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The prevalence of neck and upper extremity musculoskeletal symptoms in computer mouse users

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Abstract

Computer pointing devices such as the mouse are widely used. Despite this, the relationship between musculoskeletal symptoms and mouse use has not been established. The aim of this cross-sectional study was to determine whether a relationship existed between computer mouse use and musculoskeletal symptoms in a sample of 270 computer mouse users. Factors demonstrating a significant association with symptoms were entered into a step-wise multiple logistic regression, adjusting for age and sex and controlling for potential interdependence between variables. No relationship was found between hours of mouse use per day and reported symptoms. A relationship was found between the variable of arm abduction which is specific to mouse use and symptoms in the neck. Relationships were found between non-mouse-specific risk factors such as stress, screen height and shoulder elevation. The findings of this study support the hypothesis that mouse use may contribute to musculoskeletal injury of the neck and upper extremity. Mouse users are exposed to the same recognised risk factors associated with keyboard use as well as the additional risk factor of arm abduction during mouse use.

Relevance to industry

Computer keyboard use has been associated with musculoskeletal injuries. Most people now use a pointing device such as the mouse to supplement the computer keyboard. Additional risk factors related to mouse use have the potential to increase prevalence of computer-related injuries.

Keywords: Computer mouse; Pointing devices; Musculoskeletal symptoms

1. Introduction

Use of the computer mouse is widespread with most software packages now requiring movement of a screen cursor controlled via a pointing device. Computer mouse usage has been demonstrated to account for up to two-thirds of computer operation time, depending on the software used and the task performed (Karlqvist et al., 1994). It has been suggested that mouse use may be related to musculoskeletal discomfort and injury (Pascarelli and Kella, 1993). A number of recent studies have reported that mouse use commonly involves work postures associated with musculoskeletal disorders.

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The position of the mouse away from the midline of the body results in mouse users working with the arm unsupported, the shoulder abducted and externally rotated and the arm in forward flexion (Franzblau et al., 1993; Karlqvist et al., 1994; Cooper and Straker, 1998; Aaras et al., 1997; Fernstrom and Ericson, 1997; Harvey and Peper, 1997; Cook and Kothiyal, 1998; Karlqvist et al., 1996). In the distal upper extremity, mouse users are reported to adopt working postures of wrist extension and ulnar deviation (Karlqvist et al., 1994; Fernstrom and Ericson, 1997; Cook and Kothiyal, 1998; Burgess-Limerick et al., 1999b).

The prevalence of musculoskeletal disorders amongst keyboard users has been reported to be as high as 81% (Kamwendo et al., 1991). Recognised factors associated with keyboard use include duration of time between rest breaks, duration of computer use (Bergqvist et al., 1995b; Smith and Carayon, 1996) physical factors affecting work posture such as heights of work equipment (Hunting et al., 1981; Bergqvist et al., 1995b) and psychosocial factors such as stress (Stock, 1991; Hales et al., 1994; Gerr et al., 1996; Marcus and Gerr, 1996; Smith and Carayon, 1996; Buckle, 1997). Age and gender have been reported by some authors to have an effect on symptom prevalence (Knave et al., 1985; Rossignol et al., 1987; Stock, 1991; Hales and Bernard, 1996).

While publications related to computer mouse use are increasing, studies on the prevalence of musculoskeletal disorders related to mouse use are limited. Fogelman and Brogmus (1995) reviewed United States workers compensation claims for 1987–1993 to determine the prevalence of musculoskeletal disorders related to mouse use. The authors reported that although the prevalence of claims related to mouse use was low, there were indications that mouse use was an increasing problem. Karlqvist et al., 1996 reported a high prevalence of musculoskeletal symptoms amongst a group of CAD users, with females reporting more symptoms than males. Location of mouse in a 'non-optimal position' on the table (away from the midline of the body) and working duration were reported as possible risk factors for upper extremity symptoms (Karlqvist et al., 1994). Other than incidental findings of problems associated with mouse use (Atwood, 1989; Franzblau et al., 1993; Pascarelli and Kella, 1993), no other published epidemiological data on the relationship between musculoskeletal symptoms and mouse use could be found. The health, social and economic repercussions of this possible relationship indicate the need to establish the prevalence of musculoskeletal disorders among mouse users. The goal of this study was to examine the relationship between mouse use and upper extremity musculoskeletal symptoms within a population of computer users. The specific aims were to:

