

PRECISION DEMAND AS A RISK FACTOR FOR MUSCULOSKELETAL DISORDERS

Christensen H, Sjøgaard K, Birch L, Jensen C

Department of Physiology, National Institute of Occupational Health, Copenhagen, Denmark

hc@ami.dk

In a questionnaire study for computer users, (the BIT study), it was shown that this sector reported a higher degree of sensoric demanding work than Danish employees in general. In addition it was shown that all computer work tasks involved high levels of sensoric demands though the tasks appeared to be distinct. The 1½ years follow-up analysis in the BIT study showed that high sensoric demands predicted the development of pain and discomfort in the hand/wrist area among women.

To physiologically explain the mechanism behind this epidemiological finding, electromyographic registrations were performed during standardized computer work with different levels of precision demands. It was shown that the level of muscle activity was related to both precision demand and the speed of the work.

INTRODUCTION

High sensoric demands such as precision and hand eye coordination are traditionally related to repetitive monotonous work tasks, where employees perform the task with repetitive hand and finger movements, often involving the use of a hand tool. Examples are meat cutting and assembly line work. In the Danish National Cohort study, which is a follow-up study from 1990, 1995 and 2000, the precision demand is expressed as an index of sensoric demand to quantify the need for coordination between eye, mental attention and hand movements. It was shown that employees in the specific industries characterized by repetitive monotonous work tasks reported a higher degree of sensoric demands compared to employees in other industries.

The purpose of the present study was to examine to what extent the precision demand would be a risk factor for developing musculoskeletal symptoms during computer work.

METHODS

Questionnaire study

Subjects

Two questionnaires were delivered to computer users in 11 Danish companies and institutions. The companies were selected to provide employees with different types of computer work, i.e. data entry, word processing, graphical work and so forth. The baseline questionnaire was delivered

to 5033 computer users in the early part of 1999. The response rate at baseline was 69% (n=3475). In the baseline questionnaire the participants were asked about their home address in order to mail the follow-up questionnaire. The follow-up questionnaire was mailed ultimo 2000 to 3363 respondents and 2576 participants responded corresponding to a response rate of 77% (Jensen 2003).

Questionnaire

The baseline questionnaire is described in details (Jensen et al. 2002). The baseline questionnaire contained dimensions such as physical and ergonomic exposures and psychosocial parameters. In these dimensions among other questions we asked about repetitiveness, quantitative demands, sensorial demands and cognitive demands (Jensen 2003). The question referring to duration of computer use was: "How much of your work time do you work with a computer (including overtime and work time at home)" and the answer categories were never/seldom, ¼, ½, ¾ or almost all of the work time. Both the baseline and follow-up questionnaire contained questions on musculoskeletal symptoms according to a modified version of the Nordic questionnaire (Kuorinka et al. 1987). When analysing the development of musculoskeletal symptoms, respondents were only included if they were non-symptomatic at baseline in both the neck, shoulder, arm and hand regions.

LABORATORY STUDY

Fourteen experienced female CAD operators participated. The computer task was performed using a puck on a digitizer. Circular targets were shown on the computer screen, and the task consisted of pointing the cursor to the targets that were activated by pressing a button on the puck. Lines were automatically drawn between consecutively activated targets, and the purpose was to activate targets in a specific order to duplicate a drawing that was shown in the upper right-hand corner of the computer screen. Precision, time pressure, and mental demands could be set at 2 different levels each, high and low, giving 8 combinations of exposure.

High and low precision meant that the diameter of the target points were 4 pixels and 30 pixels, respectively, which in this set-up equaled movements with the puck of approximately 0.5 and 3.5 mm, respectively. For the high time pressure the subjects were instructed to complete as many drawings as possible within 5 minutes and told that the result would be stored. For the low time pressure the work pace was self-chosen, and the subjects were instructed to work in a relaxed, but continuous fashion. During high mental demands the subjects had to distinguish relevant points from irrelevant points in a grid with 8x8 grid points. During low mental demands only the relevant points were visible.

Bipolar surface electrodes were placed over the medial deltoid muscle, the descending part of the trapezius muscle, the infraspinatus muscle, and the extensor digitorum muscle of the mouse-operating side.

Procedure

After performing maximum voluntary contractions (MVC) of the shoulder and forearm muscles, the computer task was performed with 8 different exposure combinations of precision, time pressure and mental demand in random order. The subjects worked 5 minutes with each exposure combination, and the combinations were separated by at least 2-minute breaks.

RESULTS

Questionnaire study

For the respondents, who were non-symptomatic at baseline, the percentage of incident cases at follow-up are shown in table 1.

Table 1. Incident cases at follow-up. Only respondents with symptoms for 7 days or less during the last year prior to the baseline survey were included.

	Women			Men		
	N	%	T ¹	N	%	T ¹
Neck	168	25.5	660	82	15.4	532
Hand/wrist	223	21.6	1035	78	12.5	626

T¹ is the total number of non-symptomatic respondents at baseline

In the univariate analysis high sensoric demands (Table 2), low influence at work, a high degree of repetitiveness, low social support and disturbance by glare were risk factors for the development of symptoms among women.

Table 2. Women: Percentages of female respondents with symptoms at follow-up divided by the sensoric demands at baseline (percentage of women with symptoms >7 days during the last year of the follow-up period). P-value refers to Chi square or Mantel Haenszel Chi square test of association.

