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Effect of work with visual display units on musculo-skeletal disorders in the office environment

J. Sillanpää[1], S. Huikko[4], M. Nyberg[1], P. Kivi[3], P. Laippala[4]† and J. Uitti[1,2]

Background The increase in computer and mouse use has been associated with an increased prevalence of disorders in the neck and upper extremities. Furthermore, poor workstation design has been associated with an increased risk of developing these symptoms.

Aim The aims of this study were (i) to estimate the prevalence of musculo-skeletal disorders among full-time visual display unit (VDU) users; (ii) to examine how the prevalence varies by work environment; and (iii) to explore the association with work factors.

Method A survey was carried out on the effect of work with VDUs on musculo-skeletal disorders in workers in the office environment of 56 workplaces. Office workers (n = 298), customer service workers (n = 238) and designers (n = 247) were studied.

Results For all the occupations combined, the 12 month prevalences of musculo-skeletal symptoms in the neck, shoulders, elbows, lower arms and wrists, and fingers were 63, 24, 18, 35 and 16%, respectively. The study indicated that musculo-skeletal pain is common among computer workers in offices. There was no strong association between the duration of computer work and pain or between the duration of mouse use and pain, but workers' perception of their workstation as being poor ergonomically was strongly associated with an increased prevalence of pain.

Conclusions Musculo-skeletal symptoms are common, but the duration of daily keyboard and mouse use had no connection with musculo-skeletal symptoms. Instead, more consideration should be paid to the ergonomics of workstations, the placing of the mouse, the postures of the upper extremities and the handling of the mouse.

Key words Mouse use; musculo-skeletal disorders; office work; VDU work.

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Introduction

The increase in computer and mouse use has been associated with an increased prevalence of disorders in the neck and upper extremities [1,2]. Punnet and Bergqvist [2] found that poor workstation design, continuous computer use for the entire workday and repetitive computer work, such as data entry, were associated with an increased risk of developing symptoms. It has also been shown that the musculo-skeletal disorders associated with computer mouse use

[1]Tampere Regional Institute of Occupational Health, Tampere, Finland.

[2] Clinic of Occupational Medicine, Tampere University Hospital, Tampere, Finland

[3]Occupational Health Center in Tampere, Tampere, Finland.

[4]Tampere School of Public Health, University of Tampere, Finland.

†Deceased.

Correspondence to: Jarmo Sillanpää, Tampere Regional Institute of Occupational Health, P.O. Box 486, FIN-33101 Tampere, Finland. Tel: +358 3 2608 600; fax: +358 3 2608 615; e-mail: jarmo.sillanpaa@occuphealth.fi

are increasing [3]. Gender differences have been found among users of visual display units (VDUs), musculo-skeletal symptoms being more prevalent among women than men [1,4]. This same difference was also found in the general working population by de Zwart *et al.* [5].

The aims of this study were: (i) to estimate the prevalence of musculo-skeletal disorders among full-time VDU users; (ii) to examine how the prevalence varies by work environment (office versus customer service versus design); and (iii) to explore the association with work factors, including duration of keyboard and mouse use and self-assessment of workplace ergonomics.

Materials and methods

In 1997, two large occupational health centres located in the city of Tampere were asked to distribute a questionnaire to workers (n = 1500) employed full-time in an office environment. The questionnaire distribution took place over a period of several weeks to ensure that those absent for a short time should get the questionnaire. Altogether, 979 questionnaires (response rate 65%) were returned, from 56 workplaces in seven different occupational sectors: insurance and banking (7); architecture and design (12); industry (6); commerce (4); computer and information technology (13); publishing and advertising (7); and municipal workplaces (7). The results presented in this paper have been classified according to the following three occupations: (i) office workers (n = 298); (ii) customer service workers (n = 238); and (iii) designers (n = 247). The groups 'labour management' (n = 92) and 'others' (n = 89) were omitted from this paper because of their different physical loads and other exposures. The analyses were carried out separately for the three occupational groups because the nature of the work differed greatly between the three. Some analyses were also carried out for the whole group at the same time to determine the general effect of exposure to VDU work.

The questionnaire—a modified version of the questionnaire used in Viikari-Juntura *et al.* [6] and Miranda *et al.* [7]—consisted of 88 questions; the questions concerning personal history, the work task and pain during the previous 12 months in the neck, shoulders, elbows, lower arms and wrists, and fingers have been used in this paper. The use of the computer and the mouse refers to the number of self-reported hours per average workday in the previous year and experienced pain refers to any pain (laterality not considered) in the previous 12 months.

