Computer Use and Carpal Tunnel Syndrome
A 1-Year Follow-up Study

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Context Computer use is increasingly common among many working populations, and concern exists about possible adverse effects of computer use, such as carpal tunnel syndrome (CTS).

Objectives To estimate the prevalence and incidence of possible CTS and to evaluate the contribution of use of mouse devices and keyboards to the risk of possible CTS.

Design and Setting A 1-year follow-up study with questionnaires conducted in 2000 and 2001 at 3500 workplaces in Denmark, followed on each of the 2 occasions by a clinical interview on symptom distribution and frequency.

Participants The questionnaire was sent to 9480 members of a trade union, with an initial response rate of 73% (n=6943), and 82% (n=5658) at follow-up.

Main Outcome Measures At baseline, there were 3 outcome measures: tingling/numbness in the right hand once a week or more as reported in the questionnaire; tingling, numbness, and pain in the median nerve in the right hand confirmed by clinical interview; and tingling, numbness, and pain in the median nerve in the right hand *at night* confirmed by clinical interview. At 1 year of follow-up the main outcome of interest was onset of symptoms among participants who had no or minor symptoms at baseline.

Results The overall self-reported prevalence of tingling/numbness in the right hand at baseline was 10.9%. The interview confirmed that prevalence of tingling/numbness in the median nerve was 4.8%, of which about one third, corresponding to a prevalence of 1.4%, experienced symptoms at night. Onset of new symptoms in the 1-year follow-up was 5.5%. In the cross-sectional comparisons and in the follow-up analyses, there was an association between use of a mouse device for more than 20 h/wk and risk of possible CTS but no statistically significant association with keyboard use.

Conclusions The occurrence of possible CTS in the right hand was low. The study emphasizes that computer use does not pose a severe occupational hazard for developing symptoms of CTS.

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USE OF THE KEYBOARD AND THE mouse as key interface devices to the computer has led to much debate concerning their role in development of injuries to the nerves in the upper limbs, particularly carpal tunnel syndrome (CTS). The proposed mechanism for this relationship is regional compression or nerve stretching, which has been confirmed in animal models, but no models exist concerning the effects of repetitive hand-finger loading on nerve structure and function.[1]

There is a large epidemiological literature on CTS, but the interpretation and conclusions regarding the importance of workplace factors for CTS have been intensively discussed during the last 30 years, especially in the United States, where CTS is reported most frequently[2] and has been central in the scientific and political struggle concerning work-related musculoskeletal disorders.[3] There is evidence that industrial repetitive, forceful work is a contributing factor in CTS,[2,4] but the role of computer use, which mainly consists of repetitive, nonforceful movements, is less clear. A recent study found that the frequency of CTS in computer users was similar to that in the general population.[5]

The reported prevalence of CTS in the general population ranges from 0.7% to 9.2% among women and from 0.4% to 2.1% among men,[5-10] and the prevalence and 1-year incidence among intensive keyboard users in a data entry service company were found to be 1.1% and 0.27%, respectively, which were confirmed by diagnostic interview and nerve conduction studies.[11] In a prospective study of computer users, Gerr et al[12] found a baseline prevalence of 0.5% and an overall annual incidence of 0.9 cases per 100 person-years. In earlier studies of computer users, based on symptoms and clinical examinations, the prevalence was slightly higher.[13,14]

The aim of the current study was to determine the contribution of weekly

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use of mouse devices and keyboards, work-related physical factors, work-related psychosocial factors, and individual characteristics in the occurrence and onset of possible CTS.

METHODS

Design and Study Population

The Neck and Upper Extremity Disorders Among Technical Assistants (NUDATA) study is a 1-year follow-up study examining the relation between computer use and neck and upper-limb musculoskeletal symptoms and disorders. The cohort was established in January 2000 and was recruited from the Danish Association of Professional Technicians (a trade union), and represents a population of 9480 participants at 3500 workplaces with a wide distribution of both mouse device and keyboard use.

At baseline and at 1-year follow-up, participants completed a questionnaire, and those meeting specific criteria for a symptom case were offered a standardized clinical interview and physical examination of the neck and upper extremities. All of the participants were employed at the time of inclusion in the cohort. They represent 2 occupational groups from the Danish Association of Professional Technicians; namely, technical assistants (draftsmen) and machine technicians, jobs requiring a vocational education of about 3 years and carrying out technical drawing tasks, administrative and graphical tasks, and other mainly office-based tasks. The participation rate was 73% (n=6943) at baseline and 82% (n=5658) at follow-up. The National Scientific Ethics Committee approved the study.

