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Prevention of Work-Related Shoulder and Neck Injuries: A Systematic Review

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ABSTRACT

Background

Musculoskeletal disorders accounted for 33% of all workplace injuries and illnesses in 2011; sprains, strains and tears accounted for 38% of injuries. Typically, injuries resulted from repetitive motion and required a median of 23 days away from work. Currently, there are no practice guidelines for the prevention of work-related shoulder and neck injuries. Due to the social and economic costs of workplace musculoskeletal injuries, there is an urgent need to identify the most effective preventative interventions.

Purpose

To evaluate the current evidence for workplace interventions for the prevention of work-related shoulder and neck injuries.

Method

A systematic search of the following databases was performed using a comprehensive set of categorized search terms: CINAHL, EMBASE, MEDLINE, and PsychINFO. The search was limited to English articles published after the year 2000, yielding 17 systematic reviews and 21 randomized controlled trials. A team of 3 researchers evaluated each systematic review and 2 researchers independently reviewed each randomized controlled trial using the PEDro scale.

Results

13 randomized controlled trials received a score of at least 6/9 on the PEDro scale and were included in this review. 11 articles investigating prevention of neck pain and injury yielded mixed evidence for ergonomic intervention, strength training, and all-around exercise. 2 separate studies showed positive evidence for microbreaks and for an integrated health program. 8 studies investigating prevention of shoulder pain and injury showed strong evidence for strength training and all-around exercise and mixed evidence for ergonomic intervention. 1 study showed positive effects of microbreaks.

Conclusion

Overall, there is a lack of quality evidence for the prevention of work-related shoulder and neck injuries. Current evidence shows a strong effect of strength training and exercise for preventing shoulder injuries. Ergonomic interventions, including forearm support, workplace modifications, and microbreaks have demonstrated mixed results. Strength training and all-around exercise should be utilized for the prevention of work-related shoulder injuries; however, more quality research needs to be performed to identify more effective interventions in this area.

RESEARCH ADVISOR FINAL APPROVAL FORM

The undersigned certify that they have read, and recommended approval of the research project entitled

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submitted by
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Chapter I: Introduction

The Occupational Safety and Health Administration defines a work-related injury to be an exposure or event that occurs in the workplace that either contributes to or causes a resulting condition or significantly aggravates a pre-existing condition.[1] More specifically, work-related upper extremity disorders (WRUEDs) are defined as musculoskeletal disorders of the upper limbs and neck.[2] These disorders can include tendon-related pathology, neovascular disorders, nerve entrapment, joint and joint capsule dysfunctions and other specific and non-specific disorders. WRULDs can be characterized by symptoms including pain, tingling, swelling, numbness, loss of coordination or strength, or any physical change that may affect an individual's ability to perform work or leisure activities.[3]

Work-Related Injury Statistics

According to the National Institute of Occupational Safety and Health (NIOSH), injuries to the neck and shoulder are among the most common to occur in the workplace.[4] In a review of epidemiologic studies from 1966 to 2004 by Huisstede et al, the prevalence of upper extremity musculoskeletal disorders in workers ranged from 30% to 47%.[5] More recently, musculoskeletal disorders were reported to account for 33% of all workplace injuries and illnesses in 2011; sprains, strains and tears accounted for 38% of injuries.[1] Primary contributing factors were repetitive tasks with consequent trauma and overuse or improper use; injuries required a median of 23 days away from work.[1] There are also excessive expenses associated with both specific and non-specific WRUEDs due to medical expenses, disability pensions, decreased productivity and absenteeism.[3] According to the National Research Council and Institute of Medicine, there is a great social and economic burden associated with these injuries, with an estimated 45-54 billion dollars spent annually.[6]

Contributing Factors

Work-related musculoskeletal disorders are multi-factorial in nature.[3,7] The interaction between organizational factors, individual factors and work-related physical complaints has been reviewed extensively as work-related injuries have become more costly in the United States. An epidemiological study by Devereux found that the relative excess risk from exposure to both physical and psychosocial risk factors was significantly greater than the excess risk from high exposure to only one set of factors, indicating the potential of a profound interaction effect.[7] Psychosocial risk factors in the workplace include increased workload, pressure to perform tasks in a timely manner, feelings of lack of control over job, monotonous work and decreased support from management and coworkers.[7]

Psychosocial factors that reside within and outside of the person have been shown to contribute to WRUEDs.[8] The stress a worker experiences can be derived from personal and work-related sources. Gupta (2008) describes several models from the occupational health and industrial psychology literature, applicable to practice that helps explain the possible relationships between psychosocial risk factors and WRUEDs.[9] The two prevalent models in the occupational health literature that link stress and work-related injuries are the Demands Control model (DCM) and the Efforts- Rewards Imbalance (ERI) model.[10] Both models explain job strain experienced by the worker with the DCM model attributing strain to decreased control over job demands and the ERI explains worker strain as a consequence of a mismatch between the effort put forth by the worker and the workplace reward. The job strain then translates to stress in the workplace.

