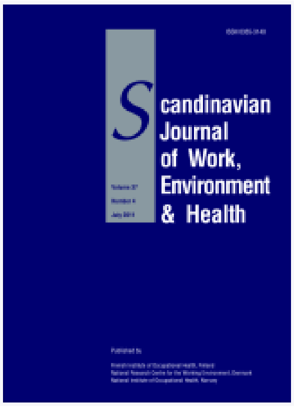

Original article

Scand J Work Environ Health 2004;30(5):399-409
doi:10.5271/sjweh.828

Neck and shoulder symptoms and disorders among Danish computer workers

by Brandt LPA, Andersen JH, Lassen CF, Kryger A, Overgaard E, Vilstrup I, Mikkelsen S

Affiliation: Department of Occupational and Environmental Medicine, Odense University Hospital, Sdr Boulevard 29, DK-5000 Odense C, Denmark. lars.brandt@ouh.fyns-amt.dk

Refers to the following texts of the Journal: 2003;29(3):197-205 1998;24(5):418-424 2002;28(4):215-221

The following articles refer to this text: 2008;34(1):55-65 2008;34(2):120-132 2013;39(6):568-577

Key terms: computer worker; Denmark; follow-up study; neck disorder; neck symptom; shoulder disorder; shoulder symptom

This article in PubMed: www.ncbi.nlm.nih.gov/pubmed/15529803

Scand J Work Environ Health 2004;30(5):399–409

Neck and shoulder symptoms and disorders among Danish computer workers

by Lars Peter Andreas Brandt, MD,[1] Johan Hviid Andersen, MD,[2] Christina Funch Lassen, MD,[3] Ann Kryger, MD,[3] Erik Overgaard, MD,[3] Imogen Vilstrup, MSc,[2] Sigurd Mikkelsen, MD[3]

Brandt LPA, Andersen JH, Lassen CF, Kryger A, Overgaard E, Vilstrup I, Mikkelsen S. Neck and shoulder symptoms and disorders among Danish computer workers. *Scand J Work Environ Health* 2004;30(5):399–409.

Objectives Neck and shoulder pain and disorders were studied among frequent computer users, and the associated effect of mouse and keyboard use was evaluated.

Methods Technical assistants and machine technicians were followed for 1 year. Questionnaires were sent to 9480 persons (initial response 73%, follow-up response 82%). Computer use information was obtained from the questionnaires. Symptom cases at baseline and follow-up were clinically examined using a standardized clinical protocol. The main outcomes were self-reported pain symptoms in the neck and right shoulder and clinical cases of rotator cuff syndrome, tension neck syndrome, and neck–shoulder pain with pressure tenderness.

Results The prevalence of moderate-to-severe pain in the neck and right shoulder was 4.1% and 3.4%, respectively, and the 1-year incidence for no or minor baseline symptoms was 1.5% and 1.9%, respectively. At baseline, the prevalence rate ratio (PRR) for neck pain was 1.7 [95% confidence interval (95% CI) 1.1–2.6] for mouse use >25 hours/week, that for right shoulder pain increased from 1.6 (95% CI 1.1–2.4) for 15–19 hours/week to 2.5 (95% CI 1.4–4.3) for >30 hours/week of mouse use, and that for tension neck syndrome increased from 3.5 (95% CI 1.0–12) for 25–29 hours/week to 4.7 (95% CI 1.2–18) for >30 hours/week of mouse use . The relative risk (RR) for new neck pain was 1.8 (95% CI 0.8–3.9) for keyboard use ≥15 hours/week and increased to 2.4 (95% CI 0.8–6.8) for ≥30 hours/week. New right-shoulder pain symptoms were associated with mouse use >20 hours/week (RR 1.9, 95% CI 1.0–3.5, and RR 3.3, 95% CI 1.2–8.9) and with keyboard use >15 hours/week (RR 2.2, 95% CI 1.0–4.9).

Conclusions Mouse use is associated with an increased risk of moderate-to-severe pain in the neck and right shoulder, and an association with tension neck syndrome is possible.

Key terms follow-up study, keyboard usage, longitudinal study, mouse device, myalgia, rotator cuff syndrome, tension neck syndrome.

Computerized technology is continuously developing, and new software has led to the introduction of new input devices and new ergonomic exposures. Concern has emerged regarding the use of the computer mouse as a new occupational hazard leading to adverse health effects in the neck and upper extremities. So far, however, there is limited evidence of a relation between work with a computer mouse and upper-extremity disorders. On the other hand, it is commonly understood that computer work can lead to neck and upper-extremity disorders. In a review, Punnett & Bergqvist (1) concluded that strong evidence exists for elevated risks of upper-extremity disorders among persons with data entry and similar intensive keying tasks, and, for hand and wrist disorders, the risk is related to hours of keying per day. The review found some evidence for the claim that computer work per se increases the risk for neck and shoulder disorders, most risk ratios varying between 1.7 and 3. Furthermore, evidence was found of an exposure–response relationship with hours of work with a computer per day. In addition, evidence of a positive association between years of employment and neck or shoulder disorders was highlighted. Results from a recent cross-sectional study among more than 25 000 computer workers suggested that self-reported physical symptoms increase with increasing duration of daily computer use with no threshold effect (2). Korhonen and his colleagues (3) found no association between computer use

1 Department of Occupational and Environmental Medicine, Odense University Hospital, Odense, Denmark.
2 Department of Occupational Medicine, Herning Hospital, Herning, Denmark.
3 Department of Occupational Medicine, Copenhagen County Hospital, Glostrup, Denmark.

Correspondence to: Dr L Brandt, Department of Occupational and Environmental Medicine, Odense University Hospital, Sdr Boulevard 29, DK-5000 Odense C, Denmark. [E-mail: lars.brandt@ouh.fyns-amt.dk]

for <50% of workhours, ≥50% of workhours, or the distance or deviance of computer mouse position and the 1-year incidence of self-reported neck pain (pain in the neck for ≥8 days during the preceding 12 months) (3). In his prospective study among 5033 computer users, Jensen (4) found an increased risk of 1.6 for neck pain among those using a computer 100% of the worktime as opposed to 0% to 25% of worktime, and a risk of 1.7 for computer mouse use 50–100% of the worktime as opposed to seldom usage (4). No data were given for shoulder pain. In a prospective study, Marcus et al (5) found that a protective effect on neck and shoulder disorders and symptoms of keying with an inner-elbow angle of <121 degrees diminished with increasing hours of keying per week. No data were given on hours of work with a mouse. In a cross-sectional study, Karlqvist et al (6) found an increased risk of 2 to 4 for disorders of the shoulders, arms, and hands with respect to work with a computer mouse ≥5.6 hours a week, when compared with <5.6 hours, among computer-assisted design (CAD) workers. Physiological studies have shown an increased load on the deltoid muscle when a computer mouse is used as opposed to nonmouse device use and keyboard work (7–9).