Statistical analyses

Cross-table calculations

Cross-tables of the basic results were analysed with the Pearson χ^2 test. Standardized residuals were computed to determine which cells produced significant differences between the observed and expected frequencies. This procedure shows which cells differ the most and cause the dependency. For the 2 × 2 tables, the odds ratios (OR) and their 95% confidence intervals (95% CI) were calculated.

Binary logistic regression modelling

Binary logistic regression models were fitted for each region of pain separately. A stepwise forward analysis was used, with the probability for entry equal to 0.05 and that for removal equal to 0.10. The models were constructed for the three occupational groups separately. The following covariates were used: sex; age; daily work with a computer (cut-off point 4 h); daily use of a computer mouse (cut-off point 4 h); placement of the mouse (next to the keyboard on the same surface or on a separate surface adjacent to the keyboard); rating of the placement of the keyboard and mouse (separately, both classified as poor or good); and general rating of the ergonomics (poor or good) of the workstation. Age was included as a continuous variable; all the other variables were dichotomous. These particular variables were chosen for the analysis because we wanted to concentrate on work time and ergonomics. Age and sex were also of interest.

Polychotomous modelling

Polychotomous logistic regression modelling was also used. It is a generalization of the usual binary logistic regression, with more than two classes for the outcome variable. The analysis concentrates on three different person classes (occupations), which were analysed separately.

The major outcome was considered to be the sum (0–5) of the number of body regions in which pain occurred (neck, shoulders, elbows, lower arms and wrists, fingers). In the analysis, the sum was classified as follows:

- class 1—0, 1 or 2 regions of pain;
- class 2—3 regions of pain;
- class 3—4 or 5 regions of pain.

In the modelling, we used the background variables (age, sex, work time on a computer and with a computer mouse, self-assessment of work ability) in every analysis. The possible risk factors were taken into the model one by one as a conceptually unified stratum: regions of pain; mouse; VDU work; ergonomics; eye strain; work strain; and sick leave. Finally, all the significant risk factors from the stratified analysis were taken into the model.

The placement of the keyboard and the mouse was rated by the subject according to the five classes (1 = very poor, 5 = very good) used in the questionnaire. A member of the research team classified 1 and 2 as poor and 4 and 5 as good. The ergonomics of the workstation was rated by the subject from 0 (worst possible) to 10 (best possible). A member of the research team classified 0–6 as 'ergonomically poor' and 7–10 as 'ergonomically good'.

SPSS/WIN (Release 10) and BMDP Statistical Software (Release 7) were used.

Results

Cross-table calculations

Table 1 presents the proportion and age of the men and women in the three occupational groups and in the three occupations combined.

The prevalence (%) of pain among the men and women during the previous 12 months and the differences between occupations are shown in Table 2. The prevalence (%) of pain was statistically significantly dependent on occupation, except for pain in the lower arms and wrists. According to the standardized residuals, the designers suffered less pain in the shoulders, elbows and fingers. The same tendency was found also for the neck. Within all the occupations, the prevalence of pain in the neck, lower arms and wrists, and fingers was dependent on sex (Table 1).

Pain in the shoulders ($P < 0.001$), elbows ($P < 0.001$) and fingers ($P < 0.05$) was dependent on age, the youngest respondents having less pain in these areas and the oldest having more pain (Table 2).

Computer work was a substantial part of the work in each of the occupations studied. Only 2% of all the workers used a computer <2 h a day. The designers used computers the most, 93% working with a computer for ≥4 h a day. Office workers and customer service workers worked 73 and 84% of the day, respectively, with a computer for ≥4 h a day (Table 3). The daily use of a computer differed statistically significantly among the studied occupations ($P < 0.001$). The designers more frequently used a computer >6 h a day than did the other groups. Pain was not statistically significantly associated with the daily use of a computer, either for all occupations or for the different occupations separately, the only exception being shoulder pain among customer service workers ($P < 0.01$).

The mouse was not used by 11% of the respondents. Mouse use was most common among the designers; only 3% of the designers did not use a mouse. Among the designers, 42% used a mouse for ≥4 h a day, whereas only 11 and 16% of the office workers and customer service workers, respectively, used a mouse for the same amount of time (Table 4). Daily mouse use differed statistically significantly among the studied occupations ($P < 0.001$). There was no statistically significant relation between mouse use and pain.

