ORIGINAL ARTICLE

Work related and individual predictors for incident neck pain among office employees working with video display units

T Korhonen, R Ketola, R Toivonen, R Luukkonen, M Häkkänen, E Viikari-Juntura

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See end of article for authors' affiliations

Correspondence to: Dr R Ketola, Musculoskeletal Research Unit, Department of Physiology, Finnish Institute of Occupational Health, Topeliuksenkatu 41 aA, FIN-00250 Helsinki, Finland; ritva.ketola@occuphealth.fi

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Aims: To investigate work related and individual factors as predictors for incident neck pain among office employees working with video display units (VDUs).
Methods: Employees in three administrative units of a medium sized city in Finland (n = 515) received mailed questionnaires in the baseline survey in 1998 and in the follow up survey in 1999. Response rate for the baseline was 81% (n = 416); respondents who reported neck pain for less than eight days during the preceding 12 months were included into the study cohort as healthy subjects (n = 232). The follow up questionnaire 12 months later was completed by 78% (n = 180). Incident neck cases were those reporting neck pain for at least eight days during the preceding 12 months.
Results: The annual incidence of neck pain was 34.4% (95% CI 25.5 to 41.3). Poor physical work environment and poor placement of the keyboard increased the risk of neck pain. Among the individual factors, female sex was a strong predictor. Smoking showed a tendency for an increased risk of neck pain. There was an interaction between mental stress and physical exercise, those with higher mental stress and less physical exercise having especially high risk.
Conclusion: In the prevention of neck disorders in office work with a high frequency of VDU tasks, attention should be given to the work environment in general and to the more specific aspects of VDU workstation layout. Physical exercise may prevent neck disorders among sedentary employees.

The evidence of risk factors for various types of neck disorders is based mostly on cross sectional studies, and a limited number of longitudinal studies. According to a recent review[1] and two later prospective studies,[2 3] a positive relation has been found between various neck disorders and work related risk factors, such as static neck and arm postures, duration of sitting, as well as workplace design. Among other job characteristics, high quantitative job demands, having little influence on one's work situation, and limited rest break opportunities have been found as predictors of neck pain.[4–7] Among individual factors, the role of psychological factors has been emphasised.[8]

Concerning video display unit (VDU) work, the evidence of risk factors is based mainly on cross sectional studies. Increasing hours of computer use and incomplete work–rest cycle control, have been associated with musculoskeletal discomfort in the neck–shoulder area and upper extremities,[9–12] especially when using input devices, such as a keyboard or a mouse.[13–15] Computer use in sustained non-neutral postures, such as neck rotation and shoulder abduction, have been identified as risk factors for neck–shoulder symptoms.[10] Postural stress caused by poor workstation ergonomics, such as inappropriate location of the screen, keyboard, or mouse, have been associated with musculoskeletal problems.[11 15–19] By ergonomic interventions, such as supporting the forearm on the tabletop, a reduction of postural load,[14] discomfort,[20 21] or neck pain[22] has been achieved. Work organisational factors, such as increasing work pressure or hurry and lack of job security or decision making opportunities, as well as problems in work atmosphere, may contribute to an increased occurrence of work related musculoskeletal complaints.[10 12 23]

Among individual factors, female gender and older age have been found to be associated with a more frequent report of neck pain.[3 8] Among health behavioural factors, smoking has been found as a risk factor,[24–26] whereas the evidence on physical exercise has been inconsistent. A low frequency of exercise has been found preventive in some studies.[27 28] Among sedentary workers a low physical activity has been a risk factor in some studies,[24 29] whereas no effect has been found in some other studies.[29–31] The role of psychosocial and psychological factors, such as stress, tension, depression, and job satisfaction has been frequently observed in the occurrence of various neck disorders.[8 32–35]

We carried out a prospective study among office workers in municipal administrative units. The aim was to investigate work related and individual factors as predictors for incident neck pain among office employees working with VDUs.

METHODS

Study population

The study was conducted in three municipal administrative units. The study population was the entire population of those full time working employees, whose job included VDU work for more than four hours per week (n = 515). Altogether 416 workers participated in the baseline survey in 1998 (81%). From the baseline respondents, the subjects of interest were those who reported local or radiating neck pain for less than eight days during the preceding 12 months. These subjects were classified as "healthy" at baseline (n = 232). This cohort was studied 12 months later, the response rate being 78% (n = 180). At follow up in 1999 the incident cases were those workers who reported local neck pain or radiating neck pain for at least eight days during the preceding 12 months.

Questionnaire

Data were collected via structured mailed questionnaires. The assessment of the potential risk factors took into consideration various physical and psychological workload and ergonomic factors. The questionnaire also included questions on lifestyle and psychosocial factors.

The incident cases were healthy subjects at the baseline who reported at follow up local or radiating neck pain for at

least eight days during the preceding 12 months. The exact wording of the question for local neck pain was as follows: "Estimate the total number of days you have had local neck pain (not radiating) during the preceding 12 months". The original question had five categories: 0 days, 1–7 days, 8–30 days, >30 days but not daily, and daily. The wording for radiating pain was as follows: "Estimate the total number of days you have had neck pain radiating to the upper extremity (forearm, hand, or fingers) during the preceding 12 months". The original question had five categories: 0 days, 1–7 days, 8–30 days, >30 days but not daily, and daily. In the analysis, we combined the first two categories, because we think that some days with neck pain does not indicate a disorder. We also combined the three last categories. Thus, a two category variable was used: 0–7 days (healthy) and 8 or more days (incident neck pain).

