Scand J Work Environ Health 2011;37(2):120-128
https://doi.org/10.5271/sjweh.3141
Published online: 10 Jan 2011, Issue date: Mar 2011

The effect of workplace intervention on pain and sickness absence caused by upper-extremity musculoskeletal disorders

by Shiri R, Martimo K-P, Miranda H, Ketola R, Kaila-Kangas L, Liira H, Karppinen J, Viikari-Juntura E

Affiliation: Centre of Expertise for Health and Work Ability, Finnish Institute of Occupational Health, FIN-00250, Helsinki, Finland. rahman.shiri@ttl.fi

Refers to the following texts of the Journal: 2009;35(1):19-36 2010;36(3):189-201 2010;36(1):25-33 2004;30(1):56-63 2005;31(5):394-400 2009;35(4):301-308 1995;21(6):450-459

The following articles refer to this text: 2011;37(6):451-453; 2012;38(2):134-143; 2015;41(2):204-215

Key terms: elbow; epicondylitis; lifestyle; MSD; musculoskeletal disorder; pain; randomized controlled trial; RCT; rotator cuff; shoulder; sickness absence; upper-extremity; workplace intervention; wrist

This article in PubMed: www.ncbi.nlm.nih.gov/pubmed/21218270

Print ISSN: 0355-3140 Electronic ISSN: 1795-990X

Original article

Scand J Work Environ Health. 2011;37(2):120–128. doi:10.5271/sjweh.3141

The effect of workplace intervention on pain and sickness absence caused by upper-extremity musculoskeletal disorders

by Rahman Shiri, MD, PhD,[1] Kari-Pekka Martimo, MD, PhD,[1, 2] Helena Miranda, MD, PhD,[1] Ritva Ketola, MSc, PhD,[1] Leena Kaila-Kangas, MSc, PhD,[1] Helena Liira, MD, PhD,[1, 3, 4] Jaro Karppinen, MD, PhD,[1, 5] Eira Viikari-Juntura, MD, PhD [1]

Shiri R, Martimo K-P, Miranda H, Ketola R, Kaila-Kangas L, Liira H, Karppinen J, Viikari-Juntura E. The effect of workplace intervention on pain and sickness absence caused by upper-extremity musculoskeletal disorders. *Scand J Work Environ Health.* 2011;37(2):120–128. doi:10.5271/sjweh.3141

Objectives The aim of this study was to assess the effect of an ergonomic intervention on pain and sickness absence caused by upper-extremity musculoskeletal disorders.

Methods In this randomized controlled study, subjects aged 18–60 years (N=177) seeking medical advice due to upper-extremity symptoms were included if their symptoms, or the exacerbation of symptoms, had started <30 days prior to the medical consultation and immediate sick leave was not required. Workplace ergonomic improvements were made in the intervention group. Data on symptoms and sickness absences were gathered during one-year follow-up.

Results Pain intensity, pain interference with work, leisure time, or sleep did not differ between the intervention and control group during the one-year follow-up. During the first three months of follow-up, the percentage of employees with sickness absence due to upper-extremity or other musculoskeletal disorders did not differ between the intervention (N=89) and control (N=84) group, but the total number of sickness absence days in the intervention group was about half of that in the control group (mean 6.2 versus 9.8 days for upper-extremity disorder and 6.0 versus 11.5 days for upper-extremity and other musculoskeletal disorders combined). During 4–12 months of follow-up, the percentage of employees with sickness absence due to upper-extremity disorder (10.1% versus 16.7%, P=0.20) or upper-extremity and other musculoskeletal disorders combined (20.2% versus 32.1%, P=0.07) was lower in the intervention than the control group.

Conclusions Our findings suggest that an early ergonomic intervention reduces sickness absence due to upper-extremity or other musculoskeletal disorders.

Key terms elbow; epicondylitis; lifestyle; MSD; RCT; randomized controlled trial; rotator cuff; shoulder; wrist.

Upper-extremity musculoskeletal disorders (MSD) are a common health problem (1). There is evidence that high-force demands, awkward postures, repetitive work tasks, and use of vibrating tools may cause or exacerbate the symptoms of upper-extremity MSD (2–4).

Upper-extremity disorders may cause temporary and sometimes long-term work disability and therefore imply considerable costs for employers and society (5, 6). The duration of work disability episodes has been shown to vary amongst the different MSD (7). Of all upper-extremity disorders, shoulder disorders and carpal tunnel syndrome cause the longest sickness absences (5, 8).

The information on work disability related specifically to upper-extremity disorders is scarce. Most of the epidemiological studies on the predictors of MSD-related work disability, and of the workplace interventions aimed at affecting them, concern low-back problems, which are the most costly musculoskeletal conditions. Increasing evidence from these studies, as well as from studies on other MSD, indicate that

1 Centre of Expertise for Health and Work Ability, Finnish Institute of Occupational Health, Helsinki, Finland.
2 Mehiläinen Occupational Health Care, Helsinki, Finland.
3 Unit of General Practice, Helsinki University Central Hospital, University of Helsinki, Helsinki, Finland.
4 Kirkkonummi Health Centre, Kirkkonummi, Finland.
5 Department of Physical Medicine and Rehabilitation, University of Oulu, Oulu, Finland.