(i) determine whether the prevalence of neck and upper extremity musculoskeletal symptoms is related to intensity of mouse use (hours per day),
(ii) explore the relationship between musculoskeletal symptoms and individual, postural, psychosocial and organisational risk factors identified in the literature,
(iii) investigate the association between musculoskeletal symptoms and computer mouse usage when risk factors identified as significant in this study are considered.

2. Methods

2.1. Sample

Ethics approval was gained prior to commencement of the study. Workplaces employing more than 20 computer users were targeted for inclusion in this cross-sectional study. The aim in sampling was to include a range of computer users, from intensive mouse users to non-mouse users. All the companies approached except one company agreed to participate. This company was undergoing restructuring at the time of data collection. Companies were asked to identify groups of employees who used computers for a majority of the workday. Questionnaires regarding work patterns and musculoskeletal symptoms were distributed to 431 people, employed by 15 workplaces in Sydney, Australia. Workplaces included architectural and interior design companies, a telecommunications

Table 1
Percentage of participants from different occupational groups ($N = 302$)

Occupational groups	Percent
Clerical	22
Technical (including draftsmen, architects, engineers)	21
Newspaper call centre representatives	27
Telephone call centre representatives	23
Managers	7

company, several departments of a large newspaper, magazine publishers, an engineering department of a steel works, a law firm and a pharmaceutical company. The person responsible for occupational health and safety within the organisation facilitated distribution of the questionnaires. A covering letter explained the purpose of the questionnaire. Questionnaires were completed by the participants and returned to the researcher in the sealed envelope provided. Three hundred and two people returned the questionnaires (203 female, 88 male, 11 not specified), a 70% response rate. The occupations represented are described in Table 1.

Mouse users constituted 90% (270) of the sample (172 female, 87 male). Mouse use reported ranged from 0.1 to 10 h per day (mean 3.96 h, SD 2.93, median 5 h, interquartile range (IQR) 5). Duration of mouse use ranged from 2 months to 17 yr (median 3 yr IQR 5). Of the 32 non-mouse-users, 31 were female call centre workers and one was a male accountant. Table 3 describes the demographics of the participants.

2.2. Instrument

An eight page self-report questionnaire was used. The first section requested information on the participant's work patterns such as hours of computer use and computer mouse use at work and at home, break frequency and duration, exercise frequency and medical history. Participants used a Likert-type scale (strongly agree to strongly disagree) to rate their job over the past month as stressful, enjoyable, interesting, and boring. Participants were asked to sit at their workstation as if they were to start work using the computer. They were then asked to report on their working posture and workstation set-up (for example 'when you are sitting, is the top of your computer screen level with, above or below your eye height'. Illustrations based on the scoring scale in the Rapid Upper Limb Assessment (McAtamney and Corlett, 1993) were used for work posture when using the mouse, with participants asked to put crosses next to the picture indicating their arm, wrist and hand position during mouse use (Fig. 1). The sections on working posture and workstation set-up were validated in 30 participants. Self-report responses were compared with observer ratings taken immediately following participant completion of these sections. The second part of the questionnaire was based on the Nordic Questionnaire (Kuorinka et al., 1987). Participants were asked to record whether they had experienced musculoskeletal trouble (ache pain or discomfort) for the neck, shoulder, wrist/hand, forearm and upper back in the past 12 months and within the last 7 days.

2.3. Data analysis

Prevalences for reported trouble in the last 12 months and within the last 7 days were calculated for the neck, shoulder, wrist, forearm and upper back.