	Neck symptoms		Hand/wrist symptoms	
	%	p-value	%	p-value
Sensoric Demands				
High	28	0.049	26	0.040
Medium high	27		18	
Medium low	19		13	
Low	21		21	

Factors associated with the development of neck symptoms in men in the univariate analyses were age and duration of employment, high cognitive demands, sufficient training in software-use and good computer skills.

LABORATORY STUDY

The number of produced drawings during each 5-minute period, the number of errors and mouse clicks, and the distance the cursor moved on the screen (pixels) were all significantly influenced by the combinations of time pressure, precision, and mental demands ($p < 0.001$ for all). When the demand for precision was increased, a smaller number of drawings were produced, and in general the number of clicks per drawing was larger. Additionally the number of errors per drawing decreased if the demand for precision was increased but only in combinations including

high mental demand. Furthermore increasing the demand for precision increased the number of pixels per drawing, but only when the mental demand was low. EMG activity was influenced by precision demands as well. That is, when high precision demand was compared to low precision demand in the combination with high time pressure and low mental demand the EMG activity levels were lower during high precision for all the muscles. For the infraspinatus muscle the lower EMG activity during high precision was also seen even if the time pressure was low. The results from the infraspinatus muscle are shown in figure 1.

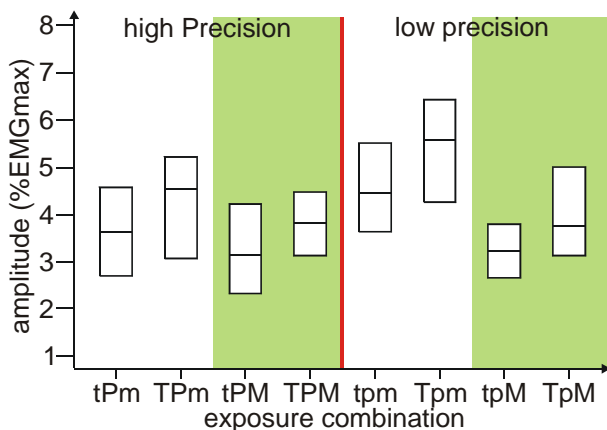


Figure 1. The EMG amplitude for the Infraspinatus muscle during the 8 different exposure combinations. Each combination is symbolized by the letters t or T (time), p or P (precision), m or M (mental), lower case letters referring to low demands and upper case letters to high demands.

DISCUSSION

Women with high sensoric demands were more likely to develop hand/wrist symptoms than women with medium/low demands. This emphasized the importance of specific job demands and job control as work environment factors, which predict the health of computer users. Faucett and Rempel (Faucett and Rempel 1994) also reported that low job control was associated with an increased prevalence of symptoms. In the present questionnaire study several dimensions of job demands were studied, as it is important to identify which specific dimension(s) may influence the development of symptoms. The dimensions and the questions contained in each dimension were developed by Kristensen et al. (Kristensen et al. 2002), who have used these questions in psychosocial surveys of people from the general workforce. In comparison with these data, office workers using computers for a large part of their work tasks are exposed to high sensoric demands compared to many

other job types. Furthermore, high sensoric demands are especially relevant to focus on during computer work, as a badly designed user interface may increase demands of vision and precision more than necessary. Such demands may increase the duration of static work postures and thereby the risk of developing musculoskeletal symptoms.

The laboratory study showed that the productivity during computer work depended on the combination of the 3 investigated factors. Large differences were found in productivity between some exposure combinations, but high time pressure per se only introduced small increases in productivity when added to a given combination of precision and mental demands. Thus an optimal work pace close to maximum may exist for a given combination of precision and mental demands. Increasing the work pace is known to result in greater muscle load (Mathiassen and Winkel 1996). The higher EMG activity in all the muscles during high time pressure (combined with low precision and mental demands) may have been caused by a faster movement speed accompanying the larger productivity (Laursen et al. 1998). But the increase in productivity was small, and the stressful situation that was introduced by high time pressure may have had an influence on the muscle activity as well (Lundberg et al. 1994; Westgaard and Bjørklund 1987).

REFERENCES

- Faucett J, Rempel D (1994) VDT-related musculoskeletal symptoms: Interactions between work posture and psychosocial work factors. *Am J Ind Med* 26:597-612
- Jensen C (2003) Development of neck and hand-wrist symptoms in relation to duration of computer use at work. *Scand J Work Environ Health*
- Jensen C, Finsen L, Sjøgaard K, Christensen H (2002) Musculoskeletal symptoms and duration of computer and mouse use. *Int J Ind Erg* 265-275
- Kristensen TS, Borg V, Hannerz H (2002) Socioeconomic status and psychosocial work environment: results from a Danish national study. *Scand J Public Health Suppl* 59:41-48
- Kuorinka I, Jonsson B, Kilbom Å, Vinterberg H, Biering-Sørensen F, Andersson G, Jørgensen K (1987) Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Applied Ergonomics* 18:233-237
- Laursen B, Jensen BR, Sjøgaard G (1998) Effect of speed and precision demands on human shoulder muscle electromyography during a repetitive task. *Eur J Appl Physiol* 78:544-548
- Lundberg U, Kadefors R, Melin B, Palmerud G, Hassmén P, Engström M, Dohns IE (1994) Psychophysiological stress and EMG activity of the trapezius muscle. *Int J Behav Med* 1:354-370
- Mathiassen SE, Winkel J (1996) Physiological comparison of three interventions in light assembly work: reduced work pace, increased break allowance and shortened working days. *Int Arch Occup Environ Health* 68:94-108
- Westgaard RH, Bjørklund R (1987) Generation of muscle tension additional to postural muscle load. *Ergonomics* 30(6):911-923