Correspondence to: Rahman Shiri, Centre of Expertise for Health and Work Ability, Finnish Institute of Occupational Health, Topeliuksenkatu 41 a A, FIN-00250, Helsinki. [E-mail: rahman.shiri@ttl.fi].

work disability is a complex phenomenon to which the worker, the employer, the healthcare provider, and the social system all contribute. Personal factors, such as female gender, older age, low social class, or the severity of the MSD all increase the risk of being disabled due to disease (5, 9–11). The most important predictors, however, can be found from the workplaces, among the physical and psychosocial exposures at work (9–11).

Ergonomic interventions have traditionally focused on adjusting physical workload factors, with the aim of reducing musculoskeletal symptoms, and the subsequent occurrence of sickness absences. A small study (12) showed that a multidisciplinary (psychological and physical) intervention is more effective than usual care in reducing the severity of upper-extremity symptoms and ensuring return to work, while another study (13) found that an ergonomic improvement in the workplace reduces the occurrence of sickness absence but not symptoms due to MSD. A systematic review (14) showed moderate evidence that workplace interventions can be effective in reducing sickness absence due to MSD, but not in decreasing musculoskeletal symptoms. Moreover, work modification is effective in helping subjects with MSD return to work (15). Another recent review (16), focusing only on upper-extremity disorders, concluded that due to the low number of high-quality studies, it is difficult to make strong evidenced-based recommendations. However, the authors discouraged activities that would engage only workstation adjustments. Some positive but limited evidence was found for ergonomics training combined with workstation adjustments (16).

In our previous paper (6), we reported that, among employees with incipient upper-extremity MSD, an ergonomic workplace intervention to improve ergonomics and adapt working conditions reduces productivity loss due to upper-extremity disorders. In this paper, we report the results of the effect of the intervention on pain intensity, pain interference with work, and sickness absence.

Methods

Participants

This randomized controlled study was carried out between February 2006 and December 2007 (6, 17). Three occupational health units covering 25 000 employees in the Helsinki metropolitan area were included. Subjects aged 18–60 years seeking medical advice due to upper-extremity symptoms were considered eligible if their symptoms or the exacerbation of symptoms had started <30 days prior to the medical consultation. The occupational health service personnel gave all potentially eligible employees preliminary information about the study and offered a possibility to be examined by a trained occupational physician at the Finnish Institute of Occupational Health in Helsinki. This assessment was scheduled to take place within three working days.

Upon arriving at the Finnish Institute of Occupational Health, the subject was informed about the study in more detail by a trained nurse and an occupational physician. After this, the subject signed an informed consent including permission for the physician to contact the subject's supervisor regarding possible changes to the subject's work. Permission was also requested for the collection of data from the medical records of the occupational health services on all diagnoses and dates of sickness absences during the follow-up.

A clinical examination was performed using standardized clinical protocol for each symptom entity proposed by Sluiter et al (18). Electroneuromyography was carried out among patients with symptoms or signs of a possible upper-extremity nerve entrapment. A consensus diagnosis was made by an expert panel of two specialists in physical medicine and rehabilitation using patients' clinical data. The subjects were invited to participate in the study if the examining physician diagnosed lateral or medial epicondylitis, rotator cuff tendinitis, impingement syndrome, de Quervain's or other wrist tenosynovitis, carpal tunnel syndrome, or entrapment of the ulnar nerve. Those whose symptoms did not meet the criteria for any specific disorder were also included in the study with the diagnosis of "nonspecific upper-extremity pain".

The subject was not included in the study if immediate sick leave was required. Other exclusion criteria included: (i) earlier or planned surgery due to upper-extremity disorder; (ii) active auto-immune disease; (iii) malignancy that was being actively treated or had been diagnosed within a year; (iv) fibromyalgia; (v) congenital or traumatic deformity of upper extremity; (vi) pregnancy; or (vii) planned retirement during follow-up.

The Coordinating Ethics Committee in the hospital district of Helsinki and Uusimaa in Finland approved this study.

Randomization

After the physical examination, the physician performed the randomization using tables of random numbers in three blocks (symptoms in wrist or forearm, elbow, and shoulder). Sealed envelopes were used.

Intervention

In the intervention group only, the physician contacted each employee's supervisor by phone (most supervisors were contacted on the same day) to discuss potential

accommodations at work, and a few days later an occupational physiotherapist visited the workplace. The aim of the worksite visit was to find ergonomic improvements that would be beneficial for the recovery from the upper-extremity disorder. The workplace assessment looked at the physical work environment, available tools or instruments, working postures, force requirements, work pace, and breaks during work, as well as the employee's possibilities to continue working. The suggestions were discussed together with the employee and the supervisor, the latter of whom then made the final decision on the technical and administrative changes and their financing. All physiotherapists working in the Finnish occupational health services have advanced training in occupational health and ergonomics. In addition, the physiotherapists in this study received special courses and web-based training on the intervention.