When a worker experiences repeated stress, the individual's physiological stress response is activated. While the stress response can be positive in short bursts, adverse health effects result when stress becomes a chronic problem.[11] Chronic stress decreases the body's immune function and impacts sleep patterns and healing. Stress may also increase a worker's sensitivity to pain, heighten symptoms or diseases, and make the body more susceptible to harmful invasions process.[12] Some individuals who continue to experience chronic stress engage in other health-destructive behaviors, such as smoking and substance abuse, to attempt to cope. This behavior can affect one's ability to perform at work and can also be a safety concern for both the individual and others around them. Psychological stress plays a major contributing role in WRUEDs and must be considered when designing a multifaceted preventative approach. Workplace rehabilitation continues to focus largely on physical aspects of work, but as the evidence suggests psychosocial interventions must also be used to fully address all the possible contributing factors.

With regards to physical or work task requirements, according to NIOSH, there is a causal relationship between workplace exposures to forceful exertion, repetition, vibration, and awkward posture and disorders of the shoulder, neck and upper extremities.[4,7] It is often found that job tasks may include a combination of these exposures, which further increases the risk of injury; for instance, performing heavy lifting activities repetitively without using proper technique can increase the risk of injury. Specific areas of work may also contribute to the risk of injury. For instance, in the United States in 2011, the highest incidence rates of total non-fatal occupation illness and injury cases occurred amongst individuals working in fire protection, nursing and residential care facilities, steel foundries, ice manufacturing and skiing facilities.[13] Consideration of the physical and psychosocial demands of these areas of work is important when evaluating the risk of injury and may be useful in determining the appropriateness of each line of work given the individual's personal and environmental contextual factors.

Chapter II: Literature Review

In 2007, Boocock et al performed a systematic review of the literature from 1999 to 2004 investigating interventions for the treatment and prevention of WRULDs.[14] Researchers found some evidence supporting the use of mechanical interventions, such as workstation set-up, work environment and ergonomic equipment. It was also found that modifier interventions, such as the incorporation of exercise and rest-breaks, may have a positive impact on managing symptoms in some worker populations. This systematic review, however, included many low-quality studies that focused primarily on secondary and tertiary interventions; many studies investigated interventions to manage symptoms of already injured workers. Another systematic review by Kennedy et al in 2010 investigated the role of safety interventions and occupational health for preventing upper-extremity musculoskeletal disorders, however the studies included were mostly low-quality randomized control trials along with additional study designs that increase the risk of bias.[15] Given the lack of quality randomized control trials addressing this area of intervention, there are no clearly defined, evidence-based practice guidelines for physical therapists to consider for the prevention of work-related shoulder and neck injuries.

Due to the social and economic costs of workplace musculoskeletal injuries, there is an urgent need to identify the most effective preventative interventions. In Phase I of this study, a systematic review of the literature was performed to evaluate the current evidence for prevention of work-related elbow, forearm, wrist and hand injuries.[16,17] The purpose of this study is to evaluate the existing evidence for workplace interventions in the prevention of work-related neck and shoulder injuries.

Chapter III: Method

Search Method

CINAHL, MEDLINE, PsychINFO, and EMBASE were systematically searched for articles related to prevention of work-related shoulder and neck injuries. The search was limited to clinical trials, systematic reviews, randomized controlled trials, meta-analyses and practice guidelines published in English since the year 2000. EMG studies and articles that addressed athletic injuries were excluded.

Five categories of faceted search terms were generated using a combination of keywords and major subject terms. These categories consisted of "work terms," "anatomical terms," "dysfunction terms," "intervention terms," and "outcomes terms" (Table 1). Search terms within each category were searched with "OR" and combinations of categories were searched with "AND" (Figure 1).