Table 5 shows the prevalence of pain in the combined groups according to poor and proper placement of the keyboard and mouse.

When daily use of a computer and a mouse was scaled into two classes, <4 h and ≥4 h a day, the use of a computer for <4 h showed an elevated risk for shoulder pain among the office workers. For the customer service workers, the risk of shoulder pain was in excess due to the use of a computer for ≥4 h a day (Table 6).

The mouse was located beside the keyboard for 55% of

Table 1. Distribution and age of the respondents and the prevalence (%) of pain among the men and women during the previous 12 months in the three occupations

Occupation	*n*	%	Age (years)		Pain prevalence (%)				
			Mean	Range	Neck	Shoulders	Elbows	Lower arms and wrists	Fingers
Office workers									
Men[a]	8	2.7	35.9	20–56	(50.0)	(50.0)	(25.0)	(37.5)	(12.5)
Women	290	97.3	43.7	22–62	68.6	27.6	22.4	35.7	18.1
Customer service workers									
Men	44	18.5	40.8	24–57	56.1	20.9	20.9	23.8	16.7
Women	194	81.5	41.2	23–59	66.1	27.3	19.4	38.8	20.9
Designers									
Men	168	68.0	37.4	22–62	54.3	17.2	11.6	29.9	6.2
Women	79	32.0	37.4	22–59	59.7	14.3	10.4	39.5	18.4
Total									
Men	220	28.1	38.0	20–62	54.5	19.2	14.0	29.0	8.5
Women	563	71.9	42.0	22–62	66.5	25.6	19.7	37.3	18.9
Significance between occupations (both genders)					*	**	**	n.s.	*
Significance between sexes (within all occupations)					**	n.s.	n.s.	*	***

***$P < 0.001$; **$P < 0.01$; *$P < 0.05$; n.s., not significant.

[a]The number of men was too low.

the office workers, 70% of the customer service workers and 72% of the designers ($P < 0.001$). When the mouse was located beside the keyboard, the risk of pain in the fingers was elevated among the designers (Table 6).

Support of the upper extremity during mouse use differed statistically significantly between the occupations ($P < 0.01$). Support of the upper extremity had no statistically significant association with pain during the previous 12 months.

For women, the risk of pain was greater than for the men (Table 6). Within the occupations, the risk of pain was not increased for either sex, except for finger pain among the designers, which was greater for the women than the men.

Poor placement of both the keyboard and the mouse had an increased risk for pain in all the body regions studied. For the office workers, poor placement of the keyboard showed an increased risk for pain in the shoulders, elbows and fingers and poor placement of the mouse was a risk factor for pain in the neck, shoulders and fingers. For customer service workers, poor placement of the keyboard was associated with a risk of pain in the neck, elbows and forearms and wrists, and poor placement of the mouse was related to pain in all the body regions studied. For the designers, poor placement of both the keyboard and the mouse was associated with a risk of pain in the neck and elbow (Table 6).

The office workers found their workstations to be ergonomically poor less frequently than the customer service workers and designers ($P < 0.01$).

Ergonomically poor workstations were associated with pain in the neck, shoulders, elbows and fingers in all the occupations, with pain in the neck, elbows and fingers among the office workers and with pain in the neck and shoulders among the customer service workers (Table 6).

Binary logistic regression modelling

When the binary logistic model was used, the rating of the ergonomics of the workstation and that of the placement of the keyboard and mouse were strongly correlated. However, the placement of the keyboard and mouse was not rated by many of the respondents and thus there was a notable loss in the number of cases included in the model. Because of this multicollinearity and loss of cases, we fitted the models without the rating for keyboard and mouse placement as covariates.

The proportion of male office workers was so low that we fitted the office workers' models first for female workers only and then checked whether or not the

Table 2. Prevalence (%) of pain during the previous 12 months according to age

Age group	Pain prevalence (%)				
	Neck	Shoulders	Elbows	Lower arms and wrists	Fingers
<35 years	64.4	12.8	9.4	31.0	11.3
35–45 years	63.9	24.7	19.2	36.8	14.6
>45 years	60.9	31.0	23.6	35.9	21.2

Table 3. Daily work with a computer within the occupations and the prevalence of pain during the previous 12 months

