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Workplace management of upper limb disorders: a systematic review

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Background Upper limb pain is common among working-aged adults and a frequent cause of absenteeism.

Aims To systematically review the evidence for workplace interventions in four common upper limb disorders.

Methods Systematic review of English articles using Medline, Embase, Cinahl, AMED, Physiotherapy Evidence Database PEDro (carpal tunnel syndrome and non-specific arm pain only) and Cochrane Library. Study inclusion criteria were randomized controlled trials, cohort studies or systematic reviews employing any workplace intervention for workers with carpal tunnel syndrome, non-specific arm pain, extensor tenosynovitis or lateral epicondylitis. Papers were selected by a single reviewer and appraised by two reviewers independently using methods based on Scottish Intercollegiate Guidelines Network (SIGN) methodology.

Results 1532 abstracts were identified, 28 papers critically appraised and four papers met the minimum quality standard (SIGN grading + or ++) for inclusion. There was limited evidence that computer keyboards with altered force displacement characteristics or altered geometry were effective in reducing carpal tunnel syndrome symptoms. There was limited, but high quality, evidence that multidisciplinary rehabilitation for non-specific musculoskeletal arm pain was beneficial for those workers absent from work for at least four weeks. In adults with tenosynovitis there was limited evidence that modified computer keyboards were effective in reducing symptoms. There was a lack of high quality evidence to inform workplace management of lateral epicondylitis.

Conclusions Further research is needed focusing on occupational management of upper limb disorders. Where evidence exists, workplace outcomes (e.g. successful return to pre-morbid employment; lost working days) are rarely addressed.

Key words Evidence-based guideline; occupational health; upper limb disorders.

Introduction

Upper limb disorders are common among working-aged adults although prevalence estimates vary substantially [1,2]. Some of this variation is explained by the diversity of case definitions employed across studies [2,3]. This diagnostic imprecision has implications for interpreting such research [4].

Physical workplace factors such as sustained abnormal posture, high force and highly repetitive movements may be associated with upper limb disorders [5,6]. For example, the NUDATA study found that intensive computer mouse use was associated with forearm pain [7]. Workplace psychosocial factors (e.g. high demand, poor social support) are also associated with an increased risk of such disorders [6,8] and cultural factors may be relevant [9].

This systematic review sought to evaluate the evidence base for guidelines on the workplace management of carpal tunnel syndrome, non-specific arm pain, tenosynovitis and epicondylitis [10].

Methods

Under the auspices of National Health Service (NHS) Plus, a multi-disciplinary Guideline Development Group (GDG) was convened. A systematic review was carried out, based on a protocol derived from the Scottish Intercollegiate Guidelines Network (SIGN) methodology [11]. The questions included in the review were framed using the PICO format [12] by defining the population (P) to be studied, intervention (I), comparison (C) and outcome (O) for each question. The key questions were 'In employees with carpal tunnel syndrome/non-specific arm pain/tenosynovitis/epicondylitis what workplace interventions are effective at preventing/reducing sickness absence/retaining normal job/preventing ill-health retirement?' A workplace intervention was defined as any action at a worker's place of work to improve the outcome of an existing upper limb disorder and, for this review, non-specific arm pain excluded neck/shoulder pain.

Literature search terms (Appendix 1, available as Supplementary data at *Occupational Medicine* online) were derived from PICO tables. Randomized controlled trials (RCTs), cohort studies or systematic reviews employing any workplace intervention for the selected upper limb disorders were identified by an information scientist using a sensitive, peer-reviewed search strategy. This used Medline (1950–2008), Embase (1980–2008), Cinahl (1981–2008), AMED (Allied and Complementary Medicine) (1985 to present), Physiotherapy Evidence Database PEDro (carpal tunnel syndrome and non-specific arm pain only) and the Cochrane Library. The search was carried out for all languages but limited to humans. The literature search was last updated on 14 August 2008.

The initial literature search results were sifted by one reviewer (F.D.D.) based on title and abstract (first sift). English language papers of possible relevance were retrieved and hand searched by a single reviewer (F.D.D.). Papers that were not relevant or did not meet basic quality criteria were rejected (second sift). Reference lists of relevant papers were hand searched, and any papers not identified previously were retrieved. Relevant studies referenced in reviews were also retrieved and assessed. The grey literature (documents such as dissertations, theses and policy documents which can be difficult to access) was not included.