Category	Term Examples
"Work Terms"	work, occupation, job, vocation…
"Anatomical Terms"	shoulder, neck, rotator cuff…
"Dysfunction Terms"	shoulder injury, shoulder pain, shoulder dysfunction, neck injury…
"Intervention Terms"	intervention, treatment, ergonomics, exercise, prevention…
"Outcomes Terms"	outcome measure, assessment, absenteeism, disability…

Table 1. Categories of search terms and examples of terms from each category.

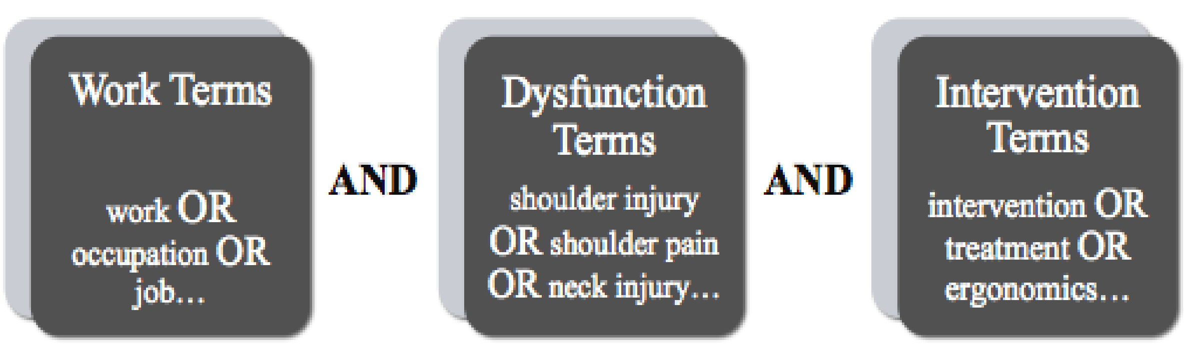

Figure 1. General search strategy: terms within each category were searched with "OR" and categories were searched with "AND."

To ensure an exhaustive search, five searches were performed in each database using unique combinations of search term categories. Because of the specific interest in work-related injuries, "work terms" were included in each search. Combinations of the four remaining categories yielded the final 5 searches (Figure 2).

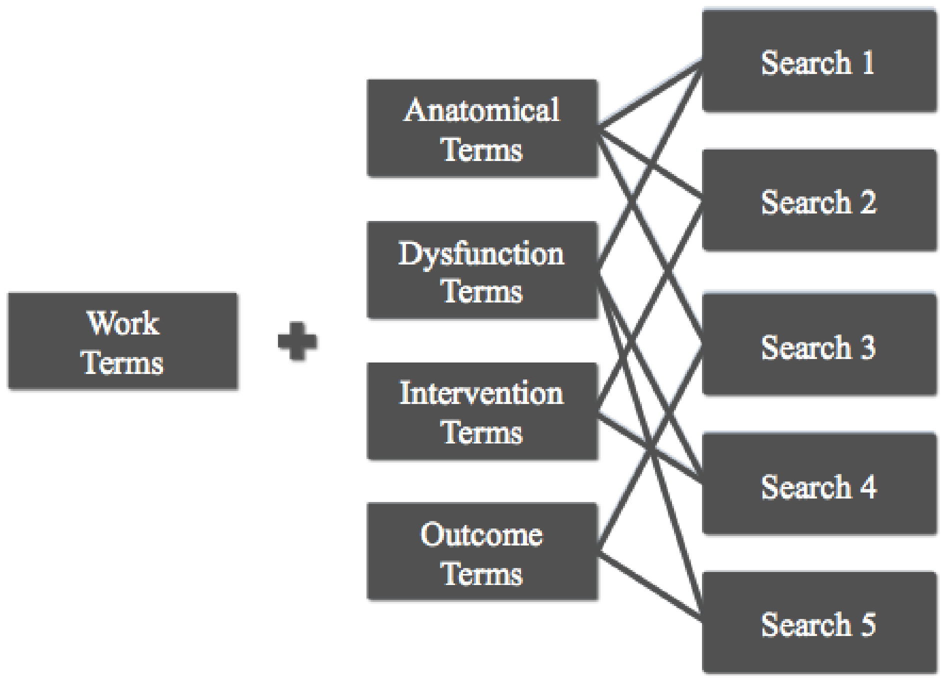

Figure 2. Various combinations of term categories resulted in 5 unique searches in each database.