We report on a 1-year prospective study designed both to assess the prevalence and incidence of neck and shoulder symptoms and disorders among frequent computer users and to evaluate weekly mouse and keyboard use with respect to neck and shoulder disorders.

Study population and methods

Study population

A cohort of 9480 technical assistants and machine technicians organized in the Danish Association of Professional Technicians was identified in January 2000 through the register of union members. Their personal identification number and private postal address were obtained from the register. At baseline 6943 persons filled out the questionnaire, and 5658 returned the follow-up questionnaire after 1-year. For further details of the study population see the report of Andersen et al (10).

Questionnaire at baseline and 1-year follow-up

The baseline and follow-up questionnaires included questions on pain and discomfort in the neck and the shoulders during the previous 12 months and pain during the past 7 days on a nominal scale (8 pain categories: no pain, very mild pain, mild pain, mild-to-moderate pain, moderate pain, moderate-to-severe pain, severe, and very severe pain). The neck and the right shoulder region were shown in figures on the questionnaire. At follow-up the questionnaire contained the same questions as at baseline (except for demographic data and ergonomic factors).

Worktime variables

The participants estimated their average hours per week in specified worktasks during the last 4 weeks. The worktasks were divided into the subheadings of "worktasks without a computer" and "worktasks with a computer". Work without a computer could be worksite visits and the attendance of meetings. Work with a computer could be, for example, computer-assisted design (CAD), text editing, and data entry. The participants summed the estimated hours per week in all of the specified worktasks and checked that the sum was equal to their average workhours during the last 4 weeks. In this report, the term "computer time" refers to the average weekly hours of work with a computer during the last 4 weeks. Mouse time and keyboard time were estimated by multiplying the computer time with the proportion of time with active use of a mouse or keyboard, respectively, as measured by questionnaire responses in six categories [ie, almost all of computer time (1.0), approximately 75% of computer time (0.75), approximately 50% of computer time (0.5), approximately 25% of computer time (0.25), approximately 10% of computer time (0.1), and never or almost never (0)].

Ergonomic measures

The participants were asked to state the most common desk positions of their computer mouse and keyboard within 20-cm intervals. The trunk, right or left shoulder, and the front edge of the desk were used as the points of reference. An abnormal mouse position was defined as a mouse positioned >40 cm from the edge of the desk or >40 cm to the right of the right shoulder. An abnormal keyboard position was defined as the center of the keyboard positioned to the left or the right of the trunk. Forearm and wrist support during active mouse and keyboard use was reported (no support, support less than half of the time, and more than half of the time). An abnormal position of the computer screen was defined as placement above or beneath the eye line or to the left or right of the body. The participants also stated whether their chair and desk had been adjusted.

To account for other aspects of the arrangement of the workplace, we used a "mixed" ergonomic–psychosocial variable (How satisfied are you with the overall arrangement of your work place?) with the following response alternatives: very satisfied, satisfied, neither satisfied or unsatisfied, unsatisfied, very unsatisfied, don't know.

Psychosocial work characteristics

We assessed the psychosocial risk factors using a standardized questionnaire developed by the Danish National Institute of Occupational Health. The questionnaire included 10 items on job demands (4 on workload, 3 on sensory demands, and 3 on cognitive demands), 7 items on job control (4 on decision latitude and 3 on freedom at work), and 2 items on social support (1 on support from supervisors and 1 on support from colleagues). Responses with five alternatives (always, often, sometimes, seldom, and never or almost never) were dichotomized and given a raw score of 1 or 0, and three scales were constructed as raw score summations for job demands, job control, and social support. High scale values indicated a high level of job demand, a low level of job control, and a low level of social support. Cronbach's alpha was 0.79 for the 10-item demand scale and 0.75 for the 7-item control scale. The Spearman coefficient of correlation between the two items on social support was 0.49. If less than half of the items in a scale were missing, the missing values were estimated as the average of the other items. If half or more than half of the items in the scale were missing, the scale value was set as missing.

Personal characteristics

Data on several personal characteristics, including age and gender, were collected. Body mass index was calculated from self-reported weight and height and categorized into low, normal, and high (<19 kg/m^2, 19–26 kg/m^2, >27 kg/m^2). Leisure-time activity was categorized into low physical activity (almost none or light physical activity <2 hours/week or light activity for 2–4 hours/week) and high physical activity (light physical activity >4 hours/week or 2–4 hours with hard physical activity or hard physical activity for >4 hours/week). Type A and negative affectivity (was measured by two global questions behavior (Do you tend to be competitive, jealous, ambitious, and somewhat impatient? and Do you tend to be worried, nervous, or somewhat pessimistic?, respectively) with seven response alternatives (not at all, very little, a little, some, quite a lot, much, very much). The responses were dichotomized between "quite a lot" and "much". Poor social network was measured only at baseline by one question: "If you have problems, is it possible to obtain the necessary support from family or friends?" Responses with six alternatives (always, nearly always, usually, often, sometimes, and seldom or never) were dichotomized between "often" and "sometimes". The participants were asked if they suffered from specific medical conditions potentially associated with musculoskeletal or neurological impairment (eg, arthritis, osteoarthritis, neuritis, inflammation of the connective tissue, paralysis of part of the body, stroke, diabetes, thyroid illness, fibromyalgia), and they were asked whether their pain, if any, was due to an accident.

Symptom cases

Neck and right shoulder symptom cases at baseline were defined as participants who reported at least moderate pain in the neck or right shoulder during the last 7 days. Incident neck and shoulder symptom cases were defined as persons with no complaints in the region during the 12 months prior to the baseline examination and who had regional baseline current pain (last 7 days) that was less than moderate (none, very mild, mild, mild-to-moderate) and who, in the follow-up questionnaire, reported current pain (last 7 days) of at least moderate degree and that the pain during the 12 months under study had bothered them quite a lot, much or very much (as opposed to very little, little or somewhat).