Occupation	No.	Percentage within occupation	Pain prevalence (%)				
			Neck	Shoulders	Elbows	Lower arms and wrists	Fingers
Office workers							
<2 h/day	10	3.4	60.0	30.0	20.0	30.0	20.0
2–4 h/day	71	23.9	71.2	40.0	23.2	34.3	22.1
4–6 h/day	131	44.1	68.8	24.8	19.5	36.2	13.2
>6 h/day	85	28.6	66.3	23.5	27.2	36.3	22.2
Customer service workers							
<2 h/day	7	3.0	66.7	33.3	28.6	33.3	16.7
2–4 h/day	32	13.6	66.7	3.4	20.7	40.0	17.9
4–6 h/day	76	32.2	66.2	22.7	19.7	34.7	16.0
>6 h/day	121	51.3	62.6	34.2	19.1	36.8	23.0
Designers							
<2 h/day	1	0.5	100.0	0.0	0.0	100.0	0.0
2–4 h/day	16	6.5	46.2	20.0	6.7	26.7	20.0
4–6 h/day	65	26.5	61.5	17.2	9.2	32.3	4.7
>6 h/day	163	66.5	53.8	15.2	12.6	33.5	11.5
Total							
<2 h/day	18	2.3	64.7	29.4	22.2	35.3	17.6
2–4 h/day	119	15.3	67.0	28.1	20.4	34.8	20.7
4–6 h/day	272	35.0	66.3	22.4	17.1	34.8	11.9
>6 h/day	369	47.4	59.5	23.2	18.0	35.2	17.7

Table 4. Daily work with a mouse within the occupations and the prevalence of pain during the previous 12 months

Occupation	Number	Percentage within occupation	Pain prevalence (%)				
			Neck	Shoulders	Elbows	Lower arms and wrists	Fingers
Office workers							
0 h/day	52	17.6	66.7	20.0	27.1	48.0	24.5
<2 h/day	139	47.0	69.6	33.3	22.5	31.7	15.2
2–4 h/day	73	24.7	65.7	27.8	20.8	33.3	18.3
4–6 h/day	24	8.1	65.2	18.2	18.2	45.5	22.7
>6 h/day	8	2.7	75.0	25.0	25.0	14.3	12.5
Customer service workers							
0 h/day	29	12.3	65.4	36.0	7.7	39.3	12.0
<2 h/day	120	50.8	67.0	21.6	18.5	34.2	23.5
2–4 h/day	49	20.8	63.8	35.6	31.1	45.7	17.8
4–6 h/day	26	11.0	48.0	23.1	24.0	24.0	16.0
>6 h/day	12	5.1	66.7	25.0	8.3	41.7	16.7
Designers							
0 h/day	7	2.9	28.6	14.3	28.6	14.3	14.3
<2 h/day	73	29.8	54.9	13.9	6.9	26.4	5.6
2–4 h/day	62	25.3	60.0	18.0	9.8	36.1	13.3
4–6 h/day	44	18.0	62.8	24.4	16.3	38.1	7.3
>6 h/day	59	24.1	50.0	10.5	12.3	36.8	14.3
Total							
0 h/day	88	11.3	63.0	24.4	21.0	42.4	19.8
<2 h/day	332	42.7	65.4	24.8	17.6	31.4	16.0
2–4 h/day	184	23.7	63.3	26.4	19.7	37.4	16.5
4–6 h/day	94	12.1	59.3	22.5	18.9	36.0	13.6
>6 h/day	79	10.2	55.3	14.3	13.0	35.5	14.5

Table 5. Prevalence of pain in accordance with the grading of the placement of the keyboard and the mouse (good–poor)

	Pain prevalence (%)				
	Neck	Shoulders	Elbows	Lower arms and wrists	Fingers
Placement of keyboard					
Good	57.3	19.3	14.2	29.0	13.3
Poor	77.3	30.0	30.1	41.1	25.7
Placement of mouse					
Good	54.1	17.1	11.0	26.5	10.4
Poor	79.7	29.1	25.1	10.4	23.8

outcome would be similar if the male workers were added. The only difference was that for shoulder pain, for which age was significant for the whole group of office workers, but not for female workers only.

For the office workers, we found that working with a computer <4 h a day increased the risk for shoulder pain (OR = 2.4, 95% CI = 1.3–4.5), whereas ergonomically poor workstations increased the risk of pain in the fingers (OR = 2.8, 95% CI = 1.3–6.1). None of the aforementioned explanatory variables were significant for pain in the wrists, neck or elbows.