The final search yielded 639 articles in CINAHL, 744 in MEDLINE, 99 in PsychINFO and 308 in EMBASE. Following removal of duplicates, 890 unique articles remained. Article titles were reviewed for broad relevancy; only articles that were particularly unrelated to the purpose of the study were removed. Next, abstracts were screened for articles that specifically addressed interventions for work-related shoulder and neck injuries. This process yielded 141 total articles, of which 17 were systematic reviews and 58 were randomized controlled trials.

The 17 systematic reviews were each independently reviewed by two researchers, while a team of three researchers reviewed the 58 randomized controlled trials. Researchers were specifically looking for articles that dealt with primary or secondary prevention of work-related shoulder and neck injuries. This process yielded two systematic reviews and 21 randomized controlled trials.

Of the 17 systematic reviews, 15 were immediately eliminated for the following reasons: subjects had pain at baseline, the article had been removed from its electronic journal because its methods were out of date, the article was a duplicate of another article, the article was not a true systematic review, and neck and shoulder articles were not included in the review. Finally, the two systematic reviews used both symptomatic and asymptomatic workers and thus had the potential for relevancy; however, it was determined that these reviews would not be included in the final review. Reasons for exclusion were that majority of the articles reviewed included subjects with pain at baseline and many of the articles that did not include subjects with pain at baseline were randomized controlled trials included in this review.

Quality Assessment

In order to assure that only high quality studies were included in our review, the physiotherapy evidence (PEDro) scale was used. Each randomized controlled trial was independently reviewed by two researchers using this scale in order to the rate the quality of each article. Disagreements between researchers were remedied by consensus or, if necessary, by third party. A criterion for inclusion in our final review was a score of 6/9 on the PEDro scale. A denominator of 9 instead of 11 was used due to the difficulty blinding subjects and therapists, and thus criterion 5 and 6 were eliminated. This process yielded 13 randomized controlled trials for inclusion in this review. Of the articles reviewed, 2 scored 8/9, 5 scored 7/9, and 6 scored 6/9 (Table 2). 8 randomized controlled trials were excluded from final review due to the following reasons: failure to meet our PEDro score inclusion criteria of 6/9, subjects had pain at baseline and lack of randomization or control group. Overall inter-rater reliability was strong as indicated by a kappa of 0.83. In addition, percent agreement was 91.9%.

Article	1	2	3	4	7	8	9	10	11	PEDro
Pillastrini et al, 2009	-	+	+	+	+	+	+	+	+	8
Rempel et al, 2006	+	+	+	+	-	+	+	+	+	8
Driessen et al, 2011	+	+	+	-	+	-	+	+	+	7
Blangsted et al, 2008	+	+	-	+	+	+	-	+	+	7
Pedersen et al, 2009	+	+	-	+	+	-	+	+	+	7
Andersen et al, 2008	+	+	-	-	+	+	+	+	+	7
Conlon et al, 2008	+	+	+	+	-	-	+	+	+	7
Horneij et al, 2001	+	+	-	+	+	-	-	+	+	6
Burnett et al, 2005	+	+	-	-	+	+	-	+	+	6
McLean et al, 2001	+	+	-	-	-	+	+	+	+	6
Tveito and Eriksen, 2009	+	+	+	+	-	-	-	+	+	6
De Kraker et al, 2008	+	+	-	+	-	+	-	+	+	6
Gerr et al, 2005	+	+	-	+	-	-	+	+	+	6

Table 2. PEDro assessment results. Items marked with a “+” indicate that this criteria was satisfied. Items marked with a “-“ indicate that this criteria was not satisfied. Criteria 5 and 6 were eliminated due to the difficulty blinding subjects and therapists.

Chapter IV: Results

Selected Study Characteristics

Of the 13 randomized control trials selected for final review, 11 articles addressed neck outcomes and 8 addressed shoulder outcomes. 7 of the 13 total articles reported on both neck and shoulder outcomes. Additional study characteristics and a summary of non-significant and significant results are listed in Tables 1-4 (Appendix).

Statistical Significance

A p value of less than .05 was used to determine statistical significance. This value is widely accepted in the literature and correlates with decreased risk of Type I error.