Full papers were distributed to pairs of trained reviewers and independently assessed for methodological quality using SIGN methodology checklists (disagreements were resolved by discussion between reviewers) and the SIGN grading system [11] (Table 1).

Data extracted included study design, study population, intervention, comparison, length of follow-up, outcome measures and effect size (Appendix 2, available as Supplementary data at *Occupational Medicine* online).

The GDG discussed the draft recommendations and assigned a grade of recommendation as per the SIGN grading system [11]. Papers meeting the minimum quality standard (SIGN grading of + or ++) were included in recommendations but those with a high potential for bias or confounding were excluded. Non-analytical studies or expert opinion were only used for recommendations where there was no higher quality evidence.

Results

From 1532 abstracts, 28 papers were deemed relevant but only 4 papers were used for the guideline recommendations (Figure 1).

There was limited published evidence exploring workplace interventions for carpal tunnel syndrome. Of nine papers retrieved, two were rejected due to methodological weaknesses [13,14]. One systematic review [15] did not identify any relevant primary research but a second [16,17] assessed two RCTs considered below [18,19]. The only workplace intervention evaluated for carpal tunnel syndrome was the use of alternative or modified computer keyboards [18–20]. One small cohort study of

Table 1. Revised SIGN grading system

Levels of evidence	
1++	High-quality meta-analyses, systematic reviews of RCTs or RCTs with a very low risk of bias
1+	Well-conducted meta-analyses, systematic reviews of RCTs or RCTs with a low risk of bias
1−	Meta-analyses, systematic reviews of RCTs or RCTs with a high risk of bias
2++	High-quality systematic reviews of case–control or cohort studies; high-quality case–control or cohort studies with a very low risk of confounding, bias or chance and a high probability that the relationship is causal
2+	Well-conducted case–control or cohort studies with a low risk of confounding, bias, or chance and a moderate probability that the relationship is causal
2−	Case–control or cohort studies with a high risk of confounding, bias or chance and a significant risk that the relationship is not causal
3	Non-analytic studies, e.g. case reports, case series
4	Expert opinion

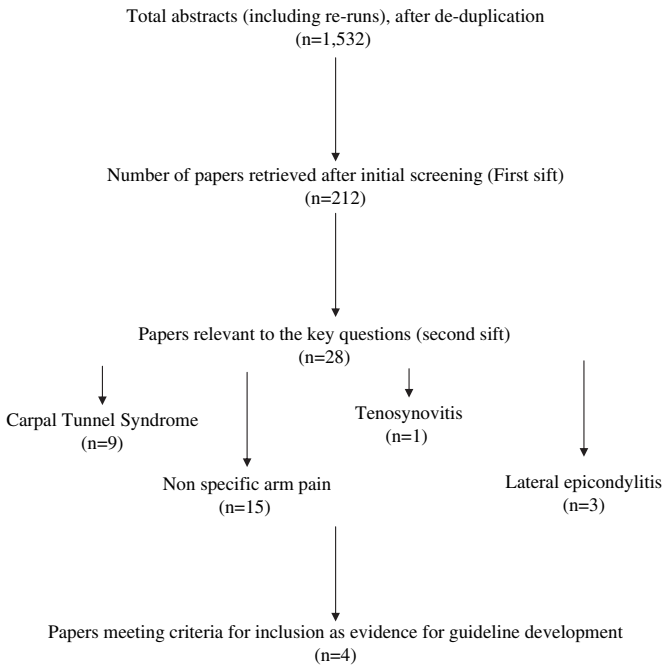

Figure 1. Flow chart showing selection of papers for all questions combined.

return to work following carpal tunnel syndrome surgery found those with supportive employers had better work functioning 6 months post-operatively [21].