As measured in the 1998 baseline questionnaire, we used 11 work related and 11 individual variables as potential predictors for the outcome. We selected these factors into our study based on our hypotheses and earlier evidence as follows.

Work related factors

- Time used for VDU work (self rated proportion of time used for VDU work as percentage of total work time). The exact wording for the question was: "Estimate how many percent of your working time during the preceding month you have used for each task of the following tasks". The definition for VDU work was use of keyboard or other input or control device, including short thinking periods and checking the results on the screen. In the analysis, a dichotomy <50% and ⩾50% was used.[9]
- Physical work environment (lighting conditions, temperature, quality of the air, size of the working room, and acoustic conditions in the work environment). The subjects rated each component by a scale from 1 to 5, where 1 was very poor and 5 very good. Since all the items were positively associated with the outcome, for each subject the mean of the five components was calculated to represent the status of the physical work environment. In the analysis a dichotomous variable was used, values higher than 3 denoting good and values from 1 to 3 poor environment.
- Ergonomics of the workstation (work chair, work desk, screen, keyboard, mouse, and document holder were considered). The workers rated each component by a scale from 1 to 5, where 1 was very poor and 5 very good. For each subject the mean of the six components was calculated to represent the value of the workstation ergonomics. In the analysis a dichotomous variable was used, in which values 4 to 5 denoted good ergonomics and values from 1 to 3 poor ergonomics, because of a positively skewed distribution.
- Viewing distance (distance between the eyes and the middle point of the screen (cm), measured by the employees themselves in their own offices). Based on the recommendations of the ISO Standard (Ergonomic requirements for office work with visual display terminals),[36] two categories were used, where the distance between 50 and 70 cm was good and other measures were poor.
- Height of the VDU screen (distance between the upper edge of the screen and the horizontal level of the eyes, measured by the employees themselves in their own offices). Based on the ISO recommendations,[36] two categories were used, where ⩾10 cm was good and <10 cm poor. As the viewing distance mostly varied between 50 and 65 cm (mean = 57 cm), poor vertical location corresponds to a viewing angle of <20° below the horizontal line.[37]
- Distance of the VDU keyboard (distance between the g-h point of the keyboard and the edge of the desk, measured by the employees themselves in their own working rooms). Based on the ISO recommendations,[36] two categories were used, where ⩾15 cm was good and <15 cm poor. Negative measurements, such as a separate keyboard holder in use, were very rare.
- Deviance of the VDU keyboard from the midpoint (deviance between the g-h point of the keyboard and the middle line of the body, measured by the employees themselves in their own working rooms). Based on the ISO recommendations,[36] two categories were used, where 0±2 cm was good and higher deviancies were poor.
- Distance of the VDU mouse (distance between the middle point of the mouse and the edge of the desk, measured by the employees themselves in their own working rooms). Based on the recommendations,[13 18] two categories were used, where ⩾15 cm was good and <15 cm poor.
- Deviance of the VDU mouse (deviance between the middle point of the mouse and the middle line of the body, measured by the employees themselves in their own working rooms). Based on the recommendations,[13 18] two categories were used, where the measures between −30 cm and +30 cm were good, and higher distances were poor.
- Breaks during work (whether there were breaks when working at the VDU). The scale ranged from "much too little" to "fully enough". In the analysis a dichotomous variable was used, where less than "fully enough" was studied as potentially involving an increased risk of neck pain.
- Influence on work load (the extent the subjects were able to influence their own work load in terms of amount and tempo of their tasks). The five level variable ranged from "very little" to "very much". A dichotomous variable was used, the potential risk associated with having some or very little influence.

Individual factors

- Sex.
- Age in 1998 (25–43, 44–51, and 52–61 years; data driven categorisation as tertiles).
- Frequency of physical exercise (times/week, two categories).
- Smoking (two categories: never smoker and current smoker/ex-smoker).
- Health status (self rated status of health; two categories: very good/rather good and average/rather poor/very poor).
- Mental stress. The wording of the question was: "Stress means the situation when a person feels tense, restless, nervous, or anxious, or is unable to sleep at night because his mind is troubled all the time. Do you feel that kind of stress these days?" (two categories: none/little and some/fairly much/much).
- Mental strain. Perceived tension was used as an indicator for this concept (two categories: never/rather seldom and sometimes/rather often/continually).
- Depression (two categories: never/rather seldom and sometimes/rather often/continuously).
- Job satisfaction (two categories: very satisfied/rather satisfied and neutral/rather dissatisfied/very dissatisfied).
- Time used for domestic activities, such as cleaning, child care, cooking, gardening, home repairs (hours spent on average during work days; two categories: <1 hour and ⩾1 hour).
- Time used for hobbies including static load on neck shoulder area, such as handicrafts, music instrument playing, computer games (hours spent on average during work days; two categories: <1 hour and ⩾1 hour).

Table 1 presents a comparison of the baseline variables among the study cohort (n = 232) between those who participated in

the follow up (n = 180) and those who dropped out from the follow up (n = 52). There were no differences between the groups regarding the majority of the variables. However, the respondents were younger and more stressed than the non-respondents. The respondents also rated the physical work environment as poorer.