Outcome Measures

At baseline, 3 outcome measures were of interest. The first was any tingling/numbness in the fingers at least once a week or daily within the last 3 months (except after sitting or lying with arms in an awkward position), as reported in the questionnaire. Response options in the questionnaire were no, seldom, at least once a month, at least once a week, or daily. The second outcome measure was tingling, numbness, and pain in the median nerve at least once a week within the last 3 months, confirmed by clinical interview among participants fulfilling the first outcome measure. The interview focused on verification of tingling/numbness, hand distribution, and frequency of symptoms. The examiner did not obtain any information on mouse and keyboard use. The third outcome measure at baseline was a combination of the second outcome measure and symptoms at night.

At 1-year follow-up, the outcomes of interest were tingling/numbness in the right hand at least once a week within the last 3 months among participants with no or minor tingling/numbness at baseline, and median nerve symptoms in the right hand.

Work-Related Factors

The baseline and follow-up questionnaires included the same questions about occupational physical factors, which enabled extraction of information about time spent per week using a computer (in hours per week) and time spent using mouse devices and keyboards separately. On the basis of the self-reported proportion of computer time during which a mouse was actively being used (and, correspondingly, the keyboard), as well as information about hand use, we estimated mouse use in hours per week for the right hand and keyboard use in hours per week (formulas available from the authors on request). Mean mouse use was 14.7 h/wk for women and 12.5 h/wk for men, and mean keyboard use was 9.3 h/wk for women and 8.0 h/wk for men. Other noncomputer work tasks including office work not using a computer, meetings, and supervision accounted for the remainder of work time.

Posture-related variables included (1) abnormal mouse position, with the mouse positioned more than 40 cm to the right of the shoulder or more than 40 cm from the desk's front edge; (2) abnormal keyboard position, with the keyboard placed to the right or left side of the body; (3) forearm/wrist support (no support, support less than half of the time, or support more than half of the time) while using mouse devices and keyboards; (4) whether the work desk chair had been adjusted suitably (no, yes, or cannot be adjusted); and (5) overall satisfaction with physical workplace environment (on a 5-point scale of very dissatisfied to very satisfied, dichotomized between satisfied and unsatisfied).

Psychosocial work characteristics were assessed by a Danish version of the Karasek job content questionnaire,[15] including questions about job demands, job control, and social support from coworkers and supervisors. On the basis of 2 questions about the ability to meet current deadlines and quality requirements of the job, a dichotomous variable termed "time pressure" represented inability vs ability to meet requirements.

Personal Characteristics

Information about age, sex, height, and weight was obtained. Negative affect and type A behavior were determined by 2 questions designed for the study: "Do you tend to be worried, nervous, or somewhat pessimistic?" and "Do you tend to be competitive, jealous, ambitious, and somewhat impatient?" Responses were reported on a 7-point nominal scale from not at all to very much, and both were dichotomized between quite a lot and much (5-7 vs 0-4). Leisure-time activity was categorized into low physical activity (almost none or light physical activity for <2 h/wk, light activity for 2-4 h/wk), and high physical activity (light physical activity >4 h/wk or 2-4 h/wk with hard physical activity, or hard physical activity for >4 h/wk). Poor private social network was measured only at baseline by 1 question: "If you have problems, is it possible to obtain the necessary support from family or friends?" Responses on a nominal scale (always, nearly always, usually, often, sometimes, or seldom/never) were dichotomized between often and sometimes. Whether pain, tingling, or numbness was related to a specific accident was reported. Concurrent medical disorders such as inflammatory rheumatic diseases, diabetes, hyperthyroid or hypothyroid disease, and

disorders of the nervous system were recorded. Participants with pain after an accident were not invited to the clinical examination.

Statistical Analyses

Baseline and follow-up analyses used logistic regression analyses, and all risk factors were retained in the models irrespective of level of significance. Mouse device use and keyboard use were analyzed by assignment of dummy variables for weekly use to the categories 0 to less than 2.5, 2.5 to less than 5, 5 to less than 10, 10 to less than 15, 15 to less than 20, 20 to less than 25, 25 to less than 30, and 30 or more h/wk. In some of the analyses, high levels of keyboard use were collapsed further because of small numbers of cases. In all multivariate analyses, participants who used both hands interchangeably were excluded (n=623).