Clinical cases

The persons defined as symptom cases at baseline, or incident symptom cases in the 1-year follow-up, were invited to a physical examination including a standardized interview and examination protocol to identify cases with specific clinical disorders. The clinical diagnoses included were (i) right-sided rotator cuff syndrome, defined as pain in the deltoid region of the upper arm on interview, a positive impingement test, and pain on resisted shoulder abduction, external rotation or internal rotation; (ii) tension neck syndrome**,** defined as pain and stiffness in the neck with palpation tenderness in the trapezius muscle on physical examination; and (iii) right shoulder myalgia, defined as substantial palpation tenderness in the trapezius muscle, the levator muscle of the scapula, or the supraspinous or infraspinous muscle. The persons with these diagnoses formed the clinical case group. Participants were not eligible for examination if they had had an operation in the neck or shoulder region, if pain was caused by trauma, or if they suffered from the aforementioned medical conditions.

The physical examination was performed by a trained physician in accordance with a standardized protocol. Immediately prior to the clinical examination the participants filled out the DASH (disabilities of the arm, shoulder, and hand) questionnaire. DASH collects 30 responses on physical function and symptoms, the raw scores being transformed to a 0–100 scale on which 100 reflects severe upper-limb disability (11). At this point, the participants also filled out a schedule concerning actual present pain in the neck and upper extremity regions.

The national ethics committee approved the study, and all the participants who attended the physical examination signed an informed consent prior to the examination.

The response rate to the questionnaire at baseline was 73.2%, and at follow-up it was 81.5%. The participation rates for those invited to the clinical examination were 82.2% and 74.2% for the neck symptom cases at baseline and at follow-up, respectively, and 84.6% and 79.7%, respectively, for the right shoulder symptom cases,

Analysis

The baseline associations were adjusted by means of Cox's proportional hazards model with a constant risk period to estimate the prevalence proportion ratio (PRR) for the cross-sectional analysis. All the risk factors were kept in the models irrespective of the level of significance (12, 13). All the risk factors are listed in table 1. Mouse device use and keyboard use were analyzed by assigning dummy variables to weekly usage time at 0–2.4, 2.5–4, 5–9, 10–14, 15–19, 20–24, 25–29, and ≥30 hours/week. Prior to this analysis we tested for nonlinearity in the relation between continuous weekly use in hours and neck and shoulder pain by fractional polynomial regression. There was no gain from including items other than the linear for mouse and keyboard use.

In the analyses with the follow-up data, the risk of developing moderate-to-severe neck or right shoulder pain was examined by Cox regression among the participants free of moderate-to-severe neck or right shoulder pain at baseline. Because of a shortage of incident cases (N=70 for neck pain, N=92 for shoulder pain) another strategy was used for the analysis of the follow-up data, for which intensity of mouse use was divided into four categories (0–9, 10–19, 20–29, and ≥30 hours/week), and keyboard use was classified as 0–4, 5–9, 10–14, and ≥15 hours/week. Other risk factors have been grouped into physical, psychosocial, and personal risk factors (see tables 2 and 3), and stepwise analyses were performed by forcing mouse and keyboard use into three models including each of the groups of potential confounders and eliminating all the factors with P-values of >0.15. The final model then included mouse and keyboard time (each with four dummy variables) and potential confounders with P-values of <0.15 in each of the models. To check for co-linearity, we calculated the correlation coefficient between the risk factors, and they were always <0.25. Time using the mouse and the keyboard were inversely correlated with a correlation coefficient of –0.33.

Results

The distribution of the neck pain scores at baseline was 64.0% for "no pain", 5.5% for "very mild pain", 10.8% for "mild pain", and 8.9% for "mild-to-moderate pain", 6.6% for "moderate pain", 3.1% for "moderate-to-severe pain", 0.8% for "severe pain", and 0.2% for "very severe pain" during the last 7 days. The corresponding figures for right shoulder pain at baseline were 78.5%, 5.2%, 8.4%, 6.3%, 4.3%, 2.4%, 0.8%, and 0.2%. The numbers, prevalences, and incidences of the symptom and clinical cases at baseline and follow-up, respectively, are shown in figure 1.

At baseline, the mean DASH score was 15.8 (SD 13.1) for the 1339 symptomatic participants and 18.4 (SD 13.6) for the 324 examined at the 1-year follow-up, representing a very mild degree of disability (13).

Weekly mouse and keyboard use

The PPR for neck and right shoulder pain and clinical disorders with mouse and keyboard times at baseline are shown in table 1. The PRR for neck pain increased from 1.7 (95% CI 1.1–2.6) for work with a mouse for 25–29 hours/week to 1.8 (95% CI 1.1–2.9) for >29 hours/week. The PRR for right shoulder pain increased from 1.6 (95% CI 1.1–2.4) for work with a mouse for 15–19 hours/week to 2.5 (95% CI 1.4–4.3) for >30 hours/week. There was no association between neck and shoulder pain and keyboard use. The PRR for tension neck syndrome at baseline increased from 3.5 (95% CI 1.0–12) to 4.7 (95% CI 1.2–18) when weekly mouse use increased from 25–29 hours to >30 hours. Due to too few cases, a restricted model was used for right shoulder myalgia. We did not find any statistically significant associations between right shoulder myalgia and weekly mouse or keyboard use.

The onset of new neck pain (incident cases) was associated with >30 hours/week of mouse use [RR 2.4 (95% CI 0.8–6.8)] and with >15 hours/week of keyboard use [RR 1.8 (95% CI 0.8–3.9)], whereas the onset of new right shoulder pain symptoms, which was associated with weekly mouse use of >20 hours/week, had risk estimates ranging from 1.9 (95% CI 1.0–3.5) to 3.3 (95% CI 1.2–8.9) (table 3) and keyboard use of >15 hours/week [RR 2.2 (95% CI 1.0–4.9)].

There were too few clinically confirmed incident cases for inclusion in the analyses of incident cases.