Table 1 Comparison of the baseline variables among the respondents (n=180) and non-respondents (n=52) of the follow up survey

	Respondents		Non-respondents		
	n	%	n	%	p value
Work related variables					
VDU working time					0.54
<50%	122	70	34	71	
⩾50%	52	30	14	29	
Physical work environment					0.08
Mean score >3	123	70	42	81	
Mean score ⩽3	53	30	10	19	
Ergonomics of workstation					0.34
Mean score >3	127	72	39	76	
Mean score ⩽3	49	28	12	24	
Distance of the screen					0.42
Good (50–70 cm)	106	69	29	66	
Poor (<50 cm or >70 cm)	48	31	15	34	
Height of the screen					0.18
Good (⩾10 cm)	102	68	33	77	
Poor (<10 cm)	48	32	10	23	
Distance of the keyboard					0.19
Good (⩾15 cm)	70	49	14	39	
Poor (<15 cm)	73	51	22	61	
Deviance of the keyboard					0.07
Good (0±2 cm)	73	51	24	67	
Poor (> ±2 cm)	70	49	12	33	
Distance of the mouse					0.19
Good (⩾15 cm)	46	51	10	38	
Poor (<15 cm)	45	49	16	62	
Deviance of the mouse					0.22
Good (0±30 cm)	38	42	8	31	
Poor (> ±30 cm)	53	58	18	69	
Breaks during work					0.59
Fully enough	66	63	17	63	
Rather enough/rather little/much too little	39	37	10	37	
Influence on work load					0.45
Somewhat/rather/very much	93	52	26	50	
Very little/rather little	85	48	26	50	
Individual variables					
Sex					0.29
Female	80	44	26	50	
Male	100	56	26	50	
Age					0.04
25–43	58	32	11	22	
44–51	59	33	12	23	
52–61	62	35	28	55	
Smoking					0.22
Never smoker	97	55	25	48	
Current/ex-smoker	78	45	27	52	
Frequency of physical exercise (times/week)					0.34
⩽1	54	30	18	35	
⩾2	124	70	34	65	
Health status					0.27
Very good/rather good	120	68	31	62	
Average/rather poor/very poor	57	32	19	38	
Mental stress					0.02
None/little	88	50	34	68	
Some/fairly much/much	89	50	16	32	
Mental strain					0.29
Never/rather seldom	99	56	31	62	
Sometimes/rather often/continually	77	44	19	38	
Depression					0.37
Never/rather seldom	117	66	35	70	
Sometimes/rather often/continually	60	34	15	30	
Job satisfaction					0.55
Very satisfied/rather satisfied	135	76	38	76	
Neutral/rather/very dissatisfied	42	24	12	24	
Time used for domestic activities (hours/day)					0.28
<1	48	27	17	33	
⩾1	128	73	35	67	
Time used for hobbies (hours/day)					0.56
<1	139	79	41	79	
⩾1	37	21	11	21	

Table 2 Incidence of neck pain among Finnish office workers in 1998–99 (cohort of the healthy subjects in 1998, n=180)

	Radiating neck pain					
	Less than 8 days (healthy)		8 days or more (cases)		Total	
Local neck pain	n	%	n	%	n	%
Less than 8 days (healthy)	118	66	26	14	144	80
8 days or more (cases)	24	13	12	7	36	20
Total	142	79	38	21	180	100

Statistical methods

Cross tabulations and logistic regression models were used as main methods of analysis for associations between the outcome variable and the potential risk factors. To construct a multivariable model a forward selection strategy was used.[38] The inclusion of the variables for the first model was based on testing the significance of the potential predictors as groups of variables, adjusting for age, sex, and VDU work time for work related variables, and for age and sex for individual variables. Among the work related variables the groups to be tested were: (1) general work conditions (influence on work load, breaks during work); (2) general ergonomics (physical work environment and ergonomics of the workstation); and (3) VDU specific ergonomics (height and distance of the screen, distance and deviance of the keyboard, distance and deviance of the mouse). Among the individual factors the groups were: (1) general health and health behaviour (perceived health status, physical exercise, smoking); (2) psychological health (stress, strain, depression); (3) job satisfaction alone; and (4) leisure time activities (time used for domestic tasks, time used for certain hobbies).

From each group of variables, those with $p < 0.2$ were selected for further analyses. Based on the first steps of modelling, physical work environment, and distance of keyboard among the work related factors, and smoking among the individual factors were included into the further stages of analysis. Thus, the model with direct effects included these predictors, plus sex, as well as age and VDU working time as possible confounders. Because of missing values in the explanatory variables, the final model was based on 138 observations.

Finally, the first level interactions were tested. We were mainly interested in interactions of age with sex and with work related risk factors, as well as of stress with the work related variables and physical exercise. The significant interactions (sex with age and mental stress with frequency of physical exercise), were added into the model of the direct effects. For the direct effect model and the interaction model, the results were presented as odds ratios (OR), with 95% confidence intervals (CI). The significance of the models was evaluated by AIC and −2 log L values, whereas the goodness of fit was tested by the Hosmer and Lemeshow method.[39] The statistical analyses were performed with the computer package SAS System for Windows (version 8.1).[40]

RESULTS

Fifty six per cent of our subjects were men (n = 100). Age range was 25–61 years (mean 47 years, median 49 years). The proportion of the total working time used for VDU tasks ranged from 2% to 100% (mean 36%, median 30%). Thirty per cent of the subjects worked actively with VDUs for 50% or more of their total working time.