Inter-method reliability between self-reports and observer recordings for body postures were assessed by Cohen's kappa (Table 2). Variables were included for further analysis if kappa was found to be above 0.41, interpreted as indicating moderate agreement between the ratings (Fleiss, 1981).

Non-mouse-users were eliminated from the following analyses. Univariate associations between symptoms (trouble) and relevant factors were calculated. Prior to analysis, the number categories were reduced for the variables stress and arm position. As only eight participants had responded 'strongly disagree' to work stress for the past month, this category was combined with 'disagree'. Arm position groups were reduced from 5 to 3: 'optimal' (arm by side elbow bent and arm in front of you, close to your body, elbow bent); 'flexion'

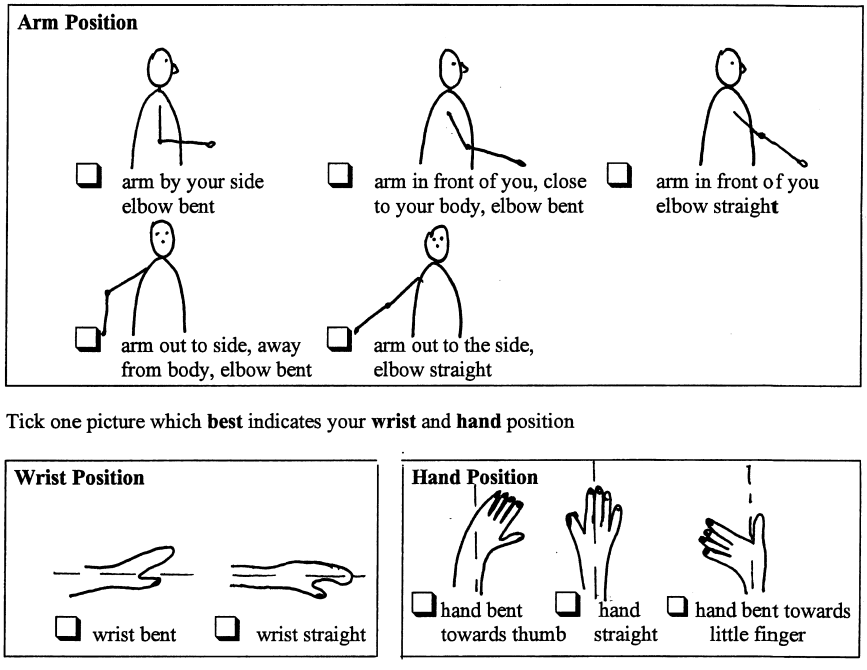

Fig. 1. Scoring scale for work postures when using the mouse (based on McAtanney and Corlett, 1993).

Table 2
Kappa coefficients and percentage agreement between observer and subject posture ratings ($N = 30$)

Mouse use	Kappa	% Agreement
Arm position	0.48	63.6
Wrist position	0.55	62
Hand position	— [a]	— [a]
Screen height	0.56	66.0
Shoulder elevation	0.49	72.7
Forearms parallel to desk	0.30	72.7

[a] Unstable.

(arm in front of you, elbow straight) and 'abduction' (arm out to side, away from body with elbow straight and with elbow bent). Participants were asked to record the 'longest time with the hand on the mouse'. This continuous variable was divided into two groups, based on the median of 5 min with the hand on the mouse.

Differences in proportions between symptom prevalence and other risk factors were examined using chi-square analysis. Differences in means of continuous variables were analysed by independent t-test. If variances of the two groups were not homogenous, separate variance estimates were used in the t-tests. Factors demonstrating a significant association with neck, shoulder, wrist/hand and upper back symptoms in the univariate analysis were entered into a stepwise multiple logistic regression, adjusting for age and sex and controlling for potential interdependence between variables. As factors associated with symptoms were not consistent, separate logisitic regression models were calculated for the neck and upper back and for the wrist/hand and shoulder. Mouse hours per day were entered into the logistic regression model as two groups: less than or equal to 4 h per day and greater than 4 h per day. Adjusted odds ratio and 95% confidence intervals were estimated using logistic regression. The analysis was performed with SPSS-PC 7.5 software.