Outcomes

Information on pain intensity on the specific body area (scale from 0 = "no pain" to 10 = "the worst possible pain") and its interference with work, sleep, and leisure during the last week (scale from 0 = "no interference at all", to 10 = "the worst possible interference") was collected through an interview at baseline and via internet or a mailed questionnaire (in case the subject did not have an access to internet) at 2-, 8-, 12- and 52-week follow-up. Non-respondents to the follow-up questionnaires were sent one reminder.

Sickness absence data from the occupational health services and employment data from the personnel administration of each workplace were reviewed 12 months after the recruitment of the subject to the study. Information on dates, lengths, and diagnoses of all physician-prescribed sickness absences were obtained including also those issued by physicians outside the occupational health services as well as those of the short self-certified and nurse-prescribed sickness absences. The medical causes of sickness absence were recorded using the specific codes of the International Classification of Diseases (ICD), 10th edition for all physician-prescribed, and using the main categories of ICD for other sickness absences.

Sample size

We used sickness absence to estimate the sample size. We assumed a 10% difference in the proportion of employees on sick leave between the groups in favor of intervention. With the power of 80% and the level of significance of 0.05, a minimum of 205 subjects was considered necessary in each study group. In order to compensate for possible loss during follow-up, we aimed at 250 subjects in each group leading to a total of 500 subjects.

Blinding

Due to the nature of the intervention, neither the physicians nor the subjects could be blinded. However, the researcher making the interviews at follow-up was not aware of the group assignment.

Covariates

Exposure to physical load factors was assessed with an interview by a physician. The main tasks were identified with their proportional duration of the workday. The subjects were asked about the frequency of lifting loads weighing 5–10, 10–15 and >15 kg. The patients were also questioned about the duration of time spent working with hand above shoulder level and whether their work required frequent shoulder elevations. Using the keyboard, prolonged forceful gripping, as well as pinch grip that either required forceful exertion or deviated wrist posture, were also recorded. The use of vibrating tools was noted. Each workload factor was graded from 0–2, where 0 = "no exposure", 1 = "exposure <10%" and 2 = "exposures ≥10%" of the duration of the workday. In the analysis, each factor was dichotomized using a cut-off point of being exposed for ≥10% of the work time during a workday.

Job strain was measured with the job content questionnaire (19). The scale comprised five items for job demands and nine for job control. Responses were given on a 5-point scale ranging from "strongly agree" to "strongly disagree". To create a job strain variable, job demand and control scales were dichotomized at the median; the category "high job strain" included cases with both high demand and low control. Fear-avoidance beliefs were assessed using four items adapted from Waddell et al (20). A sum variable was calculated and scores ≥18 out of 24 were considered as elevated.

At baseline, the employee was asked about any sick leave(s) taken as a result of upper-extremity disorder during the preceding 12 months. Smoking status was classified into three groups: "never smokers", "former smokers", and "occasional or current smokers". Waist circumference was also measured. Leisure time physical activity for >30 minutes causing sweating and breathlessness was elicited; for the analysis, it was grouped into two levels: "≤2" or "≥3" times a week.

Statistical analysis

Statistical significance (2-tailed, $P<0.05$) for differences between the intervention and control group was assessed with chi-squared test for dichotomized variables and with 2-sample t-test for continuous variables. Generalized estimating equation was applied to analyze repeated measures data on pain-related outcomes

(21). We performed subgroup analyses to identify modifiable factors that could predict the intervention's effectiveness. The following variables were used for subgroup analyses: (i) age, (ii) job demand, (iii) job control, (iv) waist circumference (all dichotomized at the median), (v) job strain, (vi) fear-avoidance beliefs, (vii) leisure-time physical activity, (viii) exposure to most prevalent physical workload factors (lifting loads weighing ≥5 kg; working with hand(s) above shoulder level or work required frequent elevations of the arms, prolonged forceful gripping or pinch grip), (ix) prior sickness absence due to upper-extremity disorder, and (x) smoking. We performed subgroup analyses for sickness absence due to upper-extremity disorders, or upper extremity and other MSD combined. Due to missing data, subgroup analyses were not performed for pain related outcomes. We used STATA, version 10, (StataCorp, College Station, TX, USA) for the analyses.

Results

Participation

Altogether 222 patients were examined at the Finnish Institute of Occupational Health. The most common occupations were nurses and other healthcare workers (64%), secretaries and other clerical workers (25%), and warehouse workers (8%). Of 222 patients, 45 patients were excluded because they did not meet the criteria for eligibility and 177 subjects fulfilling inclusion criteria were recruited (figure 1). None of the eligible subjects refused to participate. The study was ended as planned even though the expected number of subjects was not achieved. This was mainly because recruitment rate was slower than expected.