Neck Injury Prevention Results

Of the 11 studies investigating prevention of work-related neck injuries, 6 studies reported no statistically significant results.[18-23] The outcomes of these studies included pain intensity or duration, risk factor exposure and incidence of musculoskeletal disorder. Three studies investigated ergonomic interventions, such as postural training, workstation set-up, forearm support boards and use of an alternative computer mouse.[18-20] Studies by Horneij et al, Andersen et al and Blangsted et al explored individual physical training, including specific resistance exercises for the neck and back, as well as all-around physical exercise, consisting of general exercises to promote overall fitness.[21-23]

Significant results were found in 6 randomized controlled trials investigating the prevention of neck injuries. Therapeutic exercise and ergonomic intervention were the focus of these studies.

A large, examiner-blinded study by Blangsted et al, compared specific-resistance training of the neck and shoulders to all-around physical exercise and to health education alone.[23] Specific-resistance training resulted in significant differences in neck pain and development of symptoms compared to the education only group ($p<.00001$).

Burnett et al investigated the effects of exercise in a small study of high-performance aircraft pilots.[24] In this study, neck strength and discomfort were measured following resistance training using a multi-cervical unit or theraband. Resistance training in both the multi-cervical unit group and the theraband group resulted in increases in neck strength; however, only statistically significant increases were found in the multi-cervical group compared to the control group ($p<.05$).[24]

Pillastrini et al conducted a small study to examine the effectiveness of an at-work core exercise program for the prevention and management of neck and low back complaints in nursery school teachers.[25] Researchers found that performing specific core strengthening exercises throughout the day resulted in significantly improved Neck Disability Index scores and pain ($p=.0041$). It should be noted that there was a statistically significant difference in mean neck pain scores between groups at baseline ($p=.025$); therefore, the significantly improved scores of the intervention group may have been influenced by the baseline heterogeneity of the two groups.[25]

Two studies examining ergonomic interventions for neck injury prevention yielded statistically significant results. Rempel et al conducted a moderate-sized study of computer-based customer service workers to evaluate the effectiveness of using a forearm support board or trackball to reduce the incidence of upper body musculoskeletal disorders and pain.[26] Use of a forearm support board resulted in significantly reduced injury risk, indicated by a hazard risk ratio of .49 on a 95% confidence interval and reduced neck pain ($p=.01$).[26]

McLean et al investigated the effects of 20 minute and 40 minute interval micro-breaks on myoelectric signal, worker productivity and perceived discomfort in a moderate-sized study.[27] Researchers concluded that implementation of micro-breaks resulted in statistically significant reductions in neck discomfort, particularly when micro-breaks were taken in 20 minute intervals ($p< .05$).[27]

Tveito and Eriksen conducted a small study investigating the effect of an integrative health program on days of sick leave, health-related quality of life and neck complaints.[28] Researchers found that implementation of an integrative health program resulted in statistically significant fewer neck complaints when compared to the control group that received no intervention ($p <.023$).[28]

Shoulder Injury Prevention Results

Of the 8 randomized control trials investigating prevention of work-related shoulder injuries, 3 studies reported no statistically significant results. The outcomes of these studies included physical complaints or pain incidence. As previously described, Gerr et al and Conlon et al investigated ergonomic interventions and Horneij examined individual physical training interventions.[18,20,21] Horneij also included the effects of a stress management program on reducing incidence of musculoskeletal disorders and discomfort.[21]

5 randomized control trials investigating prevention of work-related shoulder injuries found statistically significant results. 3 of these studies investigated the effectiveness of therapeutic exercise interventions. The aforementioned study by Blangsted et al found highly significant decreases in shoulder pain and development of shoulder symptoms following specific resistance training and all-around physical exercise compared to education alone ($p < .00001$).[23] Andersen et al found that implementation of specific resistance training and all-around physical exercise programs resulted in statistically significant decreases in shoulder pain incidence, intensity and duration compared to the control group ($p<.01$).[22]

In a large study by Pedersen et al, researchers investigated the effects of specific resistance training and all-around physical exercise programs on strength and days of shoulder pain.[29] Results showed that implementation of a specific resistance training program or an all-around physical exercise program lead to fewer days of shoulder pain ($p<.01$).[29]

Rempel et al and McLean et al also reported significant findings for reducing risk of shoulder injury and shoulder discomfort following ergonomic intervention.[26,27] Rempel et al found a statistically significant reduction in shoulder injury risk, as evidenced by a hazard risk ratio of .49 on a 95% confidence interval and decreased shoulder pain, indicated by a p value of .002 follow the use of a forearm support board.[26] McLean et al found a statistically significant difference in shoulder discomfort following micro-breaks, specifically when micro-breaks were taken in 20 minute intervals ($p = .001$).[27]