3. Results

3.1. Prevalence of musculoskeletal symptoms

Whole sample: 75.7% of respondents reported symptoms (ache, pain or discomfort) in one or more body region in the past 12 months, with 46.4% reporting symptoms in one or more body regions in the last 7 days.

Mouse users: No relationship was found between hours of mouse use per day and symptoms or duration of mouse use and symptoms (Table 3).

3.2. Relationship of previously documented risk factors to musculoskeletal symptoms – univariate analysis

Individual: Age was found to have an effect on musculoskeletal symptoms for the shoulder. Gender differences were only found for upper back symptoms, with females reporting significantly more symptoms than males.

Posture: (a) Arm position: 55.6% reported working with their arm close to the body; 34.4% reported working with their arm in abduction and

Table 3
Prevalence of trouble (ache, pain, discomfort or numbness) and relationship with risk factors

		Neck		Shoulder		Wrist/hands		Upper back	
	N	(%)	*p*-value	(%)	*p*-value	(%)	*p*-value	(%)	*p*-value
Symptoms									
(a) Total samples – last 12 months	302	59.9		45.7		36.8		39.4	
(b) Mouse users only									
Last 7 days	270	24.4		17.8		12.6		23.3	
Last 12 months	270	63.9		47.4		39.3		41.5	
Mouse users only									
Age (yr)									
< 30	125	62.9	0.17	40.0	0.03	40.0	0.37	38.4	0.37
31–40	57	64.9		56.1		40.4		43.9	
41–50	51	74.5		60.8		45.1		51.0	
Over 50	37	51.4		40.5		27.0		35.1	
Gender									
Male	87	58.6	0.17	41.4	0.09	37.9	0.73	31.0	0.01
Female	172	67.3		52.3		40.1		48.3	
Arm position									
Optimal position	150	60.0	0.07	44.0	0.26	36.0	0.35	37.2	0.09
Flexion	21	57.1		47.6		42.9		33.3	
Abduction	93	73.9		54.8		45.2		50.5	
Screen position									
Level with the eye	110	53.2	0.009	39.1	0.04	40.9	0.59	38.2	0.68
Above the eye height	63	74.6		58.7		42.9		44.4	
Below the eye height	96	68.8		49.0		35.4		42.7	
Shoulder elev.									
No	189	58.0	0.002	40.7	0.001	32.8	0.001	34.9	0.001
Yes	81	77.8		63.0		54.3		56.8	
Hand on mouse									
0–5 min	123	56.6	0.02	43.9	0.29	39.0	0.94	39.0	0.45
> 5 min	147	70.1		50.3		39.5		43.5	
Mouse usage (h/day)									
0.1–4 h	129	61.2	0.38	46.5	0.78	35.7	0.25	38.8	0.38
> 4 h	141	66.4		48.2		42.6		44.0	
Stress									
Strongly agree	36	86.1	0.006	66.7	0.05	55.6	0.03	55.6	0.29
Agree	112	66.1		47.3		43.8		38.4	
Undecided	43	53.5		39.5		30.2		39.5	
Disagree/strongly disagree	71	54.9		40.8		29.6		38.0	

7.8% with their arm in forward flexion. Work in either flexion or abduction was not associated with more symptoms than work with the arm by the side and close to the body. (b) Screen position either above or below eye height was associated with neck and shoulder symptoms, but not wrist/hand or upper back symptoms. (c) Shoulder elevation (working with 'shoulders hunched') was associated with symptoms in the neck, shoulder, wrist/hands and upper back.