In analysis of follow-up data, the risk of developing new or worsened tingling/numbness was examined by logistic regression among participants with no or minor tingling/numbness at baseline. In these follow-up analyses, 4 dummy variables for increased or decreased (difference of >5 h/wk in either direction) use of a mouse or keyboard since baseline were introduced to adjust for the difference between mouse use and keyboard use in the 1-year follow-up period. Because of a small number of incident cases with extensive median nerve symptoms (n=35), we introduced only mouse use and keyboard use into the model. Mouse and keyboard use were negatively correlated in all analyses, and introduction of an interaction term did not contribute significantly to any of the models ($P=.45$). To check for colinearity, we calculated the correlation coefficients between all proposed risk factors, and all were less than 0.25. Stata version 7.0 software (Stata Corp, College Station, Tex) was used for the analyses.

RESULTS

Survey

The distribution of characteristics for mouse use, keyboard use, sex, age, job tasks, and baseline outcome status among respondents and nonrespondents at follow-up is shown in TABLE 1.

There was an overrepresentation among nonrespondents at follow-up of young men with executive jobs, but there was no remarkable difference in exposure time or the level of possible CTS symptoms at baseline.

Symptoms

The overall self-reported prevalence of tingling/numbness in the right hand at baseline was 10.9%. The interview confirmed that prevalence of tingling/numbness in the median nerve was 4.8%, of which about one third, corresponding to a prevalence of 1.4%, experienced symptoms at night.

The incidence of new or worsened more frequent CTS symptoms reported in the questionnaire at 1-year follow-up was 5.5% (n=198), but only 41 participants (1.2%) had symptoms in the median nerve. Changes in symptom level between baseline and follow-up are shown in TABLE 2. The majority of participants remained at the same symptom level (42.8%). A slightly higher proportion improved than worsened in symptoms (9.1% and 7.7%, respectively). The proportion missing at follow-up was greatest among participants with no symptoms at baseline (1761/4488

Table 1. Baseline Characteristics According to Status at 1-Year Follow-up*

Baseline Status	Follow-up Status: Respondents (n = 5658)	Follow-up Status: Nonrespondents (n = 1285)
Right-handed mouse use, h/wk		
0 to <2.5	1279 (23.4)	273 (22.3)
2.5 to <5	380 (7.0)	94 (7.7)
5 to <10	676 (12.4)	169 (13.8)
10 to <15	980 (18.0)	220 (18.0)
15 to <20	877 (16.1)	209 (17.1)
20 to <25	706 (12.9)	155 (12.7)
25 to <30	313 (5.7)	59 (4.8)
≥30	248 (4.5)	44 (3.6)
Keyboard use, h/wk		
0 to <2.5	532 (9.5)	134 (10.7)
2.5 to <5	864 (15.4)	195 (15.6)
5 to <10	1633 (29.2)	367 (29.3)
10 to <15	1043 (18.6)	207 (16.5)
15 to <20	686 (12.3)	168 (13.4)
20 to <25	400 (7.1)	75 (6.0)
25 to <30	236 (4.2)	48 (2.6)
≥30	201 (3.6)	58 (4.6)
Sex, female	3616 (63.9)	731 (56.9)
Age, mean (SD), y	41.7 (8.9)	39.1 (8.9)
Job title		
Technical assistant	3586 (63.4)	697 (54.2)
Machine technician	746 (13.2)	192 (14.9)
Executive, sales manager, engineer	391 (6.9)	138 (10.7)
Other	739 (13.1)	191 (14.9)
Baseline outcome status		
Questionnaire case†	585 (10.9)	129 (10.9)
Median nerve symptoms‡	255 (4.9)	53 (4.7)
Median nerve symptoms at night§	70 (1.3)	20 (1.8)

*Data are expressed as No. (%) unless otherwise noted. For right-handed mouse use, n = 5459 for respondents and n = 1223 for nonrespondents. For keyboard use, n = 5595 for respondents and n = 1252 for nonrespondents.
†Defined as tingling/numbness at least once a week within the last 3 months in the right hand.
‡Defined as tingling/numbness at least once a week within the last 3 months in the area of the right hand innervated by the median nerve.
§Defined as tingling/numbness at night at least once a week within the last 3 months in the area of the right hand innervated by the median nerve.