Chapter V: Discussion

This review yielded no strong evidence for the prevention of work-related neck injuries. Evidence for ergonomic intervention and strength training were mixed, and there was no positive evidence for all-around exercise. The results for ergonomic intervention agree with a systematic review published by Hoe et al, as well as a systematic review by Driessen et al.[2,30] Both of these systematic reviews showed moderate evidence for forearm support with an alternative mouse in reducing neck discomfort and pain incidence, but had low to very low evidence for all other ergonomic interventions. The results for strength training differ from a systematic review conducted by Sihawong et al, in which researchers found no positive evidence for strength training in preventing work-related neck injuries.[31]

Conversely, this review yielded strong evidence for strength training and all-around exercise for the prevention of work-related shoulder injuries, as well as mixed evidence for ergonomic intervention. The aforementioned review by Hoe et al demonstrates similar results for ergonomic intervention; however, no currently published systematic reviews have investigated strength training for the prevention of work-related shoulder injuries.

Implications for Physical Therapy Practice

The results from this study have implications for physical therapy practice. With regard to strength training and exercise, physical therapists working to prevent shoulder and neck injuries should incorporate neck, shoulder and core strengthening, as well as encourage aerobic activity. Additionally, physical therapists should educate workers to take microbreaks and make ergonomic adjustments to their workstations. Finally, a potential method of delivering these interventions would be in the context of a workplace wellness program as preventative interventions become more widely utilized.

Chapter VI: Conclusion

There is an overall lack of quality evidence for the prevention of work-related shoulder and neck injuries. Strong evidence exists for strength training and all-around exercise for preventing shoulder pain. In contrast, there is conflicting evidence for ergonomic interventions for preventing both shoulder and neck pain. Finally, more quality research is essential to identify effective interventions in this area of practice.

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Appendix A: Tables 3-6

Table 3: Non-Significant Neck Results

Study	**Sample**	**Outcomes**	**Interventions**	**Results**	**PEDro**
Gerr, 2005	447 male and female computer users	Time to discomfort of >6/10 on VAS, use of pain medication, postural and workstation compliance	Alternative ergonomic adjustments vs conventional ergonomic adjustments vs no intervention (control); during work-week, 20 weeks	No significant difference in physical complaints	6
Driessen, 2011	3047 male and female office workers	JCQ and DMQ	Participatory ergonomics and educational intervention (Stay@Work) vs education intervention only (control); during work-week, 12 months	No significant difference in neck risk factor exposure	**7**
Horneij, 2001	282 male and female	NMQ, VAS, Pain drawing, Borg 6-20, questionnaires to address psychosocial factors and relaxation	IPT vs SM vs no intervention (control); 1.5 hours, 7x over 7 weeks	No significant difference in pain scores	6
Conlon, 2008	206 male and female engineers	Incidence MSD and mean discomfort score VAS	Alternative mouse with forearm support vs conventional mouse with forearm support vs alternative mouse alone vs conventional mouse alone (control); during work-week, 1 month	No significant difference in incidence or discomfort	7
Andersen, 2008	549 male and female office workers	Questionnaire for physical and general health, strength, anthropometric measurements	SRT vs APE vs verbal encouragement only; 20 minutes, 3x/week, 12 months	No significant differences in pain intensity or duration	7