Work organisation: (a) General ($N = 302$) reported time of computer use (work + home) ranged from 3 to 76 h per week (median 33, IQR 15), with 89.1% reporting to use a computer more than 18 h per week. No relationship was found between hours employed per week (median 38, IQR 10) or time spent working at the computer without a break (defined as getting up from the work station) (range 0–300 min, median 120, IQR 60) and symptoms.

(b) Mouse-specific ($N = 270$): Participants were asked to record the 'longest time with the hand on the mouse' (range 0–240 min, median 10 min). When the two groups (less than 5 min and more than 5 min with hand on the mouse) were considered, a significant difference was found for neck symptoms only.

Psychosocial: Participants who agreed that work had been stressful over the past month reported significantly more symptoms in the neck, shoulder and wrist/hands but not in the upper back. No association was found between other factors such as job boredom, stimulation or level of interest reported in work and symptom reporting.

3.3. Association between computer mouse usage and musculoskeletal symptoms

Multiple logisitic regression analysis identified a number of risk factors for each of the following (See Table 4):

Neck symptoms: Four risk factors for neck symptoms were identified. These included arm position of abduction, screen position above or below eye height, stress and shoulder elevation. Time spent with hand positioned on the mouse was not found to be a significant risk factor for neck symptoms when other factors were considered.

Shoulder symptoms: Age, stress, screen height above eye level and shoulder elevation were found to be significant risk factors. Mouse usage per day and arm position were not found to contribute significantly.

Wrist/hand symptoms: Stress and shoulder elevation were identified as risk factors.

Upper back: Two risk factors were identified. These were female gender and shoulder elevation.

4. Discussion

The aim of this cross-sectional study was to examine the relationship between computer mouse use and musculoskeletal symptoms in the neck, shoulder, wrist/hand and upper back. No relationship was found between hours of mouse use per day and symptoms. A relationship between the mouse-specific variable of arm abduction and musculoskeletal symptoms in the neck was found in addition to relationships between non-mouse-specific risk factors. These included stress, screen height and shoulder elevation; risk factors previously associated with keyboard use. Stress was related to symptoms in all regions except the upper back. Neck symptoms were associated with low or high screen height and shoulder symptoms were associated with age, high screen position and shoulder elevation. Time with the hand positioned on the mouse was associated with neck symptoms when considered in univariate analysis but not when combined with other significant factors via logistic regression. Wrist/hand symptoms were related to shoulder elevation. Upper back symptoms were related to gender. These findings are now discussed in relation to existing literature.

The higher prevalence of neck symptoms when the mouse is used with the arm in abduction corresponds with findings of previous studies on mouse use. Mouse users are described as working in a position of flexion and abduction, postures that been shown to contribute to neck and shoulder work-related musculoskeletal disorders (Hagberg et al., 1995). In the present study, one-third of mouse users reported working with the arm in abduction. Increased activity in the deltoid and trapezius has been found when the mouse was used

Table 4
Logistic regression model indicating factors with the most influence on "trouble" in the past 12 months ($N = 270$)[a]

	Neck		Shoulder		Wrist/hands		Upper back	
	OR	CI	OR	CI	OR	CI	OR	CI
Age (yr)								
< 30			1.0					
1–40			2.49	1.23–5.06				
41–50			2.79	1.31–5.94				
Over 50			1.16	0.48–2.76				
Gender								
Male							1.00	
Female							2.39	1.33–4.31
Screen position								
Level with eye	1.00		1.00					
Above the eye height	3.19	1.50–6.78	2.38	1.20–4.71				
Below the eye height	2.19	1.16–4.14	1.57	0.86–2.88				
Shoulder elev.								
No	1.00		1.00		1.00		1.00	
Yes	2.01	1.04–3.88	2.69	1.49–4.90	2.28	1.30–4.00	2.26	1.28–3.98
Stress								
Dis/strongly disagree	1.00		1.00		1.00			
Strongly agree	4.30	1.43–12.95	2.66	1.08–6.58	2.64	1.13–6.20		
Agree	1.30	0.66–2.56	1.11	0.58–2.14	1.54	0.90–3.16		
Undecided	0.73	0.32–1.69	0.80	0.35–1.84	0.89	0.39–2.02		
Hand on mouse								
0–5 min	1.00							
> 5 min	1.64	0.91–2.96						
Arm position								
Optimal position	1.00						1.00	
Flexion	1.00	0.35–2.84					0.66	0.24–1.84
Abduction	2.07	1.11–3.84					1.73	0.99–3.03
Mouse usage (h/day)								
0.1–4 h	1.00		1.00		1.00		1.00	
> 4 h	1.05	0.57–1.91	1.33	0.75–2.35	1.24	0.73–2.10	1.24	0.71–2.16