For the customer service workers, the poor ergonomic rating raised the risk for neck pain (OR = 2.3, 95% CI = 1.1–4.5). Age was associated with excess risk of elbow pain (OR = 1.06, 95% CI = 1.01–1.11). None of the explanatory variables increased the risk of forearm or wrist pain.

Among the designers, age was a protective factor for neck pain (OR = 0.97, 95% CI = 0.93–0.997) and a risk factor for pain in the elbow (OR = 1.05, 95% CI = 1.002–1.103). Working with a computer <4 h per day lowered the risk for shoulder pain (OR = 0.3, 95% CI = 0.085–1.026). Pain in the fingers was explained by sex, computer time and placement of the mouse. For the women versus the men, the OR was 4.35 (95% CI = 1.69–11.11), for work with a computer <4 h a day versus

Table 6. The odds ratios (OR) (calculated for the 2 × 2 tables) with 95% confidence intervals (95% CI) for pain in the different regions according to gender, daily work with a computer and mouse, placement of the mouse, grading of the placement of the keyboard and mouse, and ergonomic grading of the workstation

	Pain, OR (95% CI)				
	Neck	Shoulders	Elbows	Forearms and wrists	Fingers
Gender (male/female)[a]					
Office workers[b]	–	–	–	–	–
Customer service workers	1.53 (0.77–3.04)	1.42 (0.64–3.17)	0.91 (0.40–2.06)	2.03 (0.94–4.38)	1.28 (0.53–3.10)
Designers	1.25 (0.72–2.16)	0.80 (0.38–1.71)	0.89 (0.37–2.12)	1.53 (0.87–2.70)	3.41 (1.44–8.09)
All occupations	1.66 (1.20–2.29)	1.45 (0.98–2.15)	1.51 (0.97–2.34)	1.46 (1.04–2.05)	**2.50 (1.48–4.25)**
Work with computer (>4 h/<4 h)[a]					
Office workers	1.10 (0.62–1.93)	1.97 (1.14–3.41)	1.02 (0.55–1.89)	0.90 (0.52–1.55)	1.39 (0.73–2.67)
Customer service workers	1.12 (0.53–2.39)	0.22 (0.07–0.76)	1.19 (0.50–2.82)	1.13 (0.55–2.36)	0.85 (0.33–2.19)
Designers	0.78 (0.27–2.31)	1.23 (0.33–4.55)	0.50 (0.06–4.00)	0.91 (0.31–2.73)	2.19 (0.58–8.26)
All occupations	1.20 (0.80–1.81)	1.33 (0.87–2.03)	1.21 (0.76–1.94)	0.99 (0.67–1.47)	1.42 (0.88–2.30)
Mouse use (>4 h/<4 h)[a]					
Office workers	1.01 (0.46–2.25)	1.65 (0.65–4.20)	1.19 (0.46–3.04)	0.89 (0.40–1.96)	0.87 (0.34–2.24)
Customer service workers	1.65 (0.81–3.37)	1.18 (0.52–2.67)	1.07 (0.44–2.62)	1.43 (0.67–3.07)	1.34 (0.52–3.44)
Designers	1.01 (0.60–1.70)	0.96 (0.47–1.93)	0.63 (0.28–1.40)	0.72 (0.42–1.24)	0.81 (0.35–1.88)
All occupations	1.34 (0.94–1.90)	1.47 (0.96–2.27)	1.19 (0.75–1.89)	0.96 (0.67–1.38)	1.23 (0.75–2.00)
Placement of the mouse (in the side or elsewhere/beside the keyboard)[a]					
Office workers	0.87 (0.50–1.52)	1.24 (0.71–2.18)	0.90 (0.48–1.67)	1.23 (0.71–2.11)	0.95 (0.48–1.90)
Customer service workers	0.98 (0.53–1.84)	1.92 (0.89–4.17)	0.99 (0.48–2.06)	1.48 (0.78–2.83)	0.94 (0.45–1.97)
Designers	1.47 (0.82–2.62)	1.83 (0.76–4.39)	0.70 (0.29–1.65)	1.45 (0.77–2.72)	4.48 (1.02–19.6)
All occupations	1.01 (0.73–1.41)	1.37 (0.93–2.01)	0.82 (0.55–1.23)	1.36 (0.97–1.92)	1.16 (0.74–1.82)
Grading of the placement of the keyboard (good/poor)[a]					
Office workers	2.16 (0.89–5.24)	2.94 (1.37–6.30)	**2.21 (1.00–4.87)**	1.43 (0.68–3.03)	4.08 (1.81–9.18)
Customer service workers	2.87 (1.17–7.09)	1.85 (0.79–4.29)	2.95 (1.22–7.14)	**2.45 (1.11–5.41)**	2.26 (0.96–5.32)
Designers	3.00 (1.39–6.46)	1.14 (0.44–2.92)	4.89 (1.82–13.13)	1.63 (0.79–3.34)	1.12 (0.34–3.72)
All occupations	2.53 (1.56–4.12)	**1.80 (1.12–2.87)**	**2.61 (1.61–4.24)**	**1.70 (1.11–2.62)**	**2.26 (1.36–3.76)**
Grading of the placement of the mouse (good/poor)[a]					
Office workers	4.10 (1.91–8.78)	**2.29 (1.19–4.39)**	1.78 (0.88–3.59)	1.59 (0.86–2.94)	2.66 (1.25–5.64)
Customer service workers	3.82 (1.75–8.34)	**2.52 (1.11–5.71)**	**4.75 (1.81–12.48)**	**2.53 (1.21–5.28)**	**2.56 (1.10–5.96)**
Designers	2.36 (1.12–4.95)	1.11 (0.43–2.83)	3.41 (1.14–10.23)	2.02 (0.98–4.15)	2.73 (0.79–9.47)
All occupations	3.32 (2.16–5.13)	**2.00 (1.28–3.10)**	**2.71 (1.65–4.42)**	**1.93 (1.31–2.87)**	**2.69 (1.62–4.46)**
Grading of the ergonomics (good/poor)[a]					
Office workers	2.00 (1.02–3.95)	1.41 (0.77–2.59)	2.23 (1.18–4.23)	1.57 (0.88–2.80)	3.05 (1.58–5.91)
Customer service workers	2.02 (1.06–3.83)	**2.11 (1.12–3.95)**	1.34 (0.67–2.68)	1.33 (0.74–2.38)	1.46 (0.72–2.94)
Designers	1.18 (0.67–2.09)	1.20 (0.56–2.58)	1.51 (0.64–3.54)	1.07 (0.59–1.95)	0.95 (0.37–2.43)
All occupations	1.57 (1.10–2.23)	**1.47 (1.02–2.13)**	**1.60 (1.07–2.39)**	1.30 (0.93–1.82)	1.72 (1.13–2.62)