Table 2. Frequency of CTS Symptoms at Baseline and 1-Year Follow-up*

Baseline CTS Symptom Level	CTS Symptom Level at 1-Year Follow-up, No. (%)				
	No Symptoms	Mild CTS Symptoms	More Frequent CTS Symptoms	Missing Data	Total
No symptoms	Stable 2322 (33.4)	Incident 331 (4.8)	Incident 74 (1.1)	1761 (25.4)	**4488 (64.6)**
Mild symptoms	Resolved 353 (5.1)	Ongoing 400 (5.8)	Worsened 124 (1.8)	348 (5.0)	**1225 (17.6)**
More frequent symptoms	Resolved 107 (1.5)	Improved 172 (2.5)	Chronic 250 (3.6)	185 (2.7)	**714 (10.3)**
Missing data	190 (2.7)	36 (0.5)	20 (0.3)	270 (3.9)	**516 (7.4)**
Total	**2972 (42.8)**	**939 (13.5)**	**468 (6.7)**	**2564 (36.9)**	**6943 (100)**

Abbreviation: CTS, carpal tunnel syndrome.
*Symptom levels were defined as follows: no symptoms, no tingling/numbness within the last 3 months; mild symptoms, tingling/numbness seldom or at least once a month within the last 3 months; and more frequent symptoms, tingling/numbness at least once a week or daily within the last 3 months. Percentages do not exactly sum to totals because of rounding.

[39.2%]) and lowest among those who reported more frequent symptoms at baseline (185/714 [25.9%]); this points against a selection out of the study of those who had the most symptoms at baseline.

Risk Factors at Baseline

Tingling/numbness in the right hand was associated with time spent using a mouse device but not time spent using a keyboard (TABLE 3). Although the 2 broadest definitions of the outcome showed an exposure response pattern for hours per week using a mouse, the inclusion of symptoms at night revealed a significant association only when time spent using a mouse exceeded 30 h/wk. None of the included posture variables were associated with any of the outcomes, but participants who were dissatisfied with their physical workplace design had a slightly elevated risk (odds ratios [ORs] for the 3 outcomes were 1.6 [95% confidence interval {CI}, 1.2-2.1], 1.7 [95% CI, 1.1-2.6], and 1.9 [95% CI, 0.9-4.2], respectively). Psychosocial risk factors were not significantly associated with possible CTS. Women had an elevated risk ranging from 2.1 to 7.4 for the 3 outcomes, and older age, other medical disorders, and smoking were also associated with possible CTS, although nonsignificantly, for all 3 outcomes.

Risk Factors at Follow-up

Onset of symptoms of possible CTS after 1 year was associated with mouse use with a somewhat irregular exposure response pattern at less than 20 h/wk, but mouse use of 20 h/wk or more was observed to be a risk factor for becoming an incident case of self-reported tingling/numbness with elevated ORs (for 20 to <25 h/wk, OR, 2.6; 95% CI, 1.2-5.5; for 25 to <30 h/wk, OR, 3.2; 95% CI, 1.3-7.9; and for ≥30 h/wk, OR, 2.7; 95% CI, 1.0-7.6) (TABLE 4). At follow-up, only 35 participants had symptoms in the median nerve, which was too few to be included in a thorough multivariate model. A model including mouse use and keyboard use showed an elevated risk when weekly use of the mouse exceeded 20 h/wk (OR, 3.6; 95% CI, 1.4-9.4). There was only a slight indication of an association between keyboard use and onset or worsening of symptoms.

A total of 60.8% reported that their weekly computer use was at the same level as in the previous year, and 83.1% of the participants reported mouse use at follow-up at nearly the same level (±5 h/wk). Introducing variables into the logistic regression model for those who used a mouse more and who used a mouse less at follow-up contributed to the final model with ORs of 0.98 (95% CI, 0.50-1.90) and 0.77 (95% CI, 0.38-1.56), respectively. The mean (SD) difference in time spent using a mouse in the right hand between baseline and 1-year follow-up was 0.3 (6.9) h/wk for participants who experienced new or more symptoms (Table 2). The mean (SD) difference for those whose symptoms resolved or improved was 1.5 (7.9) h/wk (Table 2). The corresponding mean (SD) differences for time spent using a keyboard were 0.5 (5.7) h/wk and 0.7 (5.9) h/wk, respectively.