[a]OR, adjusted odds ratio; CI, 95% confidence interval.

to the side of a keyboard (Harvey and Peper, 1997; Cook and Kothiyal, 1998), and when mouse use was compared with keyboard use (Karlqvist et al., 1994; Cooper and Straker, 1996). Karlqvist et al. (1994) reported a higher prevalence of symptoms when the mouse was used in a non-optimal position.

There is little agreement on the prevalence of musculoskeletal symptoms in computer keyboard operators, with ranges of 11–81% reported (Smith et al., 1981; Kamwendo et al., 1991). Only one other study has reported symptom prevalence amongst mouse users (Karlqvist et al., 1996). These authors reported on 'present symptoms' rather than history of symptoms over the past week or year. If symptom prevalence over the past week is considered, the prevalences in the current study appear only slightly higher than those reported by Karlqvist et al. (1996). The reported computer and computer mouse hours worked in that study were much lower than in the current study. However, the pattern of symptom reporting was similar, the highest symptom prevalence was for the neck and then for the shoulders. In their study of workers compensation records, Fogelman and Brogmus (1995) reported that mouse users had a greater prevalence of symptoms in the upper or lower arm (assumed to equate with shoulder and forearm in current study).

Neck injury related to either the computer or computer mouse was reported as minimal. The discrepancies in symptom reporting for the neck and shoulder may be partly explained by the differences in recording of symptoms or by the inter relationship between the neck and shoulder muscles. As the neck and shoulder share a number of muscles, neck pain has been associated with shoulder posture (Hagberg et al., 1995). Neck and shoulder discomfort are reported together in some studies (Bergqvist et al., 1995b; Marcus and Gerr, 1996), indicating the inter relationship between these two areas in symptom reporting. Difficulties comparing the findings of the current study with the study by Fogelman and Brogmus (1995) relate to the differences in study design. Workers compensation data underestimates the prevalence of a problem, whereas cross-sectional study designs in which symptoms alone are considered are likely to overestimate the magnitude of the problem (Stock, 1991; Fogelman and Brogmus, 1995). However, one would expect similar patterns to emerge from the two studies. Screen position above the eye level was associated with both neck and shoulder symptoms. The relationship between screen heights above the eye level and neck symptoms is consistent with the data presented by Bergqvist et al., 1995a,b. Neck symptoms were also associated with screen height below eye level. This relationship between screen heights lower than eye level and musculoskeletal symptoms is inconsistent with data on postural consequences of different screen heights (Burgess-Limerick et al., 1998, 1999a).

The finding of a higher prevalence of symptoms in the wrist supports the reports of positions of ulnar deviation and wrist extension among mouse users (Karlqvist et al., 1994; Fernstrom and Ericson, 1997; Cook and Kothiyal, 1998; Burgess-Limerick et al., 1999b). Ulnar deviation and wrist extension have been documented to be risk factors in musculoskeletal disorders of the upper extremity (Hunting et al., 1981; Hagberg et al., 1995). Fogelman and Brogmus (1995) reported an increased prevalence of wrist disorders amongst mouse users. Although the time with the hand on the mouse was not related to wrist/hand symptoms, working with the shoulders in elevation was found to be significant. This reported posture may indicate presence of a high work surface, a reported risk factor for wrist/hand symptoms in some studies (Hunting et al., 1981; Sauter et al., 1991). The increase in shoulder elevation may also be related to postures adopted during mouse use, an area which has not previously been well described in the literature. Other studies report finding low keyboard placement rather than high as a risk factor (Bergqvist et al., 1995a).

