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Original Article

Effect of physical exercise interventions on musculoskeletal pain in all body regions among office workers: A one-year randomized controlled trial

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ABSTRACT

This study investigated effects of physical exercise on musculoskeletal pain symptoms in all regions of the body, as well as on other musculoskeletal pain in association with neck pain. A single blind randomized controlled trial testing a one-year exercise intervention was performed among 549 office workers; specific neck/shoulder resistance training, all-round physical exercise, or a reference intervention. Pain symptoms were determined by questionnaire screening of twelve selected body regions. Case individuals were identified for each body region as those reporting pain intensities at baseline of 3 or more (scale of 0–9) during the last three months. For neck cases specifically, the additional number of pain regions was counted. Intensity of pain decreased significantly more in the neck, low back, right elbow and right hand in cases of the two exercise groups compared with the reference group ($P < 0.0001$–0.05). The additional number of pain regions in neck cases decreased in the two exercise groups only ($P < 0.01$–0.05). In individuals with no or minor pain at baseline, development of pain was minor in all three groups. In conclusion, both specific resistance training and all-round physical exercise for office workers caused better effects than a reference intervention in relieving musculoskeletal pain symptoms in exposed regions of the upper body.

1. Introduction

Musculoskeletal pain symptoms in the back, neck and extremities are common subjective health complaints (Ferrari and Russell, 2003; Ihlebaek et al., 2007; Sjøgren et al., 2009), with high socioeconomic consequences in terms of health expenses and lost working days (Henderson et al., 2005). In occupational groups with monotonous and repetitive work tasks, e.g. computer users, neck pain is the most prevalent musculoskeletal complaint (Juul-Kristensen et al., 2006). While the aetiology of musculoskeletal pain symptoms is multifactorial with several physical and psychosocial risk factors at work as well as during leisure (National Research Council, Institute of Medicine, 2001; Punnett and Wegman, 2004; Andersen et al., 2007), there is general consensus about the beneficial effect of physical exercise. Both specific muscle training and all-round physical exercise have shown beneficial effects on neck pain as well as low back pain (Hayden et al., 2005; Ylinen, 2007; Andersen et al., 2008b; Blangsted et al., 2008). However, there is lacking knowledge about effects of physical exercise on musculoskeletal complaints in other regions of the body, as well as the preventative effect of exercise on development of pain symptoms in individuals without complaints.

Although neck pain is the most prevalent musculoskeletal complaint in office workers (Blangsted et al., 2008), pain symptoms in other body regions are reported as well (Juul-Kristensen et al., 2006). Thus, it is relevant to assess the effect of different exercise interventions on pain in all regions of the body. Furthermore, people with neck pain are more likely to experience other musculoskeletal pain in association with neck pain (Hagen et al., 2006; Juul-Kristensen et al., 2006) likely due to increased pain sensitivity (Arendt-Nielsen and Graven-Nielsen, 2008). Therefore, it is also relevant to assess the effect of different exercise interventions on other musculoskeletal pain specifically in association with neck pain. Previous randomized controlled trials on rehabilitation of neck/shoulder pain have considered neck/shoulder pain symptoms alone (Waling et al., 2000; Ylinen et al., 2003; Andersen et al., 2008b). In the present group of participants we have recently

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reported a beneficial effect of specific resistance training and all-round physical exercise on neck/shoulder pain symptoms (Andersen et al., 2008a; Blangsted et al., 2008).

The objective of the present study was to investigate effects of two different physical exercise interventions on (1) musculoskeletal pain in all regions of the body, and (2) other musculoskeletal pain in association with neck pain specifically. We hypothesized that both specific training and all-round physical exercise are more efficient than a reference intervention for reducing and preventing musculoskeletal pain symptoms in different regions of the body among office workers.