Ergonomic factors

Among self-reported ergonomic factors (position of screen, arm support, abnormal mouse or keyboard position, and adjustment of table and chair) the PRR for neck symptoms was 1.6 (95% CI 1.1–2.3) for sitting on an unadjusted chair. In addition, we found no association between ergonomic factors and our outcome variables at baseline or at the 1-year follow-up (tables 1–3).

Table 1. Adjusted prevalence rate ratios (PRR) with 95% confidence intervals (95% CI) for symptoms and clinical disorders in the neck and right shoulder at the baseline in relation to time with mouse and keyboard, physical and psychosocial workplace factors, and personal characteristics.

Physical workplace factors	Neck symptoms case (N=733)		Tension neck (N=100)		Right shoulder symptoms case (N=526)		Right shoulder myalgia (N=35)	
	Adjusted PRR	95% CI	Adjusted PRR	95% CI	Adjusted PRR	95% CI	Adjusted PRR	95%CI
Work with mouse in right hand								
Duration (hours/week)								
0–2.4	1	..	1	..	1	..	1	..
2.5–4	1.0	0.6–1.5	1.1	0.3–4.2	1.0	0.6–1.7	.	.
5–9	1.2	0.9–1.8	1.9	0.6–5.4	1.7	1.1–2.5	.	.
10–14	1.1	0.8–1.5	1.2	0.4–3.7	1.4	0.9–2.1	1.9[a]	0.7–4.8
15–19	1.4	0.98–1.9	2.1	0.7–6.1	1.6	1.1–2.4	.	.
20–24	1.3	0.9–1.9	2.8	0.9–8.4	1.7	1.1–2.6	1.7[a]	0.5–5.6
25–29	1.7	1.1–2.6	3.5	1.0–12	2.6	1.6–4.2	.	.
≥30	1.8	1.1–2.9	4.7	1.2–18	2.5	1.4–4.3	1.3	0.1–11.6
Arm support								
No arm support (mouse)	1	..	1	..	1	..	.	.
Arm support (mouse) <50% time	1.2	0.8–1.6	0.8	0.3–1.7	1.1	0.7–1.7	.	.
Arm support (mouse) ≥50% time	0.98	0.8–1.3	0.6	0.3–1.2	1.0	0.7–1.4	.	.
Abnormal mouse position	0.9	0.6–1.2	0.2	0.02–1.1	0.8	0.5–1.3	.	.
Work with keyboard								
Duration (hours/week)								
0–2.4	1	..	1	..	1	..	1	.
2.5–4	0.8	0.6–1.1	0.5	0.2–1.4	0.9	0.6–1.5	.	.
5–9	0.9	0.6–1.2	0.8	0.3–1.7	0.9	0.6–1.4	.	.
10–14	1.0	0.7–1.4	1.1	0.4–2.6	1.1	0.7–1.8	1.9[a]	0.8–4.3
15–19	0.97	0.7–1.4	1.2	0.5–3.1	1.3	0.8–2.1	.	.
≥20	1.2	0.7–1.9	1.3	0.4–4.9	1.3	0.7–2.4	1.3	0.2–11.2
Arm support								
No arm support (keyboard)	1	..	1	..	1	..	.	.
Arm support (keyboard) <50% time	1.3	1.0–1.6	1.2	0.7–2.2	1.1	0.9–1.5	.	.
Arm support (keyboard) ≥50% time	1.0	0.8–1.3	1.0	0.6–1.7	0.8	0.6–1.0	.	.
Abnormal keyboard position	1.2	0.9–1.5	0.9	0.5–1.8	1.2	0.9–1.6	.	.
Chair not adjusted	1.6	1.1–2.3	1.7	0.6–4.8	1.2	0.7–2.1	.	.
Desk not adjusted	0.8	0.7–1.0	0.5	0.3–1.0	0.7	0.5–0.9	.	.
Screen								
Too high	1.2	0.7–2.0	0.5	0.1–3.8	0.9	0.5–1.8	.	.
Too low	1.0	0.8–1.1	1.1	0.7–1.7	1.0	0.8–1.2	.	.
To the left or right	0.9	0.6–1.2	1.4	0.6–3.1	0.8	0.6–1.2	.	.
Not satisfied with workplace design	1.6	1.3–2.0	2.3	1.2–4.1	1.9	1.5–2.6	.	.
Psychosocial workplace factors								
High demands	1.4	1.1–1.7	1.4	0.8–2.6	1.5	1.1–1.9	.	.
Low control	1.1	0.9–1.4	1.2	0.6–2.2	1.2	0.9–1.6	.	.
Low social support	1.1	0.9–1.2	1.4	0.9–2.2	1.1	0.9–1.4	.	.
Time pressure	1.2	1.0–1.5	1.1	0.7–1.8	1.2	0.9–1.4	.	.
Personal characteristics								
Negative affectivity	1.4	1.1–1.7	1.0	0.6–1.8	1.2	0.9–1.5	.	.
Type A behavior	1.0	0.8–1.3	0.6	0.3–1.4	1.0	0.7–1.3	.	.
Age (10-year increments)	1.0	0.9–1.1	1.3	1.1–1.7	1.2	1.0–1.3	1.2	0.8–1.7
Female gender	1.7	1.4–2.1	2.7	1.5–4.9	2.2	1.7–2.8	7.2	1.7–30.3
Body mass index								
<19kg/m^2	1.2	0.8–1.8	1.7	0.7–4.4	0.9	0.5–1.6	.	.
≥27kg/m^2	1.2	0.9–1.7	0.4	0.1–1.7	1.1	0.7–1.7	.	.
Poor social network	1.0	0.8–1.3	1.2	0.6–2.3	1.0	0.7–1.4	.	.
High physical activity	0.9	0.8–1.1	0.9	0.5–1.3	0.9	0.8–1.2	.	.
Medical disorder	1.6	1.3–2.1	0.5	0.2–1.7	1.5	1.1–2.1	1.6	0.5–5.4
Pain started after accident	2.4	1.9–3.2	.	.	2.6	1.6–4.1	1.4	0.2–10.7

[a] Categories are combined.

Table 2. Relative risk (RR) with 95% confidence intervals (95% CI) for becoming a new neck symptom case during the follow-up, for those with no or mild symptoms at baseline. (Number of cases with new neck symptoms =70.)