The three studies [18–20] that employed alternative or modified computer keyboards were not directly comparable. One was an RCT of a modified keyboard (looser keys with greater damping) in comparison to the same style keyboard unmodified [18]. Use of the modified keyboard resulted in a significant reduction in pain. The second was an RCT (randomization was incomplete and an intention-to-treat analysis was not employed) of an ergonomic keyboard with reduced key activation force, shorter key travel and reduced key vibration [20]. Both standard and ergonomic keyboard groups showed significantly reduced symptom severity and significantly improved functional status. The third RCT [19] compared three keyboards with alternative keyboard geometry with a standard keyboard. All alternative keyboards looked strikingly different from a standard keyboard making blinding of users implausible. There was a significant trend for improved hand function for the Microsoft Natural keyboard™, whereas the standard keyboard group's hand function worsened. Two studies [18,19] were graded as +, whereas the third [20] was graded as −, indicating that few of the quality criteria for an RCT were met. It was concluded that there was limited evidence that computer keyboards with altered force displacement characteristics [18] or altered geometry [19] were effective in reducing symptoms in carpal tunnel syndrome.

Based on one cohort study, with a high dropout rate (graded +) [21], there was very limited evidence that having employers supportive of employees with carpal tunnel syndrome returning to work after surgery can improve work outcomes.

For non-specific arm pain, 15 papers were reviewed evaluating a variety of workplace interventions; 7 RCTs, 3 prospective cohort studies, 1 retrospective cohort study, 1 unrandomised pilot study and 3 papers reporting two systematic reviews. The methods of many of these studies failed to clarify whether the case definitions employed would incorporate subjects with arm pain caused by a range of specific upper limb disorders or only those with non-specific arm pain. Five studies were of low quality [20,22–25] and had significant potential for bias.

One high quality, but small (n = 38), Dutch RCT of multi-disciplinary rehabilitation [26] focusing on workers with non-specific upper limb disorders demonstrated a positive effect of rehabilitation on physical functioning (P = 0.016), physical disability (P = 0.039) and fear/avoidance of pain ($P < 0.001$). However, return to work rates were not significantly different at 12 months, with 86% of the intervention group returning to work, compared to 73% receiving usual care. This out-patient intervention was delivered to groups of eight workers by a doctor, psychologist, physiotherapist and occupational therapist. It included 13 whole-day sessions, 5 return to work sessions and a feedback session over 2 months. Each day comprised four 90-min sessions, two graded physical activity sessions and two focussed on psychological issues. Each week, there was a relaxation session. A workplace visit was arranged in week three of the programme.

One high-quality Swedish RCT (n = 464) evaluated a multi-disciplinary rehabilitation programme for workers with non-specific musculoskeletal pain absent from work for 90 days [27]. The outcomes were rates of return to work and subsequent sickness absence over a 5-year period. There was better work stability in the multidisciplinary rehabilitation group (58% at work at 5 years compared with 52% in the control group). Over 3 years of follow-up, the mean number of sick days was reduced in the rehabilitation group more than the control group although absence rates in both remained above the Swedish average. Curiously, the better outcome was restricted to Swedish workers and was not seen in migrant workers. This out-patient programme involved a doctor, nurse, physiotherapist, occupational therapist, psychologist, social worker and a vocational counsellor. Following initial medical assessment, a multi-disciplinary case conference was held to identify obstacles to return to work with weekly reviews until return to work or another outcome (e.g. disability pension). The physiotherapist undertook sessions for pain management, relaxation, exercises and ergonomic education. The psychologist employed cognitive behavioural techniques on pain, coping strategies and stress management. The

occupational therapist and vocational counsellor supported workplace vocational training. The social worker provided social support, family counselling and liaised with authorities.

Several studies examined ergonomic training or ergonomic interventions in the workplace [28–31] and showed some benefits. In one study, the effects were not sustained throughout the 10 months of follow-up although, at 2 months, both the intensive ergonomic group and the education-only group showed significant improvements [28]. A study of active ergonomics training did not find any significant differences between the intervention and control groups in the intensity, frequency or duration of upper extremity symptoms [30]. This study excluded those receiving treatment for their disorders and included asymptomatic workers and workers with mild pain at baseline. As a result the population might not be representative and/or the effects might be diluted. A second study reported a non-significant reduction in pain severity in the hands/wrists of a group of computer operators given ergonomic training [31]. One cohort study studied staff moving to an office with improved workstations: overall satisfaction with the physical workstation was significantly associated with hand–arm symptom improvement [32]. It was unclear whether this study included non-specific arm pain and so it was rejected.