Other predictors for onset of tingling/numbness were other medical disorders, female sex (with a lower risk than in the baseline comparisons; OR, 1.6; 95% CI, 1.1-2.4), previous accident, and smoking. As in the baseline comparisons, posture variables and psychosocial risk factors were not associated with an elevated risk of possible CTS.

COMMENT

This study found a prevalence of possible CTS between 1.4% and 4.8% based on a screening questionnaire and a clinical interview, and an incidence of new or aggravated symptoms of possible CTS of 5.5%. When the median nerve was included, the incidence dropped to 1.2%. We did not include nerve conduction studies, but based on other results using the same diagnostic screening process, the prevalence and annual incidence of CTS confirmed by nerve conduction studies would have dropped to approximately one third of the values for interview-based possible CTS.[11] Another study also found a decrease from 10.5% among those who met clinical criteria to 3.5% when nerve conduction was included.[5] With that reasoning, our incidence would drop to less than 1%.

The NUDATA study benefits from a large cohort with a wide range of exposure and simultaneous analysis of physical, psychosocial, and nonoccupational personal characteristics measured at 2 separate points. The prevalence of symptoms was at the level of the general

Table 3. Prevalence of Tingling/Numbness in the Right Hand at Baseline and Results From Logistic Regression Analyses by Case Definition*