Of 173 respondents (22 men, 151 women) to the question on pain intensity at baseline, 68 were lost to follow-up and of 172 respondents to the question on pain interference with work, 70 were lost to follow-up. Controls lost to follow-up had a higher pain intensity (mean 5.1 versus 4.5) and pain interference with work (5.3 versus 4.3) than those followed-up, while there were no differences within the intervention group between those lost to follow-up and those followed-up in pain intensity (mean 4.8 versus 4.8) or pain interference with work (5.0 versus 4.9).

Descriptive information

Of 173 patients with information on sickness absence, the mean age was 45.2 years and the majority were female (87.3%). The frequencies of upper-extremity disorders were as follows: specific shoulder disorders (28.3%), epicondylitis (27.8%), non-specific upper-limb pain (26.0%), wrist tenosynovitis (11.0%), median or ulnar nerve entrapment (4.6%), and other conditions (2.3%).

There was no considerable difference between the intervention and control group with respect to age, gender, smoking, body mass index, waist circumference, and job strain. However, the intervention group was less frequently exposed to physical loads than the control group (32.6% versus 45.1%, P=0.09).

Eight weeks after enrolment, 92% of the intervention group and 8% of the control group reported a workplace visit by an occupational physiotherapist. Ergonomic measures in the intervention group consisted of 412 suggested or implemented improvements such as purchasing new tools, changes to the keyboard and monitors, adjustment of chairs and tables and modifications to work or its environment (6). The majority of improvements (60%) were related to guiding the employee in self care, working posture, use of tools and instruments, using both hands in work tasks, and reorganizing work.

Pain-related outcomes

Pain intensity, pain interference with work, leisure time, or sleep showed a constant reduction over time (table 1). At the 2-week follow-up, pain interference with work was lower in the intervention than the control group (table 1). Pain intensity, pain interference with work, leisure time or

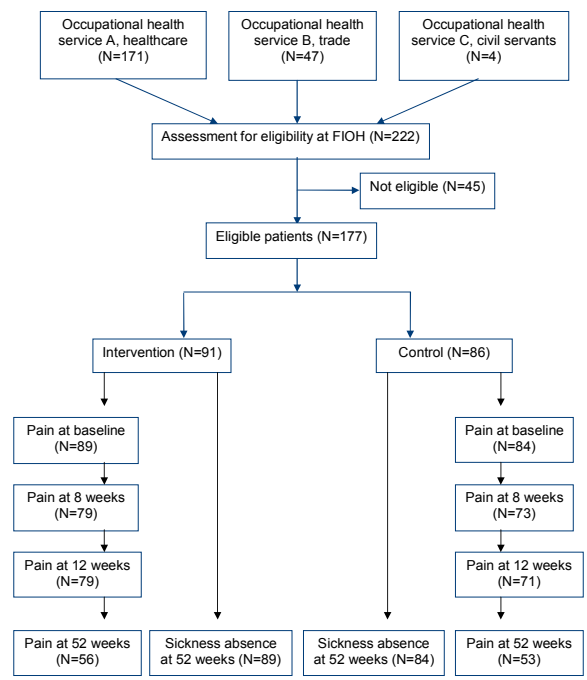

Figure 1. Flow diagram of the study

Table 1. Mean values for pain intensity and pain interference with work, leisure time and sleep in control and intervention groups during the follow-up period. [SD=standard deviation]

Pain	Control			Intervention			P-value
	N	Mean	SD	N	Mean	SD	
Baseline							
Pain intensity	84	4.75	2.25	89	4.84	2.04	0.78
Pain interference with:							
Work	83	4.69	2.60	89	4.93	2.80	0.56
Leisure time	84	4.33	2.44	89	4.73	2.51	0.28
Sleep	83	3.04	2.89	89	3.63	3.07	0.19
2-week follow-up							
Pain intensity	82	4.06	2.31	89	3.57	2.47	0.18
Pain interference with:							
Work	79	3.89	2.27	87	3.15	2.62	0.05
Leisure time	82	3.80	2.42	88	3.63	2.59	0.67
Sleep	82	2.63	2.82	89	2.36	2.70	0.51
8-week follow-up							
Pain intensity	73	2.97	2.58	79	3.27	2.53	0.48
Pain interference with:							
Work	71	2.94	2.70	79	2.56	2.48	0.36
Leisure time	72	3.17	2.78	79	3.18	2.75	0.98
Sleep	72	2.42	2.84	79	2.46	2.86	0.93
12-week follow-up							
Pain intensity	71	2.61	2.54	79	2.86	2.55	0.54
Pain interference with:							
Work	70	2.41	2.38	78	2.50	2.79	0.84
Leisure time	71	2.54	2.57	76	2.75	2.68	0.62
Sleep	69	1.81	2.45	78	2.19	2.69	0.37
52-week follow-up							
Pain intensity	53	2.43	2.85	56	1.91	1.77	0.24
Pain interference with:							
Work	52	2.08	2.69	55	1.47	1.82	0.17
Leisure time	52	2.27	2.68	56	1.82	2.05	0.32
Sleep	52	2.15	2.93	56	1.52	2.11	0.19

sleep did not differ between the intervention and control group at 8- or 12-week follow-up. At the 52-week follow-up, pain intensity and pain interference levels were again lower in the intervention than the control group.