Significant results are in bold face.

[a]The first of the two categories stated in parentheses is the reference.

[b]The number of men was too low.

work for ≥4 h a day the OR was 6.1 (95% CI = 1.3–29.4) and for keeping the mouse next to the keyboard rather than on a separate table, the OR was 8.3 (95% CI = 1.7–40.8).

Polychotomous modelling

The polychotomous models were fitted separately for each group and the sum of pain was divided into three classes, as described above. The goal was to determine whether the risk factor structures differed between the groups. Normally, the results for this analysis are presented using ORs with 95% CI. In our case, however, the sample size was too small to make this presentation applicable. Accordingly, an analysis was carried out to identify the risk factors and the presentation was made using graphics. Because the scaling of the variables differed, they were re-scaled to the range 1–100 and then the means were calculated. These means are shown in Figure 1.

As a result of the polychotomous modelling for the sum of pain, the significant risk factors for the office workers were placement of the mouse (beside the keyboard) and the rating of the placement of the mouse (poor). Of these two factors, the mouse placement rating explained the sum of the regions of pain more powerfully.

For the customer service workers, the risk factors were strain in the left wrist (after the workday), strain in the right wrist, strain in the fingers of the right hand and the use of drugs (pain, inflammation). Among these factors,

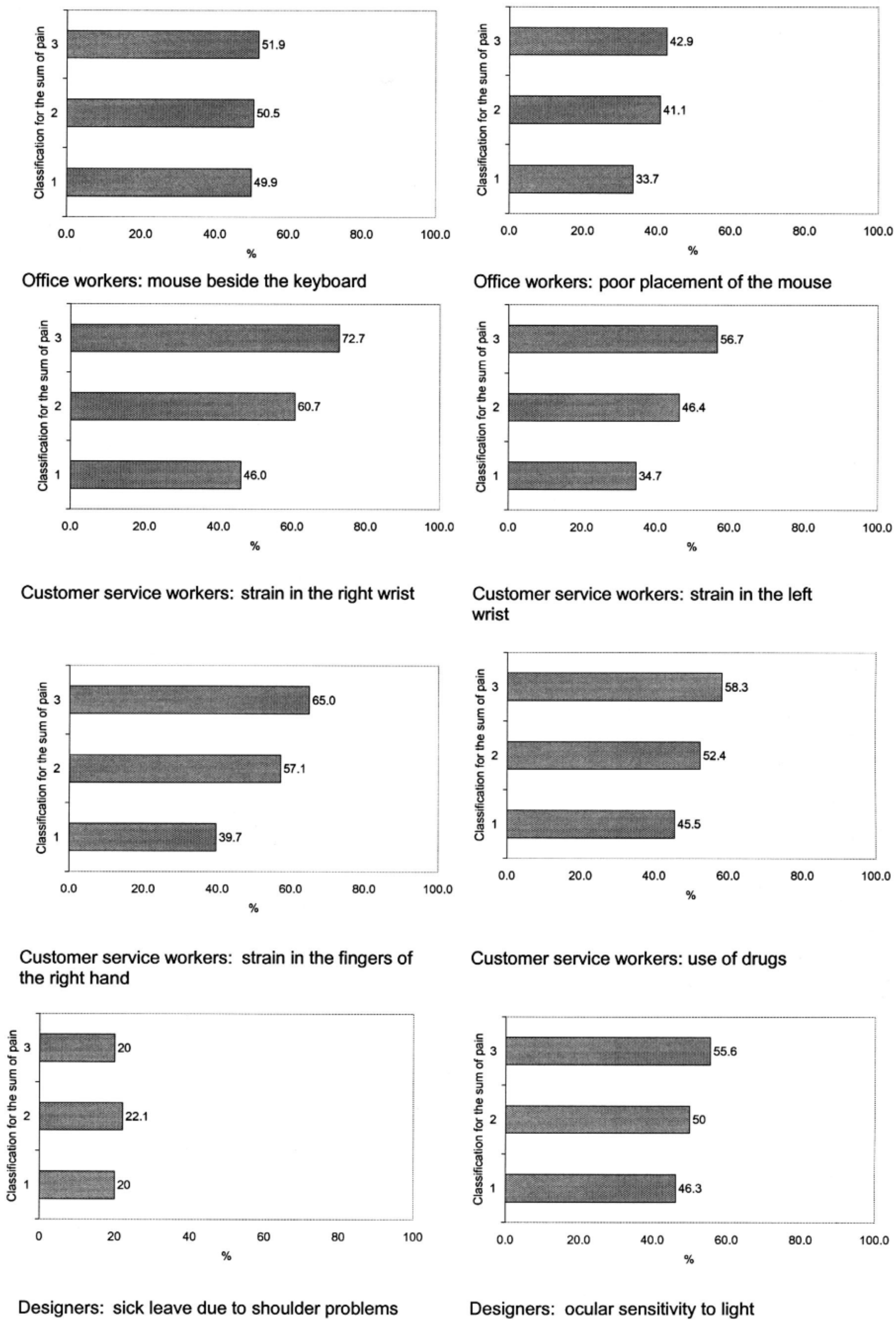

Figure 1. The risk factors identified in the three occupational groups by polychotomous modelling.

strain in the right wrist explained the sum of the pain regions the best and the use of medication the worst.