Physical workplace factors	Model I[a]		Model II[b]		Model III[c]		Model IV[d]	
	RR	95% CI	RR	95% C I	RR	95% CI	RR	95% CI
Work with mouse								
Duration (hours/week)								
0–9	1	..	1	..	1	..	1	.
10–19	1.2	0.6–2.2	1.1	0.6–2.0	1.5	0.8–2.7	1.1	0.6–1.9
20–29	1.1	0.5–2.4	0.9	0.4–2.0	1.3	0.6–2.8	0.9	0.4–1.9
≥30	1.9	0.6–6.1	2.5	0.9–7.1	3.2	1.1–9.5	2.4	0.8–6.8
Arm support								
No arm support (mouse)	1	..	.	.	.	.	.	.
Arm support (mouse) <50% time	1.0	0.3–2.9	.	.	.	.	.	.
Arm support (mouse) ≥50% time:	1.1	0.5–2.5	.	.	.	.	.	.
Abnormal mouse position	.	.	.	.	.	.	.	.
Work with keyboard								
Duration (hours/week)								
0–4	1	..	1	..	1	..	1	.
5–9	0.9	0.4–2.0	1.1	0.5–2.3	1.1	0.5–2.4	1.1	0.5–2.2
10–14	1.0	0.4–2.3	1.0	0.5–2.3	0.9	0.4–2.2	1.0	0.4–2.2
≥15	2.1	0.9–4.6	1.9	0.9–4.3	2.2	0.97–5.1	1.8	0.8–3.9
Arm support								
No arm support (keyboard)	1	..	.	.	.	.	.	.
Arm support (keyboard) <50% time	0.6	0.3–1.4	.	.	.	.	.	.
Arm support (keyboard) ≥50% time	1.0	0.6–1.8	.	.	.	.	.	.
Abnormal keyboard position	1.0	0.4–2.2	.	.	.	.	.	.
Screen								
Too high	0.8	0.1–5.7	.	.	.	.	.	.
Too low	0.9	0.5–1.4	.	.	.	.	.	.
To the right or left	1.0	0.4–2.5	.	.	.	.	.	.
Chair not adjusted	1.0	0.2–4.3	.	.	.	.	.	.
Desk not adjusted	0.9	0.5–1.8	.	.	.	.	.	.
Not satisfied with workplace design	1.4	0.7–2.9	.	.	.	.	.	.
Psychosocial workplace factors								
High demands	.	.	1.7	1.0–2.8	.	.	1.7	1.0–2.7
Low control	.	.	1.3	0.8–2.2	.	.	.	.
Low social support	.	.	1.4	0.9–2.4	.	.	1.5	0.9–2.4
Time pressure	.	.	0.8	0.4–1.4	.	.	.	.
Personal characteristics								
Negative affectivity	.	.	.	.	1.3	0.7–2.5	.	.
Type A behavior	.	.	.	.	1.7	0.9–3.1	.	.
Age (10-year increments)	.	.	.	.	1.0	0.9–1.1	.	.
Female gender	.	.	.	.	1.9	0.9–4.1	1.9	1.1–3.3
Body mass index								
<19 kg/m²	.	.	.	.	0.8	0.2–3.4	.	.
≥27 kg/m²	.	.	.	.	0.9	0.3–2.9	.	.
Poor social net work	.	.	.	.	1.3	0.6–2.9	.	.
High physical leisure activity	.	.	.	.	1.3	0.8–2.2	.	.
Chronic disease	.	.	.	.	1.6	0.7–3.6	.	.
Pain started after accident	.	.	.	.	3.8	1.4–10.6	3.4	1.3–9.5

[a] Includes time with mouse and keyboard and physical workplace factors.
[b] Includes time with mouse and keyboard and psychosocial factors.
[c] Includes time with mouse and keyboard and personal characteristics.
[d] Final model, which included time with mouse and keyboard and all the other parameters from model I to III with P<0.15.

However, not being satisfied with the overall physical workplace design was strongly associated with the outcomes in the cross-sectional analyses, although this association disappeared in the follow-up.

Psychosocial workplace factors

High demands were associated with both neck and shoulder pain at baseline, but not with the clinical

Table 3. Relative risk (RR) with 95% confidence intervals (95% CI) for becoming a new right shoulder symptom case during the follow-up, for those with no or mild symptoms at baseline. (Number of cases with new right shoulder symptoms = 92.)

Physical workplace factors	Model I[a]		Model II[b]		Model III[c]		Model IV[d]	
	RR	95% CI	RR	95% CI	RR	95% CI	RR	95% CI
Work with mouse in right hand [e]								
Duration (hours/week)								
0–9	1	..	1	..	1	..	1	..
10–19	1.1	0.6–2.0	1.1	0.6–1.9	1.3	0.7–2.2	1.2	0.7–2.1
20–29	2.0	1.0 –4.0	1.8	0.98–3.4	2.0	1.0–3.8	1.9	1.0–3.5
≥30	4.0	1.5–11.1	3.0	1.1–8.1	2.9	1.0–8.7	3.3	1.2–8.9
Arm support								
No arm support (mouse)	1	..	.	.	.	.	.	.
Arm support (mouse) <50% time	1.4	0.6–3.7	.	.	.	.	.	.
Arm support (mouse) ≥50% time:	1.0	0.5–2.3	.	.	.	.	.	.
Abnormal mouse position	0.6	0.2–1.7	.	.	.	.	.	.
Work with keyboard								
Duration (hours/week)								
0–4	1	..	1	.	1	.	1	.
5–9	1.3	0.7–2.7	1.3	0.7–2.5	1.4	0.7–2.8	1.3	0.7–2.6
10–14	1.8	0.8–3.9	1.6	0.8–3.4	1.6	0.7–3.5	1.6	0.8–3.3
≥15	2.6	1.2–5.9	2.1	0.9–4.6	2.3	0.99–5.1	2.2	1.0–4.9
Arm support								
No arm support (keyboard)	1	..	.	.	.	.	.	.
Arm support (keyboard) <50% time	0.9	0.5–1.7	.	.	.	.	.	.
Arm support (keyboard) ≥50% time	1.1	0.7–1.9	.	.	.	.	.	.
Abnormal keyboard position	0.7	0.3–1.5	.	.	.	.	.	.
Screen								
Too high	.	.	.	.	.	.	.	.
Too low	1.0	0.6–1.6	.	.	.	.	.	.
To the right or left	1.2	0.5–2.8	.	.	.	.	.	.
Chair not adjusted	1.0	0.2–4.0	.	.	.	.	.	.
Desk not adjusted	0.9	0.5–1.6	.	.	.	.	.	.
Not satisfied with workplace design	1.0	0.5–2.1	.	.	.	.	.	.
Psychosocial workplace factors								
High demands	.	.	1.4	0.9–2.2	.	.	.	.
Low control	.	.	1.9	1.2–2.9	.	.	1.9	1.2–2.9
Low social support	.	.	1.3	0.8–2.1	.	.	.	.
Time pressure	.	.	1.0	0.6–1.6	.	.	.	.
Personal characteristics								
Negative affectivity	.	.	.	.	1.1	0.6–2.1	.	.
Type A behavior	.	.	.	.	1.3	0.7–2.4	.	.
Age (10-year increments)	.	.	.	.	1.0	0.9–1.1	.	.
Female gender	.	.	.	.	1.7	1.0–3.0	1.5	0.9–2.6
Body mass index								
<19 kg/m^2	.	.	.	.	1.0	0.3–3.2	.	.
≥27 kg/m^2	.	.	.	.	1.0	0.4–2.5	.	.
Poor social net work	.	.	.	.	1.8	0.9–3.4	1.5	0.8–2.9
High physical leisure activity	.	.	.	.	0.5	0.3–0.8	.	.
Chronic disease	.	.	.	.	3.0	1.6–5.6	.	.
Pain started after accident	.	.	.	.	3.1	1.0–9.9	3.0	0.9–9.5