Among subjects with information on pain intensity at all measurement points (N=105), pain intensity declined by 2.2 [95% confidence interval (95% CI) 1.3–3.2) units in the control group and 2.9 (95% CI 2.2–3.5) units in the intervention group (P=0.24) during the follow-up (figure 2).

Among subjects with information on pain interference with work at all measurement points (N=102), pain interference with work declined more in the intervention than the control group during follow-up [3.4 (95% CI 2.7–4.1) versus 2.3 (95% CI 1.5–3.1), P=0.037] (figure 2). However, a repeated measure analysis using generalized estimation equation including baseline, 2-, 8-, 12-, and 52-week data showed no significant difference in pain interference with work between the intervention and control group (data not shown).

Sickness absence

During 12 months of follow-up, the percentage of employees with sickness absence due to upper-extremity MSD (based on physician or nurse prescription) was 23.8% in the control group versus 19.1% in the intervention group (P=0.45), and 40.5% versus 31.5% (P=0.21), respectively, due to upper-extremity and other MSD combined.

During the first three months of follow-up, the percentage of employees with sickness absence due to upper-extremity or other MSD did not differ between the intervention and control group (table 2). However, the total number of sickness absence days due to these disorders was lower in the intervention group than the control group (mean 6.0 versus 11.5 days among those with sickness absence).

During 4–12 months of follow-up, the percentage of employees with sickness absence due to upper-extremity disorder, trauma to the musculoskeletal system, and upper-extremity and other MSD combined was lower in the intervention than the control group. However, with the exception of trauma to the musculoskeletal system, the total number of sickness absence days among subjects who had been on sick leave was somewhat higher in the intervention than the control group.

Sickness absence caused by conditions other than MSD did not differ between the intervention and control group during the follow-up (table 2).

In subgroup analyses, the occurrence of sickness absence during 4–12 months of the follow-up due to

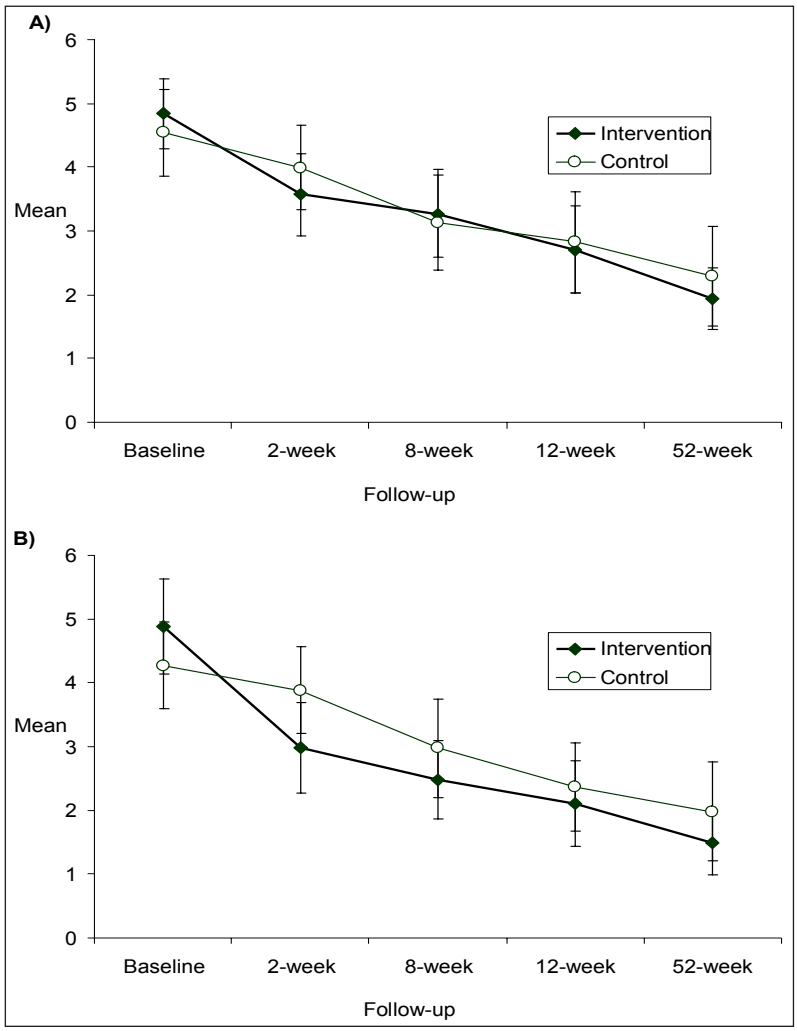

Figure 2. Pain intensity or pain interference with work in control and intervention groups among subjects with no missing information during 1-year follow-up. A) pain intensity (N=105); B) pain interference with work (N=102).