For the designers, the risk factors were sick leave due to shoulder problems and ocular sensitivity to light. Among these two factors, the sensitivity to light explained the sum of the pain regions the best.

Discussion

Our study indicates that musculo-skeletal pain is common among computer workers in offices. However, there is no strong association between the duration of daily work with a computer and pain or the duration of daily mouse use and pain, but the workers' rating of the ergonomics of their workstations as poor was strongly associated with an increased prevalence of pain.

The results of this study can be considered to be representative of computer work in offices because the occupational health personnel specifically arranged for the questionnaire to be distributed to workplaces with offices. The response rate can be considered high (65%), since the questionnaire was distributed only once, without reminders. The computer has become the main piece of equipment in the office environment and our subjects were computer users, 82.4% of the respondents having worked with a computer >4 h a day. The use of a mouse was also very common, 88.7% of the respondents having used a mouse in their work.

The 12 month prevalences of musculo-skeletal symptoms among all the workers were 63, 24, 18, 35 and 16% for the neck, shoulders, elbows, lower arms and wrists, and fingers, respectively. Cook *et al.* [8] found about the same 12 month prevalence of neck pain among computer mouse users, but the prevalences of pain in the shoulders and wrists or hands were clearly higher. The 12 month prevalences of symptoms found among computer-assisted design (CAD) operators by Jensen *et al.* [9] were higher, being 70, 54, 41 and 52% for the neck, shoulders, elbows and hands or wrists, respectively. Lower prevalences have also been found [10]. Marcus and Gerr [11] studied female office workers and found the prevalence of pain in the neck-shoulder region to be 63%.