[a] Includes time with mouse and keyboard and other physical workplace factors.
[b] Includes time with mouse and keyboard and psychosocial factors.
[c] Includes time with mouse and keyboard and personal characteristics.
[d] Final model, which includes time with mouse and keyboard, and all other parameters from model I to III with P<0.15.
[e] Mouse-related variables refer to right-handed use. Participants using the mouse in both hands were excluded from the analyses (N=524).

outcomes, and only with shoulder pain in the follow-up. Low job control did not show any association at baseline, but it predicted the onset of shoulder pain at follow-up. No associations were found with low social support or time pressure at work. All the associations between neck and

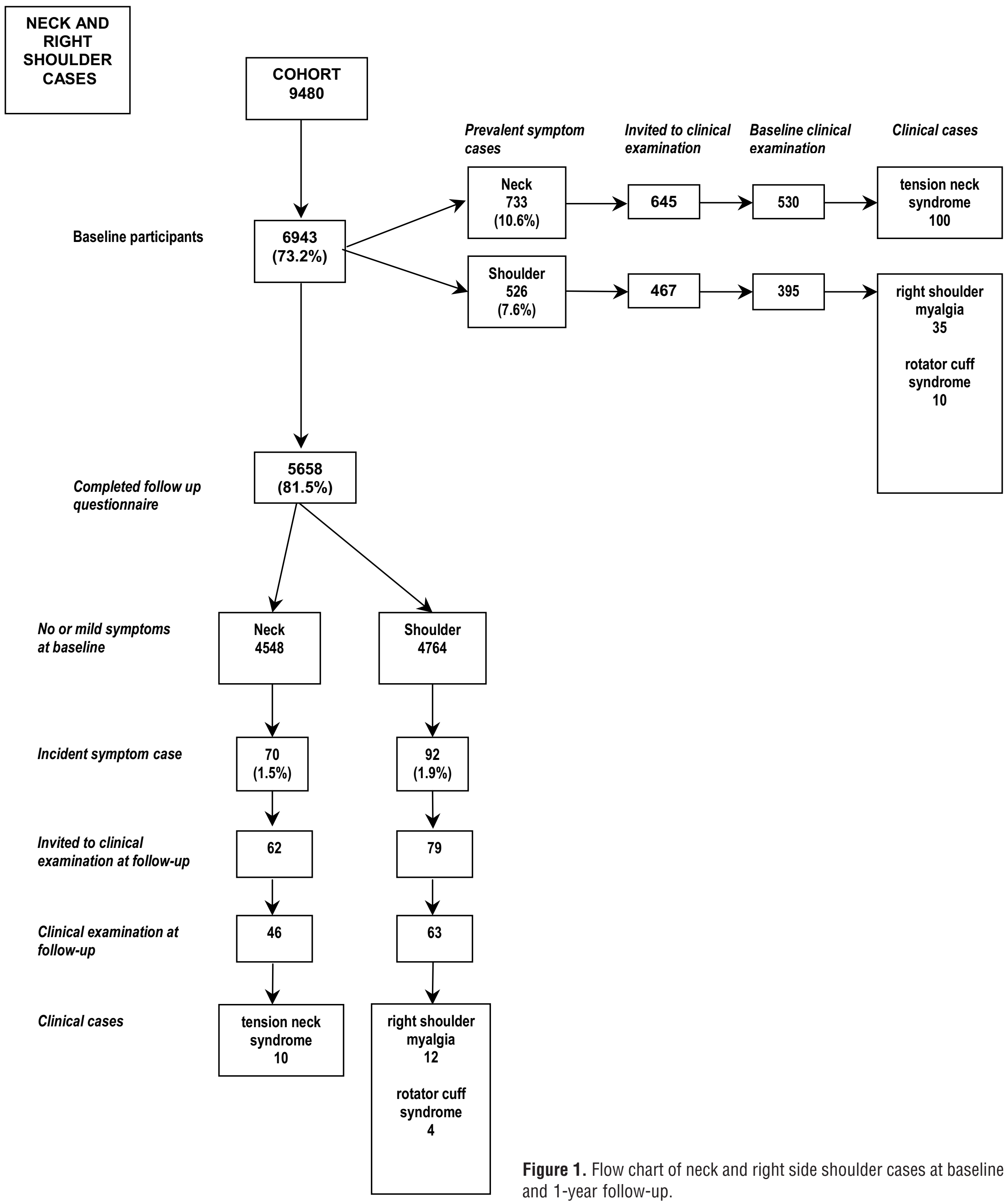

Figure 1. Flow chart of neck and right side shoulder cases at baseline and 1-year follow-up.

shoulder pain and psychosocial factors were very modest.