upper-extremity and other MSD combined was significantly lower in the intervention than the control group among older subjects, subjects with high pain intensity at baseline, subjects exposed to forceful or pinch grip, and those exposed to arm elevations or working with hand above shoulder level (table 3). The results were largely similar also with regard to sickness absence due to upper-extremity disorders, although only forceful or pinch grip reached statistical significance. Moreover, the occurrence of sickness absence was lower in the intervention than the control group in all subgroups of upper-extremity disorders (shoulder disorders, epicondylitis, non-specific upper-limb pain and wrist tenosynovitis) except median or ulnar nerve entrapment.

There were no differences in sickness absence between the control and intervention group in stratified analyses according to physical activity, job demand, job control, job strain, history of previous sickness absence due to upper-extremity MSD, waist circumference, or smoking.

Discussion

Our findings suggest that an early ergonomic intervention reduces sickness absence due to upper-extremity or other MSD. It may reduce interference of pain with work, but it does not affect upper-extremity pain.

Our findings are in line with a previous study (13) and review (14) showing that ergonomic improvements in the workplace reduce the occurrence of sickness absence but not symptoms due to MSD. This may be due to the fact that reducing exposure to physical workload factors can enable work with mild-to-moderate pain. Workers may also change their work style and cope better with their pain. Improvement in coping with pain may reduce the occurrence of sickness absence.

The intervention aimed at improving physical ergonomics at work in order to reduce disability due to upper-extremity disorders. However, in addition to a reduction in sick leaves caused by upper-extremity

Table 2. Percentage of subjects with sickness absence and mean number of sickness absence days due to musculoskeletal disorders in the control (N=84) and intervention (N=89) group.

Sickness absence	First 3 months							4-12 months						
	Control			Intervention			P- value	Control			Intervention			P- value
	%	Mean	SD	%	Mean	SD		%	Mean	SD	%	Mean	SD	
Upper-extremity disorder														
Subjects with sickness absence	11.9	·	·	10.1	·	·	0.70	16.7	·	·	10.1	·	·	0.20
Total number of days														
All subjects	·	1.17	4.6	·	0.63	2.1	0.32	·	2.88	9.4	·	2.36	10.0	0.72
Subjects with sickness absence	·	9.8	10.2	·	6.2	3.3	·	·	17.3	17.3	·	23.3	23.6	·
Musculoskeletal disorder other than upper extremity														
Subjects with sickness absence	3.6	·	·	3.4	·	·	0.94	13.1	·	·	10.1	·	·	0.54
Total number of days														
All subjects	·	0.45	3.1	·	0.10	0.6	0.30	·	0.92	3.0	·	1.46	5.1	0.39
Subjects with sickness absence	·	12.7	13.2	·	3.0	2.0	·	·	7.0	5.1	·	14.4	8.4	·
													·	·
Trauma to musculoskeletal system														
Subjects with sickness absence	0	·	·	1.1	·	·	0.33	7.1	·	·	2.3	·	·	0.12
Total number of days														
All subjects	·	0	·	·	0.12	1.2	·	·	1.00	5.4	·	0.21	1.6	0.19
Subjects with sickness absence	·	0	·	·	11	0	·	·	14.0	16.4	·	9.5	7.8	·
Any musculoskeletal disorder diagnosed by a nurse														
Subjects with sickness absence	1.2	·	·	3.4	·	·	0.34	8.3	·	·	1.1	·	·	0.02
Total number of days														
All subjects	·	0.02	0.2	·	0.09	0.6	0.32	·	0.32	1.2	·	0.03	0.3	0.02
Subjects with sickness absence	·	2.0	0	·	2.7	2.1	·	·	3.9	1.7	·	3.0	0	·
Any musculoskeletal disorder diagnosed by physician or nurse														
Subjects with sickness absence	14.3	·	·	15.7	·	·	0.79	32.1	·	·	20.2	·	·	0.07
Total number of days														
All subjects	·	1.64	5.6	·	0.94	2.53	0.28	·	5.12	13.2	·	4.07	11.2	0.57
Subjects with sickness absence	·	11.5	10.4	·	6.0	3.3	·	·	15.9	19.5	·	20.1	17.7	·
Condition other than musculoskeletal disorder														
Subjects with sickness absence	41.7	·	·	48.3	·	·	0.38	72.6	·	·	68.5	·	·	0.55
Total number of days														
All subjects	·	2.73	6.2	·	3.06	5.9	0.72	·	7.14	9.4	·	8.49	12.1	0.41
Subjects with sickness absence	·	6.54	8.3	·	6.33	7.2	·	·	9.84	9.7	·	12.39	12.9	·

disorders, we found a similar beneficial effect on other MSD (mainly low-back disorders). It is possible that the intervention was effective in reducing physical load factors, such as manual handling of loads and awkward postures, which are common risk factors for both upper-extremity disorders and low-back pain. Moreover, this intervention probably had an effect on psychosocial factors, such as supervisor's support, that are known risk factors for work disability.