There has been a reported increase in prevalence of symptoms with increasing hours of computer use (Hunting et al., 1981; Knave et al., 1985; Hagberg and Wegman, 1987; Rossignol et al., 1987; Bergqvist et al., 1995a) with other studies demonstrating no relationship (Hoekstra et al., 1996; Marcus and Gerr, 1996). Rossignol et al. (1987) reported an increased prevalence ratio of musculoskeletal symptoms for workers who worked 4–6 h per day and over 7 h per day. The current study found no association between total hours of computer use per week and musculoskeletal symptoms. Karlqvist et al. (1996) reported that more than 5.6 h of mouse time per week increased the risk of shoulder symptoms. The current results did not find an association between hours of mouse use per day and symptoms. Caution needs to be taken when considering the accuracy of reported work hours, as self-reports of computer work hours have been found to be overestimated (Faucett and Rempel, 1996) or unreliable (Gerr et al., 1996).

The relationship between work organisational factors and musculoskeletal disorders has been documented (Smith and Carayon, 1996). Work organisation can influence ergonomic risk factors such as repetition, posture or force or duration to exposures such as frequency of rest breaks. Bergqvist et al. (1995a) reported an association between neck/shoulder discomfort and limited rest break opportunity. No such association was found between symptoms and time between rest breaks in the present study. A relationship was found between the time the hand was positioned on the mouse and neck symptoms in the univariate analysis but not when other factors were considered. The large proportion of people reporting positioning their hands on the mouse for long periods of time is a concern.

Psychosocial factors have been reported to have a significant effect on reported musculoskeletal symptoms (Stock, 1991; Hales et al., 1994; Gerr et al., 1996; Buckle, 1997). Stress may affect psychological moods, work behaviours and coping styles and may result in an increase of symptom reporting (Smith and Carayon, 1996). Marcus and Gerr (1996) reported an increased odds ratio for neck and shoulder symptoms with subjects who reported work as very stressful in the previous two weeks. Similar results were found in the current study with subjects agreeing that work had been 'stressful' in the past month reporting more symptoms in the neck, shoulder and wrist/hands.

Cross-sectional studies are useful for establishing exposure disease associations, in this case providing direction for further research into the area of input device use (Sorock and Courtney, 1996). The limitations associated with cross-sectional studies of musculoskeletal symptoms have been well documented (Stock, 1991; Hales and Bernard, 1996; Sorock and Courtney, 1996; Wells et al., 1997). These include the inability to establish a temporal relationship or to track exposure over time. Use of questionnaires, which rely on symptom reporting can overestimate the magnitude of the problem as presence of symptoms do not equate with prevalence of musculoskeletal disorders (Stock, 1991; Hales and Bernard, 1996). The presence of symptoms alone may therefore be an unstable predictor of musculoskeletal disorders in a working population (Gerr et al., 1996). Many potential confounding variables were considered in this study. These included age, gender, the time spent in present type of work and frequency of exercise. The only relationships found were for gender and upper back symptoms and age and shoulder symptoms.

5. Conclusion

Mouse use has increased exponentially over the last decade. In the early 1990s, Pascarelli and Kella (1993) reported that 4% of a study population used a mouse, while in the late 1990s we encountered extreme difficulty locating non-mouse users to survey. The results of the current research suggest that mouse use constitutes an additional risk factor for musculoskeletal symptoms, particularly related to the arm posture adopted. The results also suggest that mouse use may contribute to neck and wrist discomfort, and that investigation of preventative strategies is warranted.

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