The incidence of local neck pain or radiating neck pain was 34.4% (95% CI 25.5 to 41.3). The incidence of local neck pain only was 13.3% and the incidence of the radiating pain only was 14.4%. The incidence of combined local and radiating neck pain was 6.7% (table 2). Table 3 shows the distribution of subjects in the different categories of neck pain in 1999 according to explanatory variables.

The risk of neck pain was about twofold for those rating the physical work environment as poor in comparison to those who rated their work environment as good. Each item of the score showed a positive association with the outcome as follows: lighting (OR = 1.4, 95% CI 0.7 to 2.8), temperature (OR = 1.2, 95% CI 0.6 to 2.4), quality of the air (OR = 1.7, 95% CI 0.8 to 3.5), size of the working room (OR = 1.5, 95% CI 0.7 to 3.0), and acoustic conditions in the work environment (OR = 1.4, 95% CI 0.7 to 2.8), but none of the items was significant alone. Also poor placement of the VDU keyboard increased the risk of neck pain. Women had an almost threefold risk compared with men. Current or ex-smokers had an almost twofold, although not significant, risk in comparison with the never smokers (table 4).

Table 5 shows the multivariable model with significant interactions. There was an interaction between mental stress and physical exercise: workers with a higher level of mental stress and lower frequency of physical exercise had an almost sevenfold risk compared to those with lower stress level and higher exercise frequency. The risk associated with the physical work environment became higher, whereas that for distance of the keyboard and smoking turned out to be lower, compared with the model with the direct effects only.

Tables 6 and 7 show the interactive effects of sex and age. Women had a higher risk than men, except in the age group 44–51 years (table 6). The risk of neck pain increased after the age of 43 among the men, whereas among women the risk was lower for those aged 44–51 years and increased for those older than 52 years (table 7).

DISCUSSION

In this cohort study among office employees working with VDUs, we found that incident neck pain was associated with both work related and individual factors. Inappropriate physical work environment and poor VDU related ergonomics, together with individual factors, such as gender and smoking, predicted neck pain. In addition, the employees with higher mental stress and less physical exercise had an especially high risk.

Concerning the validity of this study the crucial question would be related to possible bias caused by low participation rates. The drop out rates in various longitudinal studies of musculoskeletal disorders have ranged between 7% and 57%.[41] The response rates of our study were in the baseline survey 81% and in the follow up 78%, corresponding to drop out rates between 19% and 22%. In all, our response rates were among the highest ones in longitudinal studies, resulting in an overall participation rate of 63%. The non-respondents to the follow up questionnaire did not differ from the respondents with regard to most explanatory variables. However, the respondents seemed to be more stressed than the non-respondents.

Table 3 Distributions of the subjects in the different categories of neck pain* in 1999 according to explanatory variables; odds ratios for explanatory variables

	Neck pain* (n=62)		Healthy (n=118)		Crude OR	
	n	%	n	%	OR	95% CI
Work related variables						
VDU working time						
<50%	41	34	81	66	1.0	
⩾50%	18	35	34	65	1.0	0.6 to 2.9
Physical work environment						
Mean score >3	36	29	87	71	1.0	
Mean score ⩽3	24	45	29	55	2.0	1.0 to 3.9
Ergonomics of workstation						
Mean score >3	42	33	85	67	1.0	
Mean score ⩽3	18	37	31	63	1.2	0.6 to 2.3
Height of the screen						
Good (⩾10 cm)	31	30	71	70	1.0	
Poor (<10 cm)	19	40	29	60	1.5	0.7 to 3.1
Distance of the screen						
Good (50–70 cm)	35	33	71	67	1.0	
Poor (<50 cm or >70 cm)	17	35	31	65	1.1	0.5 to 2.3
Distance of the keyboard						
Good (⩾15 cm)	18	26	52	74	1.0	
Poor (<15 cm)	29	40	44	60	1.9	0.9 to 3.9
Deviance of the keyboard						
Good (0±2 cm)	21	29	52	71	1.0	
Poor (> ±2 cm)	26	37	44	63	1.5	0.7 to 3.0
Distance of the mouse						
Good (⩾15 cm)	15	33	31	67	1.0	
Poor (<15 cm)	15	33	30	67	1.0	0.4 to 2.5
Deviance of the mouse						
Good (0±30 cm)	12	32	26	68	1.0	
Poor (> ±30 cm)	18	34	35	66	1.1	0.5 to 2.7
Breaks during work						
Fully enough	21	32	45	68	1.0	
Rather enough/rather little/much too little	14	36	25	64	1.2	0.5 to 2.8
Influence on work load						
Somewhat/rather/very much	26	28	67	72	1.0	
Very little/rather little	34	40	51	60	1.7	0.9 to 3.2
Individual variables						
Sex						
Male	26	26	74	74	1.0	
Female	36	45	44	55	2.3	1.2 to 4.4
Age						
25–43	22	38	36	62	1.0	
44–51	17	29	42	71	0.7	0.3 to 1.5
52–61	23	37	39	63	1.0	0.5 to 2.1
Smoking						
Never smoker	31	32	66	68	1.0	
Current/ex-smoker	29	37	49	63	1.3	0.7 to 2.4
Frequency of physical exercise (times/week)						
⩾2	39	31	85	69	1.0	
⩽1	21	39	33	61	1.4	0.7 to 2.7
Health status						
Very good/rather good	43	36	77	64	1.0	
Average/rather poor/very poor	18	32	39	68	0.8	0.4 to 1.6
Mental stress						
None/little	30	34	58	66	1.0	
Some/fairly much/much	30	34	59	66	1.0	0.5 to 1.8
Mental strain						
Never/rather seldom	33	33	66	67	1.0	
Sometimes/rather often/continually	27	35	50	65	1.1	0.6 to 2.0
Depression						
Never/rather seldom	37	32	80	68	1.0	
Sometimes/rather often/continually	23	38	37	62	1.3	0.7 to 2.6
Job satisfaction						
Very satisfied/rather satisfied	45	33	90	67	1.0	
Neutral/rather/very dissatisfied	15	36	27	64	1.1	0.5 to 2.3
Time used for domestic activities (hours/day)						
<1	12	25	36	75	1.0	
⩾1	48	37	80	63	1.8	0.8 to 3.7
Time used for hobbies (hours/day)						
<1	45	32	94	68	1.0	
⩾1	15	41	22	59	1.4	0.7 to 3.0