One well-conducted RCT found that stress management training and an ergonomic intervention were associated with improved upper extremity function and reduced pain at follow-up [29]. The ergonomic intervention included a workstation assessment and, where necessary, workstation adjustments to reduce ergonomic risks. There were no significant differences between the two groups for any outcomes including total functional impairment and work stress at 3 or 12 months. However, there were significant improvements in all subjects over time for pain, symptom severity and upper extremity function.

One low-quality unblinded study explored three stress management interventions: progressive relaxation, applied relaxation and Tai Chi [25]. Occupational outcomes were not measured in this study. All interventions had a favourable impact, in the short term, on musculoskeletal symptoms in the lower arm. The intervention group mean symptom score change, between assessments one and two (3 months apart), was not significant at 0.09 ± 0.2 points but the reference group scores increased by 0.6 points ($P < 0.0001$).

Two systematic reviews [16,33] examined the management of a range of work-related upper limb disorders, including non-specific musculoskeletal disorders. The Cochrane systematic review [16] concluded that there was limited evidence that breaks from computer work improved work-related complaints of the arm, neck or shoulder [34], when compared with no breaks [relative risk (RR) 1.83, 95% confidence interval (CI) 1.27–2.64]. The evidence for massage as an add-on to physical therapy was based on only one low-quality study [35] where the improvement was non-significant, RR 1.38 (95% CI 0.88–2.16). In general, there was a lack of consistent evidence for any benefit from workplace interventions. In part, the authors attributed this to the heterogeneity of the studies identified. Although the study by Verhagen *et al.* [16] was highly rated, the evidence identified in that systematic review was generally weak and included complaints of the neck and shoulder as well as the arm. As a result, this paper was not employed in drafting the guideline recommendations.

Conlon *et al.* [36] found that, for engineers using a computer for >20 h/week, a forearm support decreased right upper extremity discomfort (mean reduction in symptoms 0.35 on a discomfort scale with a range of 0–10). This RCT was graded as + but the observed effects, although statistically significant ($P = 0.035$), were so small as to be of little clinical relevance. As a consequence, this study was not employed in drafting the recommendations.

Another RCT studied the effects of a software programme that prompted computer users to take regular breaks [34]. Neither the frequency nor the severity of musculoskeletal complaints changed over the 12-week study. Similarly, sickness absence was not affected by the intervention. This study was not considered further.

A Dutch cohort study [37] examined the impact of modified work on the recurrence of sick leave due to musculoskeletal complaints. Undertaking modified work duties before returning to full duties reduced subsequent sick leave due to musculoskeletal complaints (odds ratio 0.37, 95% CI 0.18–0.75). However, there were concerns that the difference in outcomes might be due to some other unmeasured aspect of employment rather than the intervention *per se*. This low-quality study, with a high dropout rate, was not considered further.

For tenosynovitis, of the 19 papers selected for full text review, one was selected for detailed review and a further paper identified from a hand search of references. The remaining papers were rejected as they either lacked data on tenosynovitis ($n = 15$) or did not describe a workplace intervention ($n = 3$). One systematic review of conservative treatments [15] did not identify any primary research and was not considered further.

There was limited evidence for workplace interventions employing modified keyboards, in individuals with tendonitis [19]. Details of this paper have been given above. There was a significant trend towards improved hand function for those individuals using the Microsoft Natural keyboard™ over 6 month follow-up as compared with worsening hand function among the group randomized to standard keyboards. However, the diagnostic criteria employed were unlikely to distinguish between tendonitis (historically thought to be due to inflammation

of the tendon) and tenosynovitis (inflammation of the synovial sheath). This RCT of modified computer keyboards [19] employed clinical measures such as symptom reporting or change in hand function as primary outcomes. This study was graded as +, indicating that some of the quality criteria for an RCT had been met and that those criteria that had not been met were unlikely to alter the study's conclusions.