Characteristics	Questionnaire Case (n = 602-612)†		Median Nerve Symptoms (n = 260-265)‡		Median Nerve Symptoms at Night (n = 76-77)§	
	No. (%)	OR (95% CI)	No. (%)	OR (95% CI)	No. (%)	OR (95% CI)
Physical Work Characteristics						
Right-handed mouse use, h/wk						
0 to <2.5	51 (5.9)	1.0	19 (2.2)	1.0	5 (0.6)	1.0
2.5 to <5	25 (5.7)	1.0 (0.6-1.7)	7 (1.6)	0.7 (0.3-1.9)	2 (0.5)	0.8 (0.1-4.7)
5 to <10	62 (7.9)	1.5 (0.9-2.4)	33 (4.3)	2.3 (1.2-4.5)	12 (1.6)	2.3 (0.7-7.9)
10 to <15	111 (10.0)	1.8 (1.2-2.8)	50 (4.6)	2.2 (1.1-4.2)	11 (1.0)	1.1 (0.3-3.9)
15 to <20	137 (13.2)	2.8 (1.9-4.3)	55 (5.5)	3.1 (1.6-6.0)	15 (1.5)	1.9 (0.6-6.7)
20 to <25	115 (14.2)	3.3 (2.2-5.0)	54 (6.8)	3.6 (1.8-7.1)	15 (1.9)	1.9 (0.6-6.8)
25 to <30	60 (17.2)	4.3 (2.6-7.0)	25 (7.4)	3.5 (1.6-7.4)	4 (1.2)	0.9 (0.2-4.4)
≥30	42 (15.4)	3.8 (2.2-6.5)	19 (7.2)	3.5 (1.6-8.0)	11 (4.2)	4.1 (1.0-16)
Arm/wrist support during mouse use						
Never	85 (8.9)	1.0	33 (5.0)	1.0	7 (0.8)	1.0
>0% to 50% of time	71 (12.5)	1.2 (0.8-1.7)	26 (4.7)	1.2 (0.7-2.2)	6 (1.1)	2.0 (0.6-7.1)
>50% to 100% of time	446 (10.9)	0.9 (0.7-1.2)	201 (5.1)	1.1 (0.7-1.8)	63 (1.6)	1.7 (0.6-5.0)
Keyboard use, h/wk						
0 to <2.5	59 (12.6)	1.0	22 (4.8)	1.0	8 (1.8)	1.0
2.5 to <5	115 (11.1)	0.7 (0.5-1.0)	60 (5.9)	1.0 (0.6-1.7)	20 (2.0)	0.9 (0.4-2.3)
5 to <10	190 (9.9)	0.7 (0.5-1.0)	82 (4.3)	0.8 (0.5-1.2)	26 (1.4)	0.7 (0.3-1.6)
10 to <15	140 (10.4)	0.9 (0.6-1.2)	56 (4.3)	0.7 (0.4-1.3)	14 (1.1)	0.7 (0.3-1.8)
15 to <20	72 (11.4)	0.8 (0.5-1.2)	30 (4.9)	0.8 (0.4-1.5)	7 (0.8)	0.3 (0.1-1.0)
≥20	27 (10.8)	1.5 (0.9-2.6)	12 (4.9)	1.6 (0.7-3.7)		
Arm/wrist support during keyboard use						
Never	240 (11.2)	1.0	105 (5.0)	1.0	29 (1.4)	1.0
>0% to 50% of time	122 (10.5)	1.0 (0.8-1.4)	48 (4.2)	1.0 (0.7-1.5)	11 (1.0)	1.1 (0.5-2.3)
>50% to 100% of time	249 (10.3)	1.0 (0.8-1.3)	112 (4.8)	1.1 (0.8-1.6)	37 (1.6)	1.3 (0.7-2.4)
Abnormal mouse position	40 (9.1)	0.9 (0.6-1.3)	16 (3.7)	0.8 (0.4-1.4)	4 (0.9)	0.9 (0.3-2.5)
Abnormal keyboard position	85 (10.9)	1.0 (0.8-1.3)	38 (5.0)	1.1 (0.8-1.6)	8 (1.1)	0.9 (0.4-2.0)
Work chair not adjusted	26 (15.2)	1.4 (0.8-2.6)	8 (4.9)	0.8 (0.3-2.0)	1 (0.6)	0.8 (0.1-6.5)
Work desk not adjusted	131 (9.1)	0.8 (0.6-1.0)	55 (3.9)	0.8 (0.6-1.2)	9 (0.6)	0.4 (0.2-1.0)
Not satisfied with workplace design	115 (14.7)	1.6 (1.2-2.1)	46 (6.1)	1.7 (1.1-2.6)	10 (1.3)	1.9 (0.9-4.2)
Psychosocial Work Characteristics						
High demands	276 (12.0)	1.3 (1.1-1.6)	117 (5.2)	1.2 (0.9-1.6)	36 (1.6)	1.7 (0.98-2.8)
Low control	256 (13.9)	1.3 (1.1-1.6)	106 (5.9)	1.2 (0.9-1.6)	30 (1.7)	1.2 (0.7-2.0)
Low social support	297 (13.0)	1.2 (1.0-1.5)	120 (5.4)	1.1 (0.8-1.4)	33 (1.5)	1.1 (0.7-1.9)
Time pressure	184 (13.3)	1.2 (0.9-1.5)	84 (6.2)	1.4 (1.0-1.9)	22 (1.6)	1.1 (0.6-1.9)
Personal Characteristics						
Negative affect	100 (12.9)	1.0 (0.8-1.3)	45 (5.9)	1.0 (0.7-1.5)	9 (1.2)	0.5 (0.2-1.3)
Type A behavior	78 (10.6)	1.0 (0.8-1.3)	32 (4.5)	1.0 (0.6-1.5)	9 (1.3)	0.9 (0.4-2.1)
Age‖	NA	1.1 (1.1-1.3)	NA	1.3 (1.1-1.6)	NA	1.4 (1.1-1.9)
Female sex	480 (13.2)	2.1 (1.7-2.7)	219 (6.2)	3.0 (2.1-4.4)	70 (2.0)	7.4 (2.9-19)
High body mass index	24 (14.0)	1.3 (0.8-2.0)	10 (6.0)	1.3 (0.7-2.5)	3 (1.8)	1.5 (0.4-4.9)
Low body mass index	39 (12.5)	1.1 (0.7-1.6)	17 (5.6)	1.0 (0.5-1.8)	8 (2.6)	2.0 (0.9-4.6)
Poor social network	69 (14.3)	1.3 (0.9-1.7)	31 (6.6)	1.2 (0.8-1.9)	7 (1.5)	1.4 (0.6-3.2)
High physical activity	236 (10.0)	1.0 (0.9-1.3)	110 (4.7)	1.1 (0.9-1.5)	32 (1.4)	1.3 (0.8-2.1)
Medical disorder	63 (17.3)	2.1 (1.5-2.9)	21 (6.2)	1.5 (0.9-2.4)	7 (2.1)	1.7 (0.7-4.0)
Smoking	353 (11.6)	1.2 (1.0-1.5)	153 (5.2)	1.2 (0.9-1.6)	40 (1.4)	1.0 (0.6-1.7)
Symptoms started after accident	17 (15.9)	1.8 (1.0-3.2)	0	NA	0	NA