*Local or radiating neck pain, or both.

In order to take into account the duration of exposure to VDU work, we adjusted our analyses for the proportion spent at the computer of the total working time. We found it necessary to control for this factor, since the effects of the various

Table 4 Odds ratios for predictors of neck pain among Finnish office workers in 1998–99 (logistic regression model, adjusted for age and time used for VDU work, n=138)

	Neck pain	
Predictors	OR	95% CI
Work related predictors		
Physical work environment		
Mean score >3	1.0	
Mean score ⩽3	2.1	0.9 to 4.9
Distance of the keyboard from the edge of the table		
Good (⩾15 cm)	1.0	
Poor (<15 cm)	2.1	1.0 to 4.5
Individual predictors		
Sex		
Male	1.0	
Female	2.9	1.3 to 6.7
Smoking		
Never smoker	1.0	
Current/ex-smoker	1.9	0.8 to 4.3

AIC = 174.94.
–2 log L = 158.94 (df=7).
Hosmer and Lemeshow goodness of fit test: p=0.23.

Table 5 Odds ratios for predictors of neck pain among Finnish office workers in 1998–99 (logistic regression model with interactions, adjusted for time used for VDU work; n=137)

	Neck pain	
Predictors	OR	95% CI
Work related predictors		
Physical work environment		
Mean score >3	1.0	
Mean score ⩽3	2.4	1.0 to 6.0
Distance of the keyboard from the edge of the table		
Good (⩾15 cm)	1.0	
Poor (<15 cm)	1.9	0.8 to 4.3
Individual predictors		
Sex		
Male	1.0	
Female	6.7	1.4 to 30.9
Age		
25–43	1.0	
44–51	2.7	0.6 to 12.5
52–61	2.5	0.5 to 12.1
Smoking		
Never smoker	1.0	
Current/ex-smoker	1.5	0.6 to 3.6
Mental stress		
None/little	1.0	
Some/fairly much/much	0.5	0.2 to 1.4
Frequency of physical exercise (times/week)		
⩾2	1.0	
⩽1	0.8	0.2 to 2.7
Interactions		
Age × sex		
25–43 × male	1.0	
44–51 × female	0.1	0.0 to 0.7
52–61 × female	1.1	0.1 to 10.3
Mental stress × frequency of physical exercise		
None/little × ⩾2	1.0	
Some/fairly much/much × ⩽1	6.7	1.0 to 43.6

AIC = 171.91.
–2 log L = 145.91 (df=12).
Compared with the main effects model: 158.94–145.91 = 13.04 (df=5), p<0.05.
Hosmer and Lemeshow goodness of fit test: p=0.32.

Table 6 Effect (odds ratio) of sex on neck pain in different age groups

	Age (y)		
Sex	25–43	44–51	52–61
Male (reference)	1.0	1.0	1.0
Female	6.7	0.6	7.3

Table 7 Effect (odds ratio) of age on neck pain according to sex

	Sex	
Age (y)	Male	Female
25–43 (reference)	1.0	1.0
44–51	2.7	0.2
52–61	2.5	2.8

risk factors have been dependent on the duration of VDU work.[9 42] The time used for VDU work was measured as self reported proportion of total working time during the preceding month. In a study among newspaper workers it was found that the workers overestimated their time working with the VDU when compared with that based on observation.[43] However, these validations concerned typing only, whereas in our study the definition for VDU work was use of keyboard or other input or control device, including short thinking periods and checking the results on the screen. The preliminary results of our own validation among a sample of workers support the findings of Bernard *et al* in that the workers tend to overestimate their VDU working time (data not shown).

Our data suggest that poor placement of the keyboard is a predictor for neck pain. Our finding is supported by the study of Aarås and colleagues[17] who found that supporting the forearms on the tabletop in front of the operator reduced significantly the load on both right and left trapezius. Also, the review of Bergqvist and colleagues[16] and that of Tittiranonda and colleagues[10] give evidence of associations between various aspects of keyboard use and symptoms in the neck–shoulder area and in the upper extremities.

Most of the evidence concerning placement of the mouse has been related to hand/wrist disorders.[9] A few studies have reported an association between mouse location and neck pain.[18 44] In our study, placement of the mouse was not a significant risk factor. Because of missing values for many of the subjects (n = 89) we did not include this variable into the final models. Most of the subjects who did not give the requested measure for the VDU mouse location either did not use mouse at all, or used it for less than half of their VDU working time.