For lateral epicondylitis, 37 papers were selected for full text review and 3 for detailed review. Most of the 34 papers rejected did not provide data on lateral epicondylitis, 2 explored risk factors, 6 did not employ a workplace intervention and 1 was a study protocol.

The literature search identified one prospective cohort study of low quality [38] that explored a multi-faceted intervention to reduce musculoskeletal disorders. With a significant potential for selection bias, this study was not considered further.

One retrospective cohort study of splinting for lateral epicondylitis [39] was graded 'low quality' owing to the retrospective collection of data of doubtful validity from multiple centres (e.g. it was unclear what, if any, guidance had been given to clinicians when grading condition severity). The authors had adjusted for key confounders but there were substantial concerns that other unmeasured factors might have affected the study's conclusions and so it was not considered further.

There was a single RCT of a minimal educational intervention, in addition to usual care, in lateral epicondylitis management [40]. A significant potential for bias in this study (owing to a low recruitment rate and poor compliance in the control group) meant it was not considered further.

The findings from this systematic review were used to develop evidence-based guidelines for use in the workplace. In several cases, where it was not possible to make evidence-based recommendations due to a lack of evidence, the GDG made recommendations for consensus-based good practice points. The full guidelines are available online at http://www.rcplondon.ac.uk/pubs/contents/dc9e2de6-6463-43a5-ad73-aa5dd277e0bd.pdf and also on the NHS Plus website http://www.nhsplus.nhs.uk/.

Discussion

We undertook a comprehensive systematic review of the literature for the workplace-based management of four common upper limb disorders. Our searches revealed a very high number of potentially useful papers (n = 1532). However, closer scrutiny revealed a remarkably small number of publications that incorporated a workplace intervention and even fewer that evaluated the impact of the workplace intervention on employment outcomes such as absenteeism. Even where authors had evaluated a workplace intervention and occupational outcomes, we found few studies of high methodological quality.

A specific problem arose from the historical development of the SIGN method for the assessment of clinical interventions [11]. Its emphasis on RCTs as a gold standard is not particularly well suited to the occupational health literature, which has few RCTs and comprises mostly observational studies. Therefore, it is difficult to achieve recommendations with a SIGN rating above 3 in occupational health research. Some have argued for a different approach for developing guidance aimed at improving occupational health [41].

The review was based on systematic literature searches of the published evidence in peer-reviewed journals: there was the possibility of publication bias, with positive results being more likely to be published, giving a biased view of the consistency of evidence at the synthesis stage. This was beyond the control of the authors, and it was difficult to assess the impact of any such bias. Reviewers were not blinded to the identity of article authors or their affiliations. This review was restricted to the published evidence for the management of selected upper limb disorders in the workplace and, as such, did not address the wider evidence base in general practice or other clinical settings. Given this, there may be interventions which have been trialled in other settings which might be beneficial.

This systematic review was carried out prior to the publication of the PRISMA statement (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions [42]. The SIGN grading system, although commonly used for guideline development in the UK, is a rigid system with little flexibility [43].

Because of the paucity of high quality published evidence to address the key questions, a number of research recommendations are made. The review found that there has been insufficient focus on occupational outcomes in treatment trials for upper limb disorders. There is a need for experts in this field to agree consensus definitions of conditions to facilitate further research. Efforts to validate outcomes, including subjective outcomes such as self-rated pain, should be pursued. Researchers should address important work outcomes, such as sickness absence, and standardize their measurement. Further work is needed on computer workstations and alternative input devices.

It must be emphasized that this review has addressed interventions aimed at alleviating symptoms, rather than preventative action. It should not be assumed that the same actions will prevent the occurrence of upper limb disorders. Such disorders are frequently multi-causal and the role and contribution of workplace factors is often not clear [44].

Key points

- There was limited evidence that computer keyboards with altered force displacement characteristics or altered geometry were effective in reducing carpal tunnel syndrome symptoms.
- This review found limited, but high quality, evidence that, for workers with non-specific arm pain who have been absent from work for at least 4 weeks, multi-disciplinary rehabilitation programmes, including both physical and psychosocial approaches, may be beneficial.
- Further research is needed focusing on occupational management of upper limb disorders.

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Conflicts of interest

None declared.

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