2. Methods

2.1. Study design

A single blind randomized controlled trial testing a one-year exercise intervention was performed. The procedure of participant recruitment has been described in detail previously (Andersen et al., 2008a; Blangsted et al., 2008). Briefly, participants were office workers recruited from 12 geographically different units of a national Danish public administration authority. Of the 2163 employees invited for the study, 1397 replied to the invitation, and 841 were willing to participate. Exclusion criteria were hypertension, disc prolapse, severe spinal disorders, history of severe trauma or other factors including pregnancy. In total 616 participants participated in the baseline test (397 females of age 44.6 yrs, body mass 68.2 kg, height 1.68 m; and 219 males of age 45.7 yrs, body mass 83.1 kg, height 1.81 m) of which further 24 were excluded due to the above mentioned criteria and 43 withdrew, leaving a total of 549 participants for the randomization. The participants were randomized at the cluster level into one of three intervention groups: specific resistance training (SRT, $n = 180$), all-round physical exercise (APE, $n = 187$), or a reference intervention without physical activity (REF, $n = 182$). Clusters of participants working in on the same floor or in the same building participated in the same type intervention to avoid contamination of the intervention and to enhance compliance. A total of 79 clusters were identified and cluster sizes ranged from 1 to 25 participants; only 9 clusters contained a single participant. At one-year follow-up 440 participants (~80%) replied to the questionnaire.

The study protocol was approved by the local ethics committee (KF 01-201/04), and qualified for registration in the International Standard Randomised Controlled Trial Number Register on http://isrctn.org, and has been assigned a unique trial identification number: ISRCTN31187106. All participants were informed about the purpose and content of the project, and gave written informed consent to participate.

We have previously reported the main results on this trial, showing approximately 30% reduction of neck/shoulder pain, 9–10% increase of neck/shoulder muscle strength, and improvements in metabolic syndrome related risk factors with the SRT and APE intervention (Andersen et al., 2008a; Blangsted et al., 2008; Pedersen et al., 2009).

2.2. Interventions

Intervention took place for a one-year period from February 2005 until January 2006. All participants were allowed a total of 1 h per week during working hours for the intervention activities, which have been described in detail previously (Andersen et al., 2008a; Blangsted et al., 2008) and are also described below.

SRT was performed for the neck and shoulder muscles. The core of the program was dynamic strengthening exercises (front raise, lateral raise, shoulder shrugs) performed for 2–3 sets of 10–15 repetitions, combined with static neck exercises (neck flexion, neck extension, lateral flexion) for repetitions of 5 s duration at 70–80% of MVC (Ylinen and Ruuska, 1994). The volume of training in SRT was set according to the recommendations by the ACSM for efficient gains of muscle strength in untrained individuals (Kraemer et al., 2002). The participants were encouraged to add weight when they were able to perform more than 15 repetitions per exercise. The training sessions ended with a high-speed dynamic power exercise, performed as 15 s all-out kayaking (Dansprint, Vanløse, Denmark) or ergometer rowing (Concept2, Inc., Morrisville, USA). Training was performed three times a week and each session lasted 20 min. Two of the three weekly sessions were supervised by experienced instructors.

APE had a primary goal of inspiring the participant to integrate physical activity into their daily lifestyle in a motivating way. The participants were encouraged to increase their level of physical activity both during leisure time and at work, and received information about location and opening hours of local swimming baths, fitness clubs, etc. Experienced instructors introduced different forms of physical activities for all-round strength and aerobic fitness during 1–4 monthly visits. Walking group sessions were organized, and some participants were supplied with step counters. In addition, an 8-min CD-based exercise program for aerobic fitness and general strength – but not specifically for the neck and shoulder area – was offered to the participants. The activities offered were varied throughout the year according to an activity program developed by a professional company, Dansk Firmaidrætsforbund (DFIF) in Denmark. As part of the motivation, each participant filled in a "contract" stating the ways that more physical activity could be included in the daily live, e.g. riding the bicycle for work instead of driving the car, joining the local fitness centre, climbing the stairs instead of using the elevator, etc.