Personal characteristics

Women were at higher risk of both having and contracting neck and shoulder pain with prevalence rate ratios from 1.7 to 2.7 at baseline and relative risks from 1.5 to 1.9 at follow-up at different levels of use. The participants who had experienced trauma or had a systemic disease before baseline were consistently at higher risk of neck and shoulder pain in both of the two examinations. An association between age and shoulder symptoms and tension neck was seen at baseline, but not among incident cases at the 1-year follow up. High physical leisure-time activity was inversely related to new right-shoulder pain during the follow-up (RR 0.5, 95% CL 0.3-0.8). Negative affectivity was moderately associated with neck symptoms at baseline but not after 1-year of follow-up.

Discussion

The main finding of the study was a general pattern of positive associations between neck and shoulder pain complaints and mouse device use both in cross-sectional comparisons and at follow-up, even though the small case numbers at follow-up made the associations unstable in statistical terms. Time with keyboard use only contributed significantly in the follow-up analyses.

There were no associations between self-reported outcomes or clinical case status and self-reported ergonomic factors, but there were weak associations with work-related and private psychosocial factors and personal characteristics. Pain was highly associated with female gender, a former accident affecting the specific bodily region, and current medical conditions. Very few cases met commonly accepted specific criteria for clinical diagnoses. For example, the prevalence of tension neck syndrome was 1.4% at baseline, but the risk for tension neck syndrome among the participants who used their mouse for >25 hours/week was fourfold in comparison with no-or-minor use. Only 10 participants contracted tension neck syndrome during the study, representing a 1-year incidence of 0.2%. The prevalence (0.14%) and incidence (0.07%) of rotator cuff tendonitis were too small to make any meaningful inferences about this disorder with respect to mouse and keyboard use in both the baseline and follow-up data.

Mouse and keyboard times

This study benefits from a large cohort with a wide range of exposure time with the use of a computer mouse and a keyboard. The analyses with a mouse and keyboard used as continuous time variables did not indicate a threshold level for neck or shoulder pain at baseline or the 1-year follow-up (results not shown). If physical loads cause musculoskeletal pain, a "safe level" followed by increasing effect above a threshold would be assumed, but our data did not support such an assumption. The models for the associations between mouse and keyboard times were linear relations starting at 0 hours/week. There were no indications of a threshold level.

The associations could have been distorted by selection and information bias. To check for baseline selection bias, we tested whether the 964 cases with neck or shoulder pain at baseline had lower mouse times at follow-up than the noncases did. If so, the participants with pain might have migrated in the same direction before the study. Some of the baseline cases could have been symptomatic persons with earlier high exposure, who had attracted work-related pain and reduced their workload. Such an observation was made only to a small degree. The mean time of work with a mouse dropped from 15.1 to 13.4 hours/week among the cases, whereas the mouse work of noncases decreased from 13.7 to 13.5 hours/week during the follow-up. Therefore a mechanism concerning case migration from higher to lower exposure levels could have had only a minor effect. Potential selection bias was also tested in regard to study participation. Increased risk estimates could have been a result of selection bias if the participants with neck and shoulder symptoms working with a computer mouse tended to participate to a greater extent than persons without symptoms and with less computer mouse work. We would have expected to find higher risk estimates for the persons who responded to the questionnaire immediately and lower risks for those who responded after 1 and 2 reminders. This was however not the case at either baseline or follow-up. On the contrary, selection bias seemed to move away from the null [ie, an underestimation of the risk estimates was suggested by the fact that the association between the neck and shoulder symptoms and work with a mouse became stronger after each reminder (data not shown)].

Highly exposed participants with symptoms may exaggerate pain, and symptomatic participants may exaggerate exposures if they believe that pain is caused by exposure. Although the NUDATA study was introduced as a general investigation of work and health among technicians, public and media interests had claimed a relation between computer work and musculoskeletal health for a long time, and this claim could have encouraged biased responses to the questions on exposure and pain.

The misclassification of self-reported computer time was found in a recent study (14), in which self-reported keyboard time was overestimated to a higher degree at low objective levels than at higher exposure levels. Such misclassification due to the self-assessment of exposure would tend to diminish the slope of a true exposure-response relation.

We think that the baseline findings are of interest for comparison with other studies of computer use and musculoskeletal health, most of which are cross-sectional. However, the main findings are those based on the incidence data, and, with the hypothesis of a threshold effect, it is uncertain how and in which way bias would explain the observed relations between mouse and keyboard use and incident neck and shoulder pain. The risk estimates were adjusted for other physical, psychosocial, and personal factors that have been shown to be risk factors in other studies (15–18). We do not believe that other unmeasured factors in this study could be responsible for important residual confounding. Further assessment of threshold effects requires short-interval, repeated exposure and outcome measurements under circumstances that allow for the control of health-selection forces.

Symptoms and clinical disorders

Baseline levels of reports of pain were high in the NUDATA study. Interview data were obtained from 8% of the nonrespondents at baseline, and the 12-month and 7-day prevalences were 23.6% and 15.4%, respectively, for neck pain and 9.7% and 5.6%, respectively, for right shoulder pain. These levels are below those of the respondents, whereas the levels of computer work were equal among the nonrespondents and respondents, and therefore the risks in the cohort were probably somewhat overestimated when solely calculated from respondents' data.

Diagnoses were few in our study. Only 2.1% met our criteria for a neck or shoulder disorder at baseline, and this percentage is lower than the baseline prevalence among keyboard operators in a recent study (19). The 0.5% incidence of neck or shoulder disorder was lower than in an older population study (20), and the findings related to tendons (0.14% at baseline) were fewer than in a recent prospective study, which found a baseline prevalence of 0.5% for rotator cuff tendonitis (based, however, on only three cases) (19). If our definitions of pain had been less strict, the prevalence of the diagnoses would have been about twice as high.

