ORIGINAL ARTICLE

Self-reported workplace related ergonomic conditions as prognostic factors for musculoskeletal symptoms: the ''BIT'' follow up study on office workers

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Aims: To identify prognostic ergonomic and work technique factors for musculoskeletal symptoms among office workers and in a subgroup with highly monotonous repetitive computer work.

Methods: A baseline questionnaire was delivered to 5033 office workers in 11 Danish companies in the first months of 1999, and a follow up questionnaire was mailed in the last months of 2000 to 3361 respondents. A subgroup with highly monotonous repetitive computer work was formed including those that were repeating the same movements and/or tasks for at least 75% of the work time. The questionnaire contained questions on ergonomic factors and factors related to work technique. The outcome variables were based on the frequency of musculoskeletal symptoms during the last 12 months. Logistic regression analyses were used to identify prognostic factors for symptoms in the three body regions.

Results: In total, 39%, 47%, and 51% of the symptomatic subjects had a reduced frequency of symptom days in the neck/shoulder, low back, or elbow/hand region, respectively. In all regions more men than women had reduced symptoms. In the multivariate logistic regression analyses, working no more than 75% of the work time with the computer was a prognostic factor for musculoskeletal symptoms in the neck/shoulder and elbow/hand, and a high influence on the speed of work was a prognostic factor for symptoms in the low back. In the subgroup with highly monotonous repetitive computer work, the odds ratios of the prognostic factors were similar to those for the whole group of office workers.

Conclusion: When organising computer work it is important to allow for physical variation with other work tasks, thereby avoiding working with the computer during all the work time, and further to consider the worker's own influence on the speed of work.

Musculoskeletal symptoms are common among office workers, and at the same time the duration of computer work in a modern occupational setting has increased dramatically. Consequently, studies of computer work have, to a large extent, focused on risk factors for development of musculoskeletal symptoms, including daily duration of computer work, repetitive movements, static and non-neutral wrist, arm, and neck work postures, lack of variation, and psychosocial factors.[1–7] In a review (mostly including cross-sectional studies) it was found that poor workstation ergonomics were involved in musculoskeletal problems.[8] Ergonomic exposure at computer workplaces has been described as the elements of the workstation design, including the corresponding work postures and work technique.[9–14]

Although it has been generally accepted that the risk of developing symptoms is due to a posture involving static muscle work, very few prospective studies have supported poor ergonomics as a risk factor. One study found that only a few of the ergonomic factors were linked to work postures.[9] Two prospective studies showed poor ergonomics (screen height above eye level, glare/reflection, postural and workstation factors) as risk factors for developing symptoms.[3 10 15] The two first mentioned studies were based on the same data as the present study.

Furthermore, very few prospective or intervention studies have studied the role of ergonomic conditions as prognostic factors. Two prospective studies reported that an optimal desk height, armrests, and relaxed neck postures were prognostic factors for neck/shoulder symptoms and disorders.[10] Other studies found that ergonomic changes (new lighting system, new workplaces with forearm support) decreased EMG activity of the musculus trapezius and pain in the shoulder, neck, and lumbar region compared to a control group.[16 17] The latter results were further supported in a laboratory study.[18]

Two intervention studies showed that musculoskeletal symptoms were reduced in the neck, shoulder