Among other VDU specific ergonomic factors, the location of the screen did not reach significance and was not included in the final models. However, based on the univariate analysis, high location of the screen (<10 cm below the horizontal level of the eyes or <20° below the horizontal sight line) showed a tendency for being a risk factor. It has been shown that visual discomfort and musculoskeletal strain, particularly in the neck and shoulders, are associated with computer screen height.[45 46] Among the subjects with presbyopia, higher monitor placement has been associated with neck extension caused by visual demands when using bifocals.[37] On the other hand, an extreme low location is often associated with musculoskeletal stress caused by neck flexion.[47 48] However, the benefit of a lower placement is reduction of eye irritation, when the open surface of the eyes is smaller and the lachrymation is better.[49] Finally, the results of a recent field study support the midlevel (~20°) or somewhat higher placement.[19] The subjects

of this study were younger (mean 37 years) and did not use bifocals. According to our criterion, the midlevel location or any placement lower was regarded as acceptable. This criterion was thought to be reasonable in our study, as the subjects were relatively old (mean 47 years), commonly used bifocals, and therefore may have benefited from a relatively lower location of the screen.[14 42]

The VDU specific measures, such as location of the screen, keyboard, and mouse, were based on the measurements done by the subjects themselves. This might be a source of error if there were low agreement between self assessed locations and direct measurements. An earlier validation study has found a good agreement between self reported locations and direct measurements.[13] However, the keyboard and the mouse are used in parallel, their placements being dependent on each other. The design of the keyboard affects the location of the mouse and the location of the mouse affects the shoulder and arm posture.[18 44] For example, mouse users may benefit from a shorter keyboard without a number pad.[50] We measured the placements of only three components of the VDU workstation. It should be noted that the actual work posture is not exclusively affected by these workstation dimensions.[51]

The physical work environment was a significant predictor in our data. This variable included five aspects: lighting, temperature, quality of the air, size of the working room, and acoustic conditions in the work environment. For each subject the mean of the five components was calculated to represent the status of the physical work environment. All items of the score showed a positive association with the outcome. It has been suggested that, especially, lighting conditions are important for the reduction of visual discomfort in VDU work. Visual discomfort, in turn, correlates highly with neck pain.[14 22] Of thermal conditions in VDU work, draught has been reported as a problem in connection with discomfort in the neck–shoulder area.[52] In our study the quality of indoor air was also associated with neck pain.

The variables of the physical work environment were self reported. Although this assessment preceded incident neck pain, there is a possibility of bias, if those who in the follow up reported neck pain had a different perception of their work environment at baseline.

The risk for neck pain was significantly higher for the women than for the men. This agrees with earlier studies. Smaller stature and lower strength of the shoulder muscles have been suggested to partly explain the sex difference.[3 15 18 53] Concerning VDU work in particular, gender differences have been found, for example, in the use of a computer mouse. Women are working with higher relative musculoskeletal load, for instance, applying higher forces to the mouse and using greater range of motion, than are men.[54] On the other hand, female sex may entail risk factors which were not measured in the study.[55] Concerning the present study, different types of work tasks may be one explanation for the sex effect in the results. Among our subjects, the women worked in more monotonous tasks, such as assisting and secretarial.

The men showed a tendency for increasing neck pain after the age of 40 years. Among the women there was a U shaped association. The youngest (aged 25–43) and the oldest (aged 52–61) workers had higher incidence than the middle aged (44–51) workers. The higher incidence among our oldest group is in line with earlier incidence studies.[3] The high incidence among the youngest group was somewhat unexpected. One could ask whether the youngest workers do the most monotonous tasks and have the least influence on their work. Concerning leisure time activities, women in this age group are often involved with a considerable amount of homework and childcare. We tested the effect of hours spent on domestic activities, but it did not turn out as a significant predictor in our data.

In the model with direct effects only, mental stress was not a significant predictor. However, stress had an interaction with physical activity. Among those whose stress level was higher and who exercised less frequently, the risk for neck pain was especially high. There is consistent evidence that stress is associated with neck pain in cross sectional studies,[16 32 34] yet there are only few longitudinal studies suggesting stress as a predictor of neck pain.[3 8] Results concerning the relation of physical exercise and musculoskeletal pain are less consistent.[27–29 31] However, it should be noted that among sedentary workers, exercise has been shown as beneficial.[24 29] For the sedentary workers with a low frequency of leisure time physical exercise, other leisure time activities may play a role, especially if they impose on musculoskeletal organs as the work does. We tested the effect of hours spent with hobbies, such as computer games, handicrafts, and musical instrument playing, but this variable was not a significant predictor in our data.

We conclude that in the prevention of neck disorders in office work with a high frequency of VDU tasks, attention should be given to the work environment in general and to the more specific aspects of VDU workstation layout. In addition, our study provided further evidence that physical exercise may be preventive of neck disorders among sedentary employees.

Main messages

- Both work related and individual factors, and their interactions, were found to predict incident neck pain among office employees working with VDUs.
- Among work related factors, inappropriate general and VDU specific ergonomics predicted neck pain; whereas among individual factors, gender predicted neck pain.
- Employees with a high stress level and sedentary lifestyle had a particularly high risk for neck pain.

Policy implications

- In the prevention of neck disorders in VDU work, attention should be given to the physical work environment in general and to the specific aspects of the VDU workstation layout.