Reference group (REF) had a main purpose of ensuring that the participants received attention similar to the two other groups. Participants were encouraged to form groups which should try to improve health and working conditions, e.g. through improved workplace ergonomics, stress management, organization of work, and cafeteria food quality. The participants themselves were responsible for organizing presentations about health-promoting activities that they found interesting, e.g. diet, stress management, weight loss, meditation, relaxation, and indoor climate. Staff from our departments supported the group by helping to organize the presentations. The participants in REF received the same amount of attention as the participants in SRT and APE, however no actual changes were implemented at the worksites.

2.3. Musculoskeletal pain symptoms

The participants replied to an internet-based questionnaire with regard to musculoskeletal pain symptoms in the neck, shoulders, elbows, hands, upper back, low back, hips, knees and feet. The regions were defined according to the Nordic Questionnaire (Kuorinka et al., 1987). Both the right and left side were included for the shoulders, elbows, and hands. Thus, a total of 12 body regions were included. Intensity of pain during the last three months was rated on a 10-point ordinal scale ranging from 0 to 9, where the following question was answered: "On average, how intense was your pain in [body part] during the last three months on a 0–9 scale?" (where 0 corresponded to "no complaints" and 9 corresponded to "pain as bad as it could be") (Brauer et al., 2003).

Subsequently, 'control' and 'case' individuals were defined for each region of the body as those reporting pain intensities at baseline of 0–2 (controls, i.e. no or minor pain) and 3 or more (cases, i.e. more severe pain), respectively, on a scale of 0–9. Thus, the frequency of cases and controls varies for each body region according to the percentage of cases as shown in Table 1.

For neck pain cases specifically, the additional number of pain regions was counted (i.e. 0–11 regions). A pain region was defined as a region with a reported pain intensity of 3 or more. For example, in a neck pain case individual reporting pain intensities of 3 or more simultaneously in the low back, shoulder, elbow, and hand, respectively, the additional number of pain regions were 4.

2.4. Statistics

All data were analyzed according to the principle of intention-to-treat. Baseline associations of pain intensity between different body regions were evaluated with non-parametric Spearman's correlation coefficient. Analysis of variance (ANOVA) was performed in SAS version 9 using the mixed procedure. While the distribution of pain intensity was skewed with a tail towards higher values, the change in response to the intervention (i.e. delta values) followed a normal distribution and was therefore used in the analysis. Test for main effects for the pre- to post-training change in pain intensity included *Region* (12 regions), *Group* (SRT, APE and REF) and *Status* (Case or Control). When a significant main effect was found, e.g. for *Region*, subsequent ANOVAs with fewer factors were used to locate differences. All values are reported as group mean ± SE unless otherwise stated.

3. Results

3.1. Baseline

At baseline, the most prevalent pain symptoms were in the neck region, whereas the least prevalent symptoms were in the left hand, left elbow and hips (Table 1). Intensity of neck pain was significantly related to pain in all other regions of the body ($P < 0.0001$), with correlation coefficients ranging from 0.17 to 0.21 for the left elbow, left hand, hips, knees and feet, 0.26 to 0.27 for the right elbow and right hand, 0.36 for the low back, and 0.46 to 0.57 for the left shoulder, right shoulder and upper back. The overall prevalence of symptoms was generally higher in women compared with men (Table 1).

Table 1
Baseline prevalence of pain symptoms in different regions of the body in female (F) and male (M) office workers, as well as for females and males together (F + M, $n = 544$).