A comparison of prevalence rates is difficult due to the different definitions of musculo-skeletal discomfort and prevalence times. The body parts used also differ (hand/wrist, forearm/wrist, hand/fingers, fingers, etc.).

Our study indicated statistically significantly higher prevalences of pain in the neck, lower arms and wrists, and fingers for the women than for the men. Karlqvist *et al.* [1] also reported higher prevalences of musculo-skeletal symptoms in the neck and upper extremities of female CAD operators than in male CAD operators. Ekman *et al.* [12] studied 2044 computer workers who worked at least half of their workday with a computer and also used a computer mouse; in all the occupational groups studied they found a higher prevalence of musculo-skeletal symptoms for the women than for the men. Their results indicated that, in the studied population, there may have been a difference in occupational exposure among the men and women that would have explained the gender difference. The same explanation may also be relevant in our study; however, women are known to report more symptoms than men.

Our study did not show the same association between the duration of daily computer use and musculo-skeletal pain or daily mouse use and musculo-skeletal pain that was found in some recent studies [1,2,13]. Karlqvist *et al.* [1] found that working at least 5.6 h a week with a computer mouse increased the risk of musculo-skeletal symptoms in the shoulder joint (upper arm), elbow, wrist and hand or fingers. Demure *et al.* [13] found an increased risk for wrist/hand and neck/shoulder discomfort among persons working with a computer ≥7 h per day, as compared with working ≤3 h. Cook *et al.* [8] confirmed our findings and found no relationship between the hours of mouse use a day and reported symptoms. It may be that those who experience pain minimize the use of the computer, or that a training effect takes place among those without symptoms and this phenomenon makes it possible for these workers to work longer hours. Such assumptions cannot be evaluated in a cross-sectional study such as ours.

Ergonomic conditions, as evaluated by the workers, proved to play an important role in our study. The respondents who rated the placement of the keyboard or the mouse as poor had an elevated risk for pain in all the body regions studied. Furthermore, the respondents who rated the ergonomics of their workstations as poor also had an elevated risk for pain in all the body regions studied. In cross-sectional study designs it is always possible for response bias to affect the results, i.e. those having symptoms consider their work environment to be worse than healthy workers do.

Demure *et al.* [13] found that new, directly adjustable furniture significantly increased wrist/hand discomfort over that of workers with dated, non-adjustable furniture, despite the presence of more precise ergonomic measures in the model. They also found that 'poor keyboard position' increased wrist/hand discomfort but 'poor layout' of the workstation, interestingly, decreased wrist/hand discomfort.

In our study, placement of the mouse beside the keyboard showed an elevated risk for finger pain among the designers. This placement, generally considered to be ergonomic, may have caused finger pain due to unsatisfactory room for the mouse and the need to raise the mouse to make movement possible. Karlqvist *et al.* [1] found the risk of musculo-skeletal symptoms in the shoulder (scapular), shoulder joint (upper arm), elbow and wrist to be greater when the mouse was 'nonoptimally' located. Cook *et al*. [8] found an association between symptoms in the neck and arm abduction specific to mouse use.

According to our polychotomous modelling, the three occupations differed from each other substantially. Among the office workers, problems associated with the mouse were emphasized. For the customer service workers, strain in the wrists and fingers after an ordinary workday proved to be a problem, possibly as a consequence of the worker considering the client and neglecting the need to work ergonomically. Designers showed a sensitivity to light that emphasizes the importance of visual aspects and illumination.

Conclusions

Musculo-skeletal symptoms are common, but the duration of daily keyboard and mouse use had no connection with musculo-skeletal symptoms in our study. Therefore, the mouse itself may not be a problem; rather it may be the manner in which it is used. More consideration should be paid to the ergonomics of workstations, the placing of the mouse, the postures of the upper extremities and the handling of the mouse.

The subjective estimations of the time used with the keyboard and mouse may be too inaccurate and they should be replaced with actual measurements.

Our statistical multivariate analysis indicated that the three occupations studied differ substantially. The differences indicated that an ergonomic analysis should always be carried out before improvements in VDU work are undertaken.

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