Abbreviations: CI, confidence interval; NA, not applicable; OR, odds ratio.
*Mouse related variables refer to right-handed use. Participants who operated the mouse with both hands (n = 623) were excluded. The ORs shown are adjusted for effects of psychosocial and personal factors listed in this table. Because of missing values for the outcomes and explanatory variables, sample sizes for each model were different.
†Defined as tingling/numbness at least once a week within the last 3 months in the right hand.
‡Defined as tingling/numbness at least once a week within the last 3 months in the area of the right hand innervated by the median nerve.
§Defined as tingling/numbness at night at least once a week within the last 3 months in the area of the right hand innervated by the median nerve.
‖Continuous variable; data show effect of 10-year increments.

Table 4. Incidence of Possible CTS in the Right Hand at Follow-up Among Participants With No or Minor Symptoms at Baseline and Results From Logistic Regression Analyses*

Characteristics	Incidence of Possible CTS in the Right Hand (n = 166-173)	
	No. (%)	OR (95% CI)
Physical Work Characteristics		
Right-handed mouse use, h/wk		
0 to <2.5	16 (3.3)	1.0
2.5 to <5	7 (2.8)	0.7 (0.3-1.9)
5 to <10	24 (5.6)	1.9 (0.9-4.0)
10 to <15	36 (5.8)	1.6 (0.8-3.3)
15 to <20	34 (5.9)	2.0 (0.9-4.2)
20 to <25	29 (6.4)	2.6 (1.2-5.5)
25 to <30	16 (8.4)	3.2 (1.3-7.9)
≥30	11 (7.0)	2.7 (1.0-7.6)
Arm/wrist support during mouse use		
Never	16 (3.3)	1.0
>0% to 50% of time	16 (5.2)	1.5 (0.7-3.3)
>50% to 100% of time	137 (5.9)	1.9 (0.99-3.5)
Keyboard use, h/wk		
0 to <2.5	15 (6.0)	1.0
2.5 to <5	32 (5.5)	0.9 (0.4-1.8)
5 to <10	54 (5.1)	0.8 (0.4-1.5)
10 to <15	51 (6.5)	1.2 (0.6-2.5)
15 to <20	14 (4.0)	0.8 (0.4-1.5)
≥20	7 (5.2)	1.4 (0.5-4.3)
Arm/wrist support during keyboard use		
Never	67 (5.8)	1.0
>0% to 50% of time	45 (7.0)	1.2 (0.8-1.8)
>50% to 100% of time	61 (4.5)	0.7 (0.5-1.1)
Abnormal mouse position	6 (2.4)	0.4 (0.1-0.9)
Abnormal keyboard position	25 (6.0)	1.1 (0.7-1.7)
Work chair not adjusted	6 (6.5)	1.3 (0.5-3.3)
Work desk not adjusted	41 (5.3)	1.0 (0.7-1.6)
Not satisfied with workplace design	25 (5.9)	0.9 (0.5-1.6)
Psychosocial Work Characteristics		
High demands	78 (6.4)	1.3 (0.9-1.8)
Low control	62 (6.0)	0.9 (0.7-1.4)
Low social support	78 (6.3)	1.2 (0.9-1.8)
Time pressure	44 (5.9)	1.0 (0.7-1.6)
Personal Characteristics		
Negative affect	25 (6.0)	0.9 (0.6-1.5)
Type A behavior	25 (6.5)	1.1 (0.7-1.8)
Age†	NA	1.1 (0.9-1.3)
Female sex	127 (6.2)	1.6 (1.1-2.4)
High body mass index	10 (5.9)	1.1 (0.6-2.3)
Low body mass index	3 (3.1)	0.6 (0.2-1.9)
Poor social network	19 (7.5)	1.2 (0.7-2.2)
High physical activity	72 (5.3)	1.1 (0.8-1.5)
Medical disorder	18 (8.8)	1.7 (1.0-3.1)
Smoking	111 (6.8)	1.7 (1.2-2.4)
Symptoms started after accident	11 (12.9)	3.1 (1.5-6.1)

Abbreviations: CI, confidence interval; CTS, carpal tunnel syndrome; NA, not applicable; OR, odds ratio.
*The ORs for incidence of possible CTS shown are adjusted for effects of psychosocial and personal factors. Because of missing values for the outcomes and explanatory variables, sample sizes differ. The Hosmer-Lemeshow goodness-of-fit test for 10 groups yielded $P = .31$.
†Continuous variable; data show effect of 10-year increments.

population and, in cross-sectional comparisons, we found an association with time spent using a mouse device, although the most rigorous definition including symptoms at night showed an elevated risk only among those who used a mouse for 30 h/wk or more. A differential loss of participants from baseline to 1-year follow-up could explain the very low incidence, but the prevalence at baseline of tingling/numbness among nonrespondents was the same as for those who remained in the study (Table 1), and participants with more frequent symptoms at baseline remained in the study to a higher extent than participants without symptoms at baseline (Table 2).