	% Cases ($n = 544$)			Pain intensity (0–9)	
	F	M	F + M	Cases	Controls
Neck	53***	29	44	4.66 (0.10)	0.95 (0.05)
Low Back	43**	30	39	4.48 (0.11)	0.91 (0.05)
R Shoulder	36***	22	31	4.79 (0.13)	0.59 (0.04)
Upper Back	33***	17	27	4.29 (0.12)	0.57 (0.04)
Knees	20	19	20	4.37 (0.14)	0.41 (0.03)
R Hand	22*	14	19	4.18 (0.15)	0.42 (0.03)
L Shoulder	24***	9	19	4.83 (0.16)	0.37 (0.03)
Feet	18*	11	16	4.35 (0.16)	0.34 (0.03)
R Elbow	16	13	15	4.56 (0.19)	0.30 (0.03)
Hips	15***	5	11	4.70 (0.20)	0.19 (0.02)
L Hand	10	6	9	4.51 (0.24)	0.20 (0.02)
L Elbow	10*	4	8	4.27 (0.25)	0.13 (0.02)

*, **, *** Higher prevalence in F compared with M, $P < 0.05$, 0.01, 0.001, respectively. On the right hand side of the table is mean (SE) pain intensity for cases and controls at baseline. 'Cases' and 'Controls' were defined for each body region as those reporting pain intensities of ≥3 and 0–2, respectively, on a scale of 0–9.

3.2. Post intervention

In response to the intervention, there were main effects for *Region* ($F = 3.04$, $P < 0.0005$), *Group* ($F = 2.93$, $P = 0.05$), and *Status* ($F = 905$, $P < 0.0001$). Subsequent ANOVAs for each body region showed greater decrease in intensity of pain in the feet in APE compared with both SRT ($P < 0.001$) and REF ($P < 0.05$). For the remainder of body regions, no significant differences were observed between APE and SRT, and these were therefore collapsed in the statistical analysis and compared with REF to yield higher statistical power. Intensity of pain generally decreased over time among cases in all three intervention groups. However, an overall better pain relief was seen in SRT and APE compared with REF. Thus, intensity of pain decreased more in the neck, low back, right elbow and right hand ($P < 0.0001$–0.05) (Fig. 1, *left*). In individuals with no or minor pain symptoms of each specific body region (i.e. 'controls'), APE compared with REF had a preventative effect on development of pain symptoms in the right shoulder ($P < 0.05$) (Fig. 1, *right*), whereas no significant difference between the two exercise groups was found.

3.3. Neck cases

In neck pain cases compared with neck controls the additional number of pain regions (i.e. excluding the neck region) was 3.6 ± 0.16 and 0.98 ± 0.07 ($P < 0.0001$), respectively, at baseline. Thus, the number of additional pain regions was significantly higher for neck pain cases compared with individuals with no or minor pain symptoms of the neck.

In response to the intervention, the additional number of pain regions in neck cases decreased in SRT (−0.73 ± 0.36, $P < 0.05$) and APE (−0.91 ± 0.31, $P < 0.01$), whereas no significant decrease from baseline was observed in REF (−0.40 ± 0.32, n.s.).

4. Discussion

The main findings of this study are the beneficial effect of exercise on musculoskeletal pain symptoms in several regions of the upper body, as well as the decrease of additional number of pain regions in neck pain cases specifically. In contrast, the overall preventative effect of exercise in individuals without pain at baseline was less convincing, due to minor development of pain in all three groups.

The baseline questionnaire survey confirmed the high prevalence of neck pain among office workers, and verified the positive relation between neck pain and pain in other regions of the body (Hagen et al., 2006; Juul-Kristensen et al., 2006). These cross-sectional baseline data illustrate the importance of reducing not only neck pain in office workers, but also pain in other regions of the body.

During the one-year intervention period, complaints decreased more in the neck, low back, right elbow and right hand in the two exercise groups compared with the reference group. These findings were not significantly different between the two exercise groups. Whereas all-round physical exercise included overall body conditioning, the specific resistance training program was designed to target the neck/shoulder area specifically. However, a certain conditioning of the elbow, hand, and low back region inevitable occurs in response to neck/shoulder training with dumbbells, which may partially explain reduction of pain in these regions as well. This finding is of clinical relevance since these regions are exposed to prolonged low-force muscle contractions throughout the working day due to the monotony and repetitiveness of muscle activity during office work (Kilbom, 1994; Malchaire et al., 2001; Sluiter et al., 2001).