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Authors' affiliations

T Korhonen, R Ketola, R Toivonen, R Luukkonen, M Häkkänen, E Viikari-Juntura, Finnish Institute of Occupational Health, Helsinki, Finland

REFERENCES

1 **Ariens G**, van Mechelen W, Bongers P, *et al*. Physical risk factors for neck pain. *Scand J Work Environ Health* 2000;**26**:7–19.
2 **Ariens G**, Bongers P, Douwes M, *et al*. Are neck flexion, neck rotation, and sitting at work risk factors for neck pain? Results of a prospective cohort study. *Occup Environ Med* 2001;**58**:200–7.
3 **Viikari-Juntura E**, Martikainen R, Luukkonen P, *et al*. Longitudinal study on work related and individual risk factors affecting radiating neck pain. *Occup Environ Med* 2001;**58**:345–52.
4 **Eriksen W**, Natvig B, Knardahl S, *et al*. Job characteristics as predictors of neck pain. A 4-year prospective study. *J Occup Environ Med* 1999;**41**:893–902.
5 **Ariens G**, Bongers P, Hoogendoorn W, *et al*. High quantitative job demands and low coworker support as risk factors for neck pain: results of a prospective cohort study. *Spine* 2001;**26**:1896–901.
6 **Ariens G**, van Mechelen W. Psychosocial risk factors for neck pain: a systematic review. *Am J Ind Med* 2001;**39**:180–93.
7 **Shannon H**, Woodward C, Cunningham C, *et al*. Changes in general health and musculoskeletal outcomes in the workforce of a hospital undergoing rapid change: a longitudinal study. *J Occup Health Psychol* 2001;**6**:3–14.

