a second librarian to help minimize errors. Second, we used clear inclusion and exclusion criteria for the selection of studies and only considered studies with a clearly defined inception cohort of workers. Third, we used the SIGN criteria to standardize the critical appraisal process and inform our scientific judgment. Fourth, we contacted authors when there was insufficient information in studies. Of the ten authors contacted, eight responded to our queries regarding study methods (Table 1). Fifth, our conclusions were based on the best-evidence synthesis method to minimize the risk of bias associated with using low quality studies [43].

Table 3 Components of work disability prevention interventions used in scientifically admissible studies[a]

Author (year)	Treatment arms	Ergonomic intervention		Work hardening/ graded activity	Return-to-work coordination	Clinical rehabilitation at the workplace				
		Ergonomic assessment and modification	Ergonomic education			Exercise	Work hardening/ graded activity	General education	Psychological stress management	Work breaks
Cheng and Hung [41]	Workplace-based work hardening training		Biomechanic and ergonomic education		Supervise, train, and support workers; advise regarding proper body mechanics, safe work practices, and appropriate pacing of work activities; provide on-site monitoring and evaluation of the workers' occupational performance; educate and inform employers about activities to restore the worker's level of functioning; advocate understanding for the worker, and facilitate successful return to work	Shoulder stretch and strengthening; scapular control	Overhead activities; manual handling of load; static posture; and repetitive work			
Cheng and Hung [41]	Clinic-based work hardening training			Work simulation (simulated work stations, computerized work simulators, Valpar work samples)						
Feuerstein et al. [42]	Ergonomic intervention and job stress management	Worksite visit and consultation from an occupational health nurse and a former rehabilitation engineer; adjustments by ergonomist to workstation	Advice on how to modify environment and certain task behaviors to prevent ergonomic risk; ergonomic information website (ErgoClinic)			Stretching exercises			Education and application of psychological stress management; stress diary; relaxation; education on problem solving and effective communication within the workplace	

Table 3 continued

Author (year)	Treatment arms	Ergonomic intervention		Work hardening/ graded activity	Return-to-work coordination	Clinical rehabilitation at the workplace				
		Ergonomic assessment and modification	Ergonomic education			Exercise	Work hardening/ graded activity	General education	Psychological stress management	Work breaks
Feuerstein et al. [42]	Ergonomic intervention	Worksite visit and consultation from an occupational health nurse and a former rehabilitation engineer; adjustments by ergonomist to workstation	Advice on how to modify environment and certain task behaviors to prevent ergonomic risk; ergonomic information website (ErgoClinic)			Stretching exercises				
van den Heuvel et al. [15]	Computer breaks	Checked and adjusted (if necessary) position of seat, table height, position of monitor, keyboard, and mouse						Provided small booklet with general information on neck and upper-limb disorders and neck and upper-limb disorder risk test		5 min rest break after 35 min of continuous computer usage; 7 s microbreak after 5 min of continuous computer usage; during breaks computer was blocked
van den Heuvel et al. [15]	Computer breaks + Exercise	Checked and adjusted (if necessary) position of seat, table height, position of monitor, keyboard, and mouse				After 35 min of continuous computer usage workers stimulated to perform four physical exercises (45 s each)		Provided small booklet with general information on neck and upper-limb disorders and neck and upper-limb disorder risk test		2 Min rest break after 3 min of exercise; 7 s microbreak after 5 min of continuous computer usage; during breaks computer was blocked
	Ergonomic adjustment and general education at work	Checked and adjusted (if necessary) position of seat, table height, position of monitor, keyboard, and mouse						Provided small booklet with general information on neck and upper-limb disorders and neck and upper-limb disorder risk test		

Table 3 continued

Author (year)	Treatment arms	Ergonomic intervention		Work hardening/ graded activity	Return-to-work coordination	Clinical rehabilitation at the workplace				
		Ergonomic assessment and modification	Ergonomic education			Exercise	Work hardening/ graded activity	General education	Psychological stress management	Work breaks
van Eijsden-Besseling et al. [40]	Mensendieck/Cesar postural exercises at work					Postural exercises with feedback from muscle, joint, tendon, and ligaments through audio visual and proprioceptive signals, verbal instructions and demonstration by therapists	Training in patient-specific everyday activities (e.g. computer work)			
	Strength and fitness exercises									
Zebis et al. [43]	Strength training at work					Supervised and unsupervised strength training				
	Advice provided at work to stay active							Advice to stay active; consultation with supervisor once a week		

[a] Empty cells indicate that the intervention component was not provided in the treatment arm

Our review has some limitations. First, we restricted our search to the English literature, which may have excluded some relevant studies. However, this is an unlikely source of bias as the majority of large trials are published in English [65]. Also, systematic reviews studying the effect of language-restrictions have shown that excluding non-English clinical trials does not produce biased results [66–69]. Second, critically appraising articles requires scientific judgment which may vary between reviewers. This potential bias was limited by training the reviewers and using a standardized critical appraisal tool. Third, our ability to make recommendations about the management of neck pain and upper extremity disorders in workers is limited to the types of WDP interventions included in our systematic review. WDP interventions vary greatly and are commonly multimodal. Thus, it is difficult to comment on the effectiveness of the individual components of each WDP intervention. Also, qualitative studies that explored the lived experience of patients treated with WDP interventions for the management of neck and upper extremities were not included. Thus, this review cannot comment on the values and experiences of patients' who have used WDP interventions. Although this is not a source of bias in our review, we recommend that future reviews consider looking at qualitative studies to gain insight into the patient's perspective on WDP interventions. Finally, the generalizability of our results is limited to the short follow-up periods in the majority of the admissible literature (3/5 studies). Three of the five admissible studies reported on outcomes that were only measured immediately post-intervention [15, 49, 51].

Conclusion

At present, no firm conclusions can be drawn regarding the effectiveness of WDP interventions for managing neck pain, WAD, and upper extremity disorders. However, our review suggests that a return-to-work coordination program (including work hardening) is more effective than clinical work hardening. It also suggests that the addition of computer-prompted breaks to ergonomic adjustments and workplace education was beneficial in recovering workers. Finally, the current quality of evidence does not allow for a definitive evaluation of the effectiveness of ergonomic interventions.

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