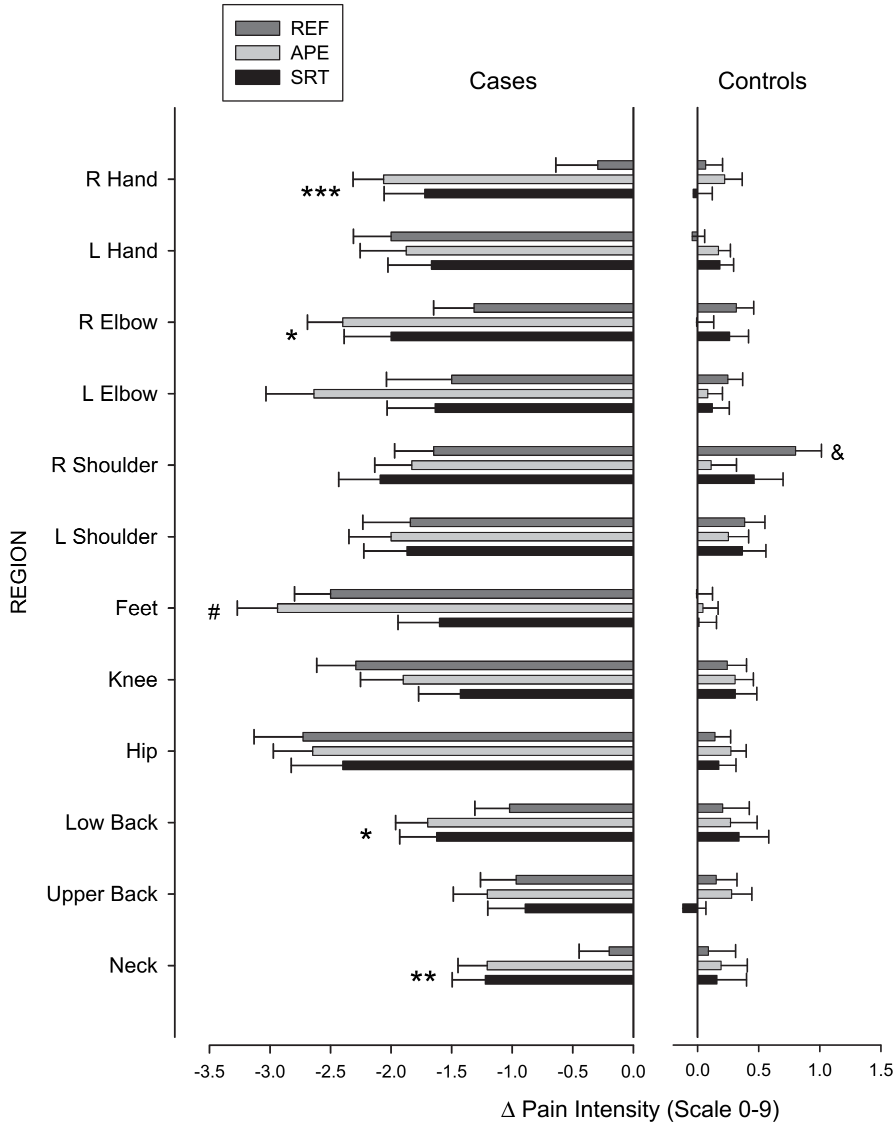

Fig. 1. Changes in pain intensity for each separate body region in cases (*left*) and controls (*right*) in response to the one-year intervention. 'Cases' and 'Controls' were defined for each body region as those reporting pain intensities at baseline of ≥3 and 0–2, respectively, on a scale of 0–9. (*, **, ***) Larger decrease from baseline in SRT and APE compared with REF, $P < 0.05$, 0.001, 0.0001, respectively. (&) Larger increase from baseline in REF compared with APE, $P < 0.05$. (#) Larger decrease from baseline in APE compared with SRT and REF, $P < 0.001$–0.05. SRT: Specific Resistance Training, APE: All-round Physical Exercise, REF: Reference intervention.