Table 4: Significant Neck Results

Study	Sample	Outcomes	Interventions	Results	PEDro
Blangsted, 2008	549 male and female office workers	MSD questionnaire, modified NMQ	SRT vs APE vs health education only; 1 hour/week, 12 months	Decreased neck pain and development of symptoms in SRT group (p<.00001)	7
Burnett, 2005	32 male, high-performance aircraft pilots	Isometric cervical neck strength	MCU training vs THER training vs no intervention (control); 2x/week, 10 weeks	Increased neck flexion strength in MCU and THER groups vs control (64.4% and 42.0%); Increased neck extension and lateral flexion strength in MCU group vs control (62.9% and 53.5% /49.1%)	6
Tveito, 2009	40 female nursing home workers	Days of sick leave, SHC, DCM, HRQOL, SF36, IMOCF	Integrative health program vs no intervention; 1 hour/ week, 3x/week, 9 months	Fewer neck complaints in integrative health group vs control (p<.023)	6
Rempel, 2006	182 male and female call center workers	Incidence of MSD, pain VAS, incidence of acute injury, productivity	Forearm support vs trackball vs education only; work-week for 52 weeks	Protective effect of forearm support board - reduced injury risk by 50% (HRR = .49) Reduction in neck pain (p=.001)	8
McLean, 2001	15 female, computer workers	MES, discomfort VAS and productivity	40 and 20 minute interval microbreaks vs self-selected breaks; 3 hours during work-week for 4 weeks	Significant trend towards decreased neck discomfort with both 20-minute and 40-minute micro-breaks compared to control after 3 hours of computer work (p=.01)	6
Pillastrini, 2009	71 nursery school teachers	RMDQ, ODI and cervical-lumbar discomfort VAS	Graded core strengthening vs no intervention; 1 hour, 2x/week, 3 weeks	Significantly improved RMDQ (50%) and ODI (40%) scores (p<.0041) in graded core strengthening group compared to control	9

Table 5: Non-Significant Shoulder Results					
Study	**Sample**	**Outcomes**	**Interventions**	**Results**	**PEDro**
Gerr, 2005	447 male and female computer users	Time to discomfort of >6/10 on VAS, use of pain medication, postural and workstation compliance	Alternative ergonomic adjustments vs conventional ergonomic adjustments vs no intervention (control); during work-week, 20 weeks	No significant difference in physical complaints	6
Horneij, 2001	282 male and female	NMQ, VAS, Pain drawing, Borg 6-20, questionnaires to address psychosocial factors and relaxation	IPT vs SM vs no intervention (control); 1.5 hours, 7x over 7 weeks	No significant difference in pain scores	6
Conlon, 2008	206 male and female engineers	Incidence MSD and mean discomfort score VAS	Alternative mouse with forearm support vs conventional mouse with forearm support vs alternative mouse alone vs conventional mouse alone (control); during work-week, 1 month	No significant difference in incidence or discomfort	7

Table 6: Significant Shoulder Results

Study	Sample	Outcomes	Interventions	Results	PEDro
Blangsted, 2008	549 male and female office workers	MSD questionnaire and modified Nordic for neck and shoulders	SRT vs APE vs health education only; 1 hour/week, 12 months	Decreased shoulder pain and development of symptoms in SRT and APE group ($p<.00001$)	7
Pedersen, 2009	549 male and female office workers	Pain, physical activity, general health, strength, anthropometric measures	SRT vs APE vs no intervention, 20 minutes, 2-3x/week for 12 months	SRT and APE resulted fewer days of shoulder pain ($p<.01$)	7
Andersen, 2008	549 male and female office workers	Questionnaire for physical and general health, strength, anthropometric measurements	SRT vs APE vs verbal encouragement only; 20 minutes, 3x/week, 12 months	SRT and APE demonstrated statistically significant decreases in shoulder pain, intensity and duration compared to verbal encouragement group ($p<.01$)	7
Rempel, 2006	182 male and female call center workers	Incidence of MSD, pain VAS, incidence of acute injury, productivity	Forearm support vs trackball vs education only; work-week for 52 weeks	Protective effect of forearm support board - reduced injury risk by 50% (HRR = .49) Reduction in neck pain ($p=.002$)	8
McLean, 2001	15 female, computer workers	MES, discomfort VAS and productivity	40 and 20 minute interval microbreaks vs self-selected breaks; 3 hours during work-week for 4 weeks	Significant trend towards decreased neck discomfort with both 20-minute and 40-minute micro-breaks compared to control after 3 hours of computer work ($p=.01$)	6

Key: JCQ = Job Content Questionnaire; DMQ = Dutch Musculoskeletal Questionnaire; IPT= individual physical training; SM= stress management; NMQ= Nordic Musculoskeletal Questionnaire; SRT=specific resistance training; APE=all-around physical exercise; MSD=musculoskeletal discomfort; MCU=multi-cervical unit; THER=theraband tubing; SHC= subjective health complaints; DCML =Demand/Control Model - psychological demands and control; HRQL= health-related quality of life; SF-36= short-form 36; IMOCF= Instrumental Mastery Oriented Coping Factor; VAS = visual analogue scale; HRR = hazard risk ratio; MES= myoelectric signals; RMDQ = Rolland Morris Disability Questionnaire; ODI = Oswestry Disability Index