A differential loss to follow-up could have contributed to the level of incident diagnoses in our study. Altogether 1285 participants were lost to follow-up, while 283 persons who were no longer working at follow-up participated. The prevalence of pain and clinical signs at baseline among those who left the cohort did not differ from those of the persons who participated in the 1-year follow-up, nor did the level of pain differ among the group that did not work at follow-up and those who did work. It is unlikely that selection bias accounted for the few clinical diagnoses, but more likely our findings represent a truly low prevalence and incidence of clinical disorders among computer operators. In spite of this finding, many computer users do have pain complaints. The 1-year incidence of neck pain reported in recent studies was 25.5% (4) to 34.4% (3). In these studies, case definitions were similar, including baseline pain for <7 days, and ≥8 days with pain in the follow-up year. According to this case definition, our annual incidence of neck pain would have been 17.2% (95% CI 15.8–18.5). The argument for the aforementioned case definition was that some days with neck pain (<8 days) do not indicate a disorder, but how many days should one experience pain before it becomes a disorder? However, the higher level of pain, and the more clinical the findings, the more limited the social functioning (18). Pain levels also seem to vary a great deal. On the day of the clinical examination, our participants filled out the same screening instrument that they had filled out 2 to 3 weeks before the examination. Less than 30% of cases scored ≥4 on the day of the examination. It seems that pain symptoms are, to a large extent, temporary and variable, and these characteristics could be one explanation for the very low prevalences and incidences of more chronic conditions.

In the absence of an understanding of the relevance and importance of different degrees of pain, it would seem meaningful to collect data on other outcome measures than just pain. Additional studies should involve measures of pain intensity and duration, clinical investigations, and measures of social functioning. With DASH as the instrument for obtaining information on functioning, the scores showed that, despite pain complaints, the participants experienced very mild disability.

In conclusion, complaints of pain in the neck and right shoulder were found among computer users in the NUDATA study to be associated with increasing use of a computer mouse. However, very few clinical findings and very mild disability were documented in this group of frequent computer users. From the perspective of this study, it seems unjustified to claim any serious adverse effects on the neck and shoulders from mouse or keyboard use.

Acknowledgments

This study was supported by the following grant sponsors: the Danish Medical Research Council (grant 9801292) and the Danish Ministry of Employment, via the National Work Environment Authority (grant 20000010486).

References

1. Punnett L, Bergqvist U. Visual display unit work and upper extremity musculoskeletal disorders: a review of epidemiological findings. Solna: Arbetslivsinstitutet; 1997. Arbete och Hälsa 16.
2. Nakazawa T, Okubo Y, Suwazono Y, Kobayashi E, Komine S, Kato N, et al. Association between duration of daily VDT use and subjective symptoms. Am J Ind Med 2002; 42(5):421–6.
3. Korhonen T, Ketola R, Toivonen R, Luukkonen R, Hakkanen M, Viikari-Juntura E. Work related and individual predictors for incident neck pain among office employees working with video display units. Occup Environ Med 2003;60(7):475–82.
4. Jensen C. Development of neck and hand-wrist symptoms in

relation to duration of computer use at work. Scand J Work Environ Health 2003;29(3):197–205.
5. Marcus M, Gerr F, Monteilh C, Ortiz DJ, Gentry E, Cohen S, et al. A prospective study of computer users, II: postural risk factors for musculoskeletal symptoms and disorders. Am J Ind Med 2002;41(4):236–49.
6. Karlqvist LK, Hagberg M, Koster M, Wenemark M, Nell R. Musculoskeletal symptoms among computer-assisted design (CAD) operators and evaluation of a self-assessment questionnaire. Int J Occup Environ Health 1996;2(3):185–94.
7. Jensen C, Borg V, Finsen L, Hansen K, Juul-Kristensen B, Christensen H. Job demands, muscle activity and musculoskeletal symptoms in relation to work with the computer mouse. Scand J Work Environ Health 1998;24(5):418–24.
8. Cooper A, Straker L. Mouse versus keyboard use: a comparison of shoulder muscle load. Int J Ind Ergon 1998;22:351–7.
9. Laursen B, Jensen BR, Garde AH, Jørgensen AH. Effect of mental and physical demands on muscular activity during the use of a computer mouse and a keyboard. Scand J Work Environ Health 2002;28(4):215–21.
10. Andersen JH, Thomsen JF, Overgaard E, Lassen CF, Brandt LP, Vilstrup I, et al. Computer use and carpal tunnel syndrome: a 1-year follow-up study. JAMA 2003;289(22):2963–9.
11. McConnell S, Beaton DE, Bombardier C. The DASH outcome measure—users manual. 1st ed. Toronto: Institute for Work & Health; 1999.
12. Thompson ML, Myers JE, Kriebel D. Prevalence odds ratio or prevalence ratio in the analysis of cross sectional data: what is to be done? Occup Environ Med 1998;55:272–7.
13. Skov T, Deddens J, Petersen MR, Endahl L. Prevalence proportion ratios: estimation and hypothesis testing. Int J Epidemiol 1998;27(1):91–5.
14. Homan MM, Armstrong TJ. Evaluation of three methodologies for assessing work activity during computer use. AIHA J 2003;64(1):48–55.
15. Bernard B, Sauter S, Fine L, Petersen M, Hales T. Job task and psychosocial risk factors for work-related musculoskeletal disorders among newspaper employees. Scand J Work Environ Health 1994;20(6):417–26.
16. Hales TR, Sauter SL, Peterson MR, Fine LJ, Putz-Anderson V, Schleifer LR, et al. Musculoskeletal disorders among visual display terminal users in a telecommunications company. Ergonomics 1994;37(10):1603–21.
17. Polanyi MF, Cole DC, Beaton DE, Chung J, Wells R, Abdolell M, et al. Upper limb work-related musculoskeletal disorders among newspaper employees: cross-sectional survey results. Am J Ind Med 1997;32(6):620–8.
18. Andersen JH, Kaergaard A, Frost P, Thomsen JF, Bonde JP, Fallentin N, et al. Physical, psychosocial, and individual risk factors for neck/shoulder pain with pressure tenderness in the muscles among workers performing monotonous, repetitive work. Spine 2002;27(6):660–7.
19. Gerr F, Marcus M, Ensor C, Kleinbaum D, Cohen S, Edwards A, et al. A prospective study of computer users, I: study design and incidence of musculoskeletal symptoms and disorders. Am J Ind Med 2002;41(4):221–35.
20. Allander E. Prevalence, incidence, and remission rates of some common rheumatic diseases or syndromes. Scand J Rheumatol 1974;3(3):145–53.

Received for publication: 30 October 2003