Another clinically relevant finding was the decrease of additional number of pain regions in neck cases in response to both types of exercise intervention. Several mechanisms can be speculated upon to cause this finding. Pain perception is known to be altered in chronic pain conditions, leading to central pain sensitization (Arendt-Nielsen and Graven-Nielsen, 2008). The present findings show beneficial changes in overall pain perception in response to exercise, indicating decreased pain sensitization.

A significant difference between the two exercise groups was only observed for pain intensity in the feet, which may be explained by the fact that all-round physical exercise also included conditioning of the lower extremities. However, this could also be a statistical type I error.

The overall preventative effect of exercise on pain development in office workers without pain at baseline was less convincing. Whereas all-round physical exercise compared with the reference intervention had a preventative effect of development of pain symptoms in the right shoulder, no significant differences between the two exercise groups were found. Further, no significant differences between the three intervention groups were observed for the remaining eleven body regions. Altogether, the overall preventative effect of exercise compared with the reference intervention on development of complaints in different regions of the body was very limited. This may be due to the length of the intervention period during which development of complaints was minor in those without symptoms at baseline in all three groups. On a scale of 0–9, the overall development of pain during the one-year period was less than 0.5 in most regions of the body. Likewise, previous preventative efforts have shown minor effects (Linton and van Tulder, 2001; van Poppel et al., 2004). Thus, future studies are recommended to employ long-term prospective follow-ups of several years to investigate possible preventative effects of exercise on development of musculoskeletal complaints in office workers, or to investigate preventative effects in more heavily exposed occupational groups, e.g. blue-collar workers.

Based on the present results, both all-round physical exercise and specific strength training can reduce pain in several regions of the body. Thus, the preferred type of exercise may be chosen when the goal is to reduce overall musculoskeletal pain.

In conclusion, both specific resistance training and all-round physical exercise for office workers caused better effects than a reference intervention on musculoskeletal pain symptoms in several regions of the upper body, as well as on the additional number of pain regions in individuals with neck pain specifically. In contrast, the overall preventative effect of exercise in individuals without pain at baseline was less convincing, due to minor development of pain in all three groups.

References

Andersen JH, Haahr JP, Frost P. Risk factors for more severe regional musculoskeletal symptoms: a two-year prospective study of a general working population. Arthritis Rheum 2007;56:1355–64.

Andersen LL, Jorgensen MB, Blangsted AK, Pedersen MT, Hansen EA, Sjogaard G. A randomized controlled intervention trial to relieve and prevent neck/shoulder pain. Med Sci Sports Exerc 2008a;40:983–90.

Andersen LL, Kjaer M, Sogaard K, Hansen L, Kryger AI, Sjogaard G. Effect of two contrasting types of physical exercise on chronic neck muscle pain. Arthritis Rheum 2008b;59:84–91.

Arendt-Nielsen L, Graven-Nielsen T. Muscle pain: sensory implications and interaction with motor control. Clin J Pain 2008;24:291–8.

Blangsted AK, Sogaard K, Hansen EA, Hannerz H, Sjogaard G. One-year randomized controlled trial with different physical-activity programs to reduce musculoskeletal symptoms in the neck and shoulders among office workers. Scand J Work Environ Health 2008;34:55–65.

Brauer C, Thomsen JF, Loft IP, Mikkelsen S. Can we rely on retrospective pain assessments? Am J Epidemiol 2003;157:552–7.

Ferrari R, Russell AS. Regional musculoskeletal conditions: neck pain. Best Pract Res Clin Rheumatol 2003;17:57–70.