8 **Leclerc A**, Niedhammer I, Landre M, *et al*. One-year predictive factors for various aspects of neck disorders. *Spine* 1999;**24**:1455–62.
9 **Punnett L**, Berqvist U. Visual display unit work and upper extremity musculoskeletal disorders. *Arbete och hälsa* 1997;**16**.
10 **Tittiranonda P**, Burastero S, Rempel D. Risk factors for musculoskeletal disorders among computer users. *Occupational Medicine: State of the Art Reviews* 1999;**14**:17–38.
11 **Demure B**, Luippold R, Bigelow C, *et al*. Video display terminal workstation improvement program: I. Baseline associations between musculoskeletal discomfort and ergonomic features of workstations. *J Occup Environ Med* 2000;**42**:783–91.
12 **Seppälä P**. Experience of stress, musculoskeletal discomfort, and eyestrain in computer-based office work: a study in municipal workplaces. *Int J Hum Comput Interaction* 2001;**13**:279–304.
13 **Karlqvist L**, Hagberg M, Koster M, *et al*. Musculoskeletal symptoms among computer-assisted design (CAD) operators and evaluation of a self-assessment questionnaire. *Int J Occup Environ Health* 1996;**2**:185–94.
14 **Aarås A**, Horgen G, Bjorset H, *et al*. Musculoskeletal, visual and psychosocial stress in VDU operators before and after multidisciplinary ergonomic interventions. *Appl Ergon* 1998;**29**:335–54.
15 **Karlqvist L**. [Avoid the mouse-trap! Musculoskeletal injuries can be reduced by placing the mouse within shoulder space]. *Lakartidningen* 1998;**95**:3768–71.
16 **Bergqvist U**, Wolgast E, Nilsson B, *et al*. Musculoskeletal disorders among visual display terminal workers: individual, ergonomic, and work organizational factors. *Ergonomics* 1995;**38**:763–76.
17 **Aarås A**, Fostervold K, Ro O, *et al*. Postural load during VDU work: a comparison between various work postures. *Ergonomics* 1997;**40**:1255–68.
18 **Karlqvist L**, Bernmark E, Ejenvall L, *et al*. Computer mouse position as a determinant of posture, muscular load and perceived exertion. *Scand J Work Environ Health* 1998;**24**:62–73.
19 **Psihogios J**, Sommerich C, Mirka G, *et al*. A field evaluation of monitor placement effects in VDT users. *Appl Ergon* 2001;**32**:313–25.
20 **Bayeh A**, Smith M. Effect of physical ergonomics on VDT worker's health: a longitudinal intervention field study in a service organization. *Int J Hum Comput Interaction* 1999;**11**:109–35.
21 **Ketola R**, Toivonen R, Häkkänen M, *et al*. Effects of ergonomic intervention in work with video display units. *Scand J Work Environ Health* 2002;**28**:18–24.
22 **Aarås A**, Horgen G, Bjorset H, *et al*. Musculoskeletal, visual and psychosocial stress in VDU operators before and after multidisciplinary ergonomic interventions. A 6 years prospective study—Part II. *Appl Ergon* 2001;**32**:559–71.
23 **Marcus M**, Gerr F. Upper extremity musculoskeletal symptoms among female office workers: associations with video display terminal use and occupational psychosocial stressors. *Am J Ind Med* 1996;**29**:161–70.
24 **Viikari-Juntura E**, Riihimäki H, Tola S, *et al*. Neck trouble in machine operating, dynamic physical work and sedentary work: a prospective study on occupational and individual risk factors. *J Clin Epidemiol* 1994;**47**:1411–22.
25 **Ekberg K**, Karlsson M, Axelson O, *et al*. Cross-sectional study of risk factors for symptoms in the neck and shoulder area. *Ergonomics* 1995;**38**:971–80.
26 **Kaergaard A**, Andersen J. Musculoskeletal disorders of the neck and shoulders in female sewing machine operators: prevalence, incidence and prognosis. *Occup Environ Med* 2000;**57**:528–34.
27 **Ekberg K**, Bjorkvist B. Case-control study of risk factors for disease in the neck and shoulder area. *Occup Environ Med* 1994;**51**:262–6.
28 **Miranda H**, Viikari-Juntura E, Martikainen R, *et al*. Physical exercise and musculoskeletal pain among forest industry workers. *Scand J Med Sci Sports* 2001;**11**:239–46.
29 **Hildebrandt V**, Bongers P, Dul J, *et al*. The relationship between leisure time, physical activities and musculoskeletal symptoms and disability in worker populations. *Int Arch Occup Environ Health* 2000;**73**:507–18.
30 **Kamwendo K**, Linton S. A controlled study of the effect of neck school in medical secretaries. *Scand J Rehabil Med* 1991;**23**:143–52.
31 **Takala E**, Viikari-Juntura E, Tynkkynen E. Does group gymnastics at the workplace help in neck pain? A controlled study. *Scand J Rehabil Med* 1994;**26**:17–20.
32 **Holmstrom E**, Lindell J, Moritz U. Low back and neck/shoulder pain in construction workers: occupational workload and psychosocial risk factors. Part 2: Relationship to neck and shoulder pain. *Spine* 1992;**17**:672–7.
33 **Leino P**, Magni G. Depressive and distress symptoms as predictors of low back pain, neck-shoulder pain, and other musculoskeletal morbidity: a 10-year follow-up of metal industry employees. *Pain* 1993;**53**:89–94.
34 **Palmer K**, Walker-Bone K, Griffin MJ, *et al*. Prevalence and occupational associations of neck pain in the British population. *Scand J Work Environ Health* 2001;**27**:49–56.
35 **Vasseljen O**, Holte K, Westgaard R. Shoulder and neck complaints in customer relations: individual risk factors and perceived exposures at work. *Ergonomics* 2001;**44**:355–72.
36 **SFS**. *Handbook 72. Ergonomics of visual display terminal work. Basic guidelines, furniture and workstation, software, hardware*. Helsinki: Finnish Standards Association SFS, 1998:107–47.
37 **Burgess-Limerick R**, Plooy A, Fraser K, *et al*. The influence of computer monitor height on head and neck posture. *International Journal of Industrial Ergonomics* 1999;**23**:171–9.
38 **Greenland S**. Modeling and variable selection in epidemiologic analysis. *Am J Public Health* 1989;**79**:340–9.
39 **Hosmer D**, Lemeshow S. *Applied logistic regression*. New York: Wiley, 1989.
40 **SAS I, Inc**. *SAS/STAT users's guide; version 8*. Cary, NC: SAS Institute Inc., 1999.
41 **Bildt C**, Alfredsson L, Punnett L, *et al*. Effects of drop out in a longitudinal study of musculoskeletal disorders. *Occup Environ Med* 2001;**58**:194–9.
42 **Bergqvist U**, Wolgast E, Nilsson B, *et al*. The influence of VDT work on musculoskeletal disorders. *Ergonomics* 1995;**38**:754–62.
43 **Bernard B**, Sauter S, Petersen M, *et al*. *Upper extremity musculoskeletal disorders among newspaper employees*. Los Angeles: US Department of Health and Human Services, 1993.
44 **Aarås A**, Ro O. Workload when using a mouse as an input device. *Int J Hum Comput Interaction* 1997;**9**:105–18.
45 **Bergqvist U**, Knave B. Eye discomfort and work with visual display terminals. *Scand J Work Environ Health* 1994;**20**:27–33.
46 **Villanueva MB**, Sotoyama M, Jonai H, *et al*. Adjustments of posture and viewing parameters of the eye to changes in the screen height of the visual display terminal. *Ergonomics* 1996;**39**:933–45.
47 **Turville K**, Psihogios J, Ulmer T, *et al*. The effects of video display terminal height on the operator: a comparison of the 15 and 40 recommendations. *Appl Ergon* 1998;**29**:239–46.
48 **Fries Svensson H**, Svensson O. The influence of the viewing angle on neck-load during work with video display units. *J Rehabil Med* 2001;**33**:133–6.
49 **Sotoyama M**, Jonai H, Saito S, *et al*. Analysis of ocular surface area for comfortable VDT workstation layout. *Ergonomics* 1996;**39**:877–84.
50 **Tittiranonda P**, Rempel D, Armstrong T, *et al*. Effect of four computer keyboards in computer users with upper extremity musculoskeletal disorders. *Am J Ind Med* 1999;**35**:647–61.
51 **Gerr F**, Marcus M, Ortiz D, *et al*. Computer users' postures and associations with workstation characteristics. *Am Ind Hygiene Assoc J* 2000;**61**:223–30.
52 **Fanger P**, Christensen N. Perception of draught in ventilated spaces. *Ergonomics* 1986;**29**:215–35.
53 **Mäkelä M**, Heliövaara M, Sievers K, *et al*. Prevalence, determinants, and consequences of chronic neck pain in Finland. *Am J Epidemiol* 1991;**134**:1356–67.
54 **Wahlstrom B**, Svensson J, Hagberg M, *et al*. Differences between work methods and gender in computer mouse use. *Scand J Work Environ Health* 2000;**26**:390–7.
55 **Mergler D**. Combining quantitative and qualitative approaches in occupational health for a better understanding of the impact of work-related disorders. *Scand J Work Environ Health* 1999;**25**:54–60.

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T Korhonen, R Ketola, R Toivonen, et al.

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