Associations between mouse use and onset or worsening of tingling/numbness were confirmed by follow-up analyses. Mouse use for 20 h/wk or more seems to imply a slightly elevated risk of possible CTS. This risk could be underestimated if participants with symptoms had moved to lower exposure groups in the follow-up period, but accounting for decrease or increase in mouse/keyboard use did not change the risk estimates.

Other Studies

In a national survey assessing occupational exposures to vibration, 1 item concerned regular use of keyboards.[16] This study found no association between keyboard use for more than 4 hours in an average workday and tingling/numbness during the previous week. The ORs for men and women were 1.1 (95% CI, 0.8-1.3) and 1.1 (95% CI, 0.9-1.3), respectively. In a recent follow-up study of newly hired computer users with jobs requiring more than 15 h/wk of computer use, Gerr et al[12] found a baseline prevalence of CTS of 0.5%, verified by nerve conduction studies. During the follow-up phase of that study, 3 new cases with CTS were found, corresponding to an incidence of 0.9%. Other studies that have investigated CTS among computer users have reported prevalences of 1.0% and 1.3%.[13,14] Taken together, previous studies and the present study are in contrast with a common belief

that CTS is a frequent disorder among computer users.

Keyboard Use

The NUDATA study is, to our knowledge, the first study to attempt to dissect computer use into mouse use and keyboard use. Keyboard use for 20 h/wk or more was slightly associated with tingling/numbness at baseline and follow-up for 2 of the outcome definitions. This finding could be explained by too little variation and contrast in our cohort concerning use of a keyboard. Mean (SD) self-reported keyboard use was about 8 to 9 (5-6) h/wk. Repetitive keying of 8000 to 12 000 keystrokes/h has been found to be a risk factor for arm, hand, and elbow pain.[17] In a study of data entry workers in which the keying speed was around 12 000 keystrokes/h, a 10-h/wk increase in data entry work was associated with an increased risk of CTS (OR, 1.8; 95% CI, 1.1-3.2), but this finding was based on only 8 cases. In a subgroup of our cohort (n=2146), the keying speed in the 75th percentile was measured to be 8000 to 22 000 keystrokes/h. There was variation and some heavy keyboard use, but there were too few cases in the highest exposure groups to make proper use of the wide exposure range.

Can keyboard use then be considered an occupational risk for developing CTS? From our data it seems unlikely, but based on other studies, we cannot exclude the possibility that very intensive and repetitive keyboard use could be a risk factor for CTS. However, our opinion is that it is not an important one.

Mouse Device Use

Use of a mouse device was associated with symptoms in the cross-sectional comparisons as well as in the follow-up analyses. Despite efforts to introduce the study as a general study of work environment and health among computer users, the study funding was initiated because of public concern and discussions in the media of "mouse-related disorders," "mouse arm," and other such terms, implying a focus on the mouse at this time. This could explain the cross-sectional associations, which could be skewed by information bias. The finding of an exposure response pattern between use and symptoms and the findings from the follow-up make the associations plausible. But the irregular exposure response pattern for the amount of use of a mouse or a keyboard makes it difficult to establish any threshold time values for use of the devices. One would expect low risks at the lower end of exposure and a threshold level at which the risk increases. We did not find such a pattern, and, by introduction of the time variables as continuous instead of categorical, we could not obtain a better fit of powers other than linear in predicting any of the outcomes (results not shown).

There were strong contributions to the onset of new symptoms by an accident prior to symptom onset, other medical disorders, and smoking—risk factors that have been found in other studies.[18] Tingling/numbness is related to nerve entrapment, but most people who experience tingling/numbness do so because of reasons other than nerve entrapment. It is probable that tingling and numbness are common symptoms of either specific medical conditions other than CTS or are part of a large burden of medically unexplained symptoms that reflect the stresses and strains of everyday life.

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