Hagen EM, Svensen E, Eriksen HR, Ihlebaek CM, Ursin H. Comorbid subjective health complaints in low back pain. Spine 2006;31:1491–5.

Hayden JA, van Tulder MW, Malmivaara A, Koes BW. Exercise therapy for treatment of non-specific low back pain. Cochrane Database Syst Rev 2005. CD000335.

Henderson M, Glozier N, Holland EK. Long term sickness absence. BMJ 2005;330:802–3.

Ihlebaek C, Brage S, Eriksen HR. Health complaints and sickness absence in Norway. Occup Med (Lond) 2007;57:43–9.

Juul-Kristensen B, Kadefors R, Hansen K, Bystrom P, Sandsjo L, Sjogaard G. Clinical signs and physical function in neck and upper extremities among elderly female computer users: the NEW study. Eur J Appl Physiol 2006;96:136–45.

Kilbom Å. Repetitive work of the upper extremity: part I – guidelines for the practitioner. Int J Ind Erg 1994;14:51–7.

Kraemer WJ, Adams K, Cafarelli E, Dudley GA, Dooly C, Feigenbaum MS, et al, American College of Sports Medicine Position Stand. Progression models in resistance training for healthy adults. Med Sci Sports Exerc 2002;34: 364–80.

Kuorinka I, Jonsson B, Kilbom Å, Vinterberg H, Biering-Sørensen F, Andersson G, et al. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. Appl Ergon 1987;18:233–7.

Linton SJ, van Tulder MW. Preventive interventions for back and neck pain problems: what is the evidence? Spine 2001;26:778–87.

Malchaire JB, Roquelaure Y, Cock N, Piette A, Vergracht S, Chiron H. Musculoskeletal complaints, functional capacity, personality and psychosocial factors. Int Arch Occup Environ Health 2001;74:549–57.

National Research Council, Institute of Medicine. Musculoskeletal disorders and the workplase – low back and upper extremities. Washington D.C.: National Research Council, Institute of Medicine; 2001. ISBN-10: 0-309-07284-0.

Pedersen MT, Blangsted AK, Andersen LL, Jorgensen MB, Hansen EA, Sjogaard G. The effect of worksite physical activity intervention on physical capacity, health, and productivity: a 1-year randomized controlled trial. J Occup Environ Med 2009;51:759–70.

Punnett L, Wegman DH. Work-related musculoskeletal disorders: the epidemiologic evidence and the debate. J Electromyogr Kinesiol 2004;14:13–23.

Sjøgren P, Ekholm O, Peuckmann V, Grønbaek M. Epidemiology of chronic pain in Denmark: an update. Eur J Pain 2009;13:287–92.

Sluiter JK, Rest KM, Frings-Dresen MH. Criteria document for evaluating the work-relatedness of upper-extremity musculoskeletal disorders. Scand J Work Environ Health 2001;(27 Suppl. 1):1–102.

van Poppel MN, Hooftman WE, Koes BW. An update of a systematic review of controlled clinical trials on the primary prevention of back pain at the workplace. Occup Med (Lond) 2004;54:345–52.

Waling K, Sundelin G, Ahlgren C, Jarvholm B. Perceived pain before and after three exercise programs – a controlled clinical trial of women with work-related trapezius myalgia. Pain 2000;85:201–7.

Ylinen J. Physical exercises and functional rehabilitation for the management of chronic neck pain. Eur Medicophys 2007;43:119–32.

Ylinen J, Ruuska J. Clinical use of neck isometric strength measurement in rehabilitation. Arch Phys Med Rehabil 1994;75:465–9.

Ylinen J, Takala EP, Nykanen M, Hakkinen A, Malkia E, Pohjolainen T, et al. Active neck muscle training in the treatment of chronic neck pain in women: a randomized controlled trial. JAMA 2003;289:2509–16.