The aetiology of upper-extremity MSD is multifactorial (22). In addition to work-related physical factors, psychosocial and individual factors also contribute to the development of upper-extremity disorders. Therefore, multifactorial intervention including modification of behavioral and lifestyle factors in addition to ergonomic modification may be more effective than merely ergonomic intervention. In this study, the subgroup analyses showed that subjects exposed to work-related physical load factors, older subjects, those with high pain intensity as well as those with higher level of physical activity especially benefitted from the intervention. However, the results of subgroup analyses should be interpreted cautiously, because of relatively small sample. Also, after correcting for multiple testing (Bonferroni correction), only physical load factors remained statistically significant in the subgroup analysis.

In our study, exposure to physical load factors was more common in the control than the intervention group. According to our subgroup analyses, employees with exposure to physical load factors benefitted more from the intervention than those without such exposures. Therefore, we may have underestimated the beneficial effects of the intervention. Pain intensity and pain interference with work decreased more in the intervention than the control group during the 1-year follow-up. However, repeated measures analysis showed no difference in pain-related outcomes between intervention and control groups. Controls lost to follow-up had a higher

Table 3. Percentage (%) of subjects with sickness absence due to any musculoskeletal and upper-extremity disorder during 4–12 months follow-up in the control (N=84) and intervention (N=89) group according to baseline characteristics (subgroup analyses).

Sickness absence	N	Musculoskeletal disorder			Upper-extremity disorder		
		Control	Intervention	P-value	Control	Intervention	P-value
Age (years)							
20–46	86	29	27	0.78	15	11	0.62
47–64	87	35	14	0.02	19	9	0.19
Physical activity							
≤2 times/week	86	34	25	0.35	24	13	0.17
≥3 times/week	82	31	14	0.06	11	5	0.35
Pain intensity							
Low (score <5)	85	22	20	0.80	9	10	0.86
High (score ≥5)	84	41	21	0.05	24	11	0.09
Lifting ≥5 kg							
No	120	22	17	0.56	12	9	0.58
Yes	51	48	30	0.19	26	15	0.36
Arm elevations or above shoulder							
No	148	26	21	0.44	14	9	0.37
Yes	23	70	15	0.008	40	15	0.18
Forceful or pinch grip							
No	153	25	22	0.60	13	10	0.55
Yes	18	100	9	<0.001	57	9	0.02
Job strain							
Low	117	33	21	0.13	18	11	0.23
High	38	30	22	0.58	15	11	0.72
Fear avoidance							
Low	144	30	19	0.11	16	7	0.09
High	24	56	27	0.15	22	20	0.89
Sickness absence during the past 12 months							
No	103	28	19	0.27	16	9	0.31
Yes	65	39	22	0.12	18	9	0.30

level of pain at baseline than those in the intervention group. It is difficult to know to what extent this loss to follow-up affected the results of the intervention. Assuming controls with high level of pain at baseline would continue to have high level of pain during the follow-up, we may have underestimated the true effect of intervention. However, assuming that controls with high pain improved more during the follow-up, we may have overestimated the beneficial effects of intervention. Moreover, the present study had a low power to detect the true effect of the intervention. A total of 410 subjects, 205 subjects in each arm, would have been necessary for the power of 80%.

Physicians contacted the supervisors by phone to discuss possible workplace modifications, which is not a common way to initiate an ergonomic modification, although it can be recommended. The supervisors were contacted after the workplace visit and made their final decision on the improvements suggested by the physiotherapist. It is possible that social support from the supervisor or the health service personnel decreased the willingness to seek sick leave (23).

In this study, due to the nature of the intervention, neither the physician nor the subject could be blinded. It is possible that physicians treated the intervention and control subjects differently during the follow-up when prescribing medication or sick leave. This may have had an effect on our findings; however, the direction of effect is unknown. It is possible that workers with pain may have high expectations about workplace interventions and their ability to reduce pain; if these expectations are not met, they may seek care and especially sick leave more eagerly ("nothing else helps my pain"). Only few employees in the control group were able to obtain ergonomic assistance. This may have slightly attenuated the beneficial effects of the intervention in our study.

In summary, our study suggests that, among workers with incipient upper-extremity disorders, an early ergonomic intervention reduces sickness absence due to upper-extremity or other MSD. This is contrary to many medical guidelines that recommend watchful waiting at an early stage of a MSD. Our findings encourage work disability prevention with measures targeted at work at an early stage of upper-extremity disorders.

Acknowledgements

This study was supported by Work Environment Fund and Academy of Finland. We thank Martti Rechardt, MD, for the physical examinations of the subjects.

References

1. Shiri R, Varonen H, Heliövaara M, et al. Hand dominance in upper-extremity musculoskeletal disorders. The Journal of Rheumatology. 2007;34:1076-82.
2. van Rijn RM, Huisstede BM, Koes BW, et al. Associations between work-related factors and the carpal tunnel syndrome--a systematic review. Scand J Work Environ Health. 2009;35:19-36.
3. van Rijn RM, Huisstede BM, Koes BW, et al. Associations between work-related factors and specific disorders at the elbow: a systematic literature review. Rheumatology. 2009;48:528-36.
4. van Rijn RM, Huisstede BM, Koes BW, et al. Associations between work-related factors and specific disorders of the shoulder--a systematic review of the literature. Scand J Work Environ Health. 2010;36:189-201.
5. Wilson d'Almeida K, Godard C, Leclerc A, et al. Sickness absence for upper limb disorders in a French company. Occup Med. 2008;58 (7):506-8.
6. Martimo KP, Shiri R, Miranda H, et al. Effectiveness of an ergonomic intervention on the productivity of workers with upper-extremity disorders--a randomized controlled trial. Scand J Work Environ Health. 2010;36:25-33.
7. Abasolo L, Carmona L, Hernandez-Garcia C, et al. Musculoskeletal work disability for clinicians: time course and effectiveness of a specialized intervention program by diagnosis. Arthritis and Rheumatism. 2007;57:335-42.
8. IJzelenberg W, Molenaar D, Burdorf A. Different risk factors for musculoskeletal complaints and musculoskeletal sickness absence. Scand J Work Environ Health. 2004;30:56-63.
9. Melchior M, Krieger N, Kawachi I, et al. Work factors and occupational class disparities in sickness absence: findings from the GAZEL cohort study. American Journal of Public Health. 2005;95:1206-12.
10. IJzelenberg W, Burdorf A. Risk factors for musculoskeletal symptoms and ensuing health care use and sick leave. Spine (Phila Pa 1976). 2005;30:1550-6.
11. Lötters F, Burdorf A. Prognostic factors for duration of sickness absence due to musculoskeletal disorders. The Clinical Journal of Pain. 2006;22:212-21.
12. Meijer EM, Sluiter JK, Heyma A, et al. Cost-effectiveness of multidisciplinary treatment in sick-listed patients with upper-extremity musculoskeletal disorders: a randomized, controlled trial with one-year follow-up. International Archives of Occupational and Environmental Health. 2006;79:654-64.
13. Luijsterburg PA, Bongers PM, de Vroome EM. A new bricklayers' method for use in the construction industry. Scand J Work Environ Health. 2005;31:394-400.
14. van Oostrom SH, Driessen MT, de Vet HC, et al. Workplace interventions for preventing work disability. Cochrane database of systematic reviews (Online) 2009:CD006955.
15. Carroll C, Rick J, Pilgrim H, et al. Workplace involvement improves return to work rates among employees with back pain on long-term sick leave: a systematic review of the effectiveness and cost-effectiveness of interventions. Disabil Rehabil. 2010;32:607-21.
16. Kennedy CA, Amick BC, 3rd, Dennerlein JT, et al. Systematic review of the role of occupational health and safety interventions in the prevention of upper-extremity musculoskeletal symptoms, signs, disorders, injuries, claims and lost time. J Occup Rehabil. 2010;20:127-62.
17. Martimo KP, Shiri R, Miranda H, et al. Self-reported productivity loss among workers with upper-extremitydisorders. Scand J Work Environ Health. 2009;35:301-8.
18. 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.
19. Karasek R, Brisson C, Kawakami N, et al. The Job Content Questionnaire (JCQ): an instrument for internationally comparative assessments of psychosocial job characteristics. Journal of Occupational Health Psychology. 1998;3:322-55.
20. Waddell G, Newton M, Henderson I, et al. A Fear-Avoidance Beliefs Questionnaire (FABQ) and the role of fear-avoidance beliefs in chronic low back pain and disability. Pain. 1993;52:157-68.
21. Hanley JA, Negassa A, Edwardes MD, et al. Statistical analysis of correlated data using generalized estimating equations: an orientation. American Journal of Epidemiology. 2003;157:364-75.
22. Staal JB, de Bie RA, Hendriks EJ. Aetiology and management of work-related upper-extremitydisorders. Best Practice & Research. 2007;21:123-33.
23. Melchior M, Niedhammer I, Berkman LF, et al. Do psychosocial work factors and social relations exert independent effects on sickness absence? A six year prospective study of the GAZEL cohort. Journal of Epidemiology and Community Health. 2003;57:285-93.

Received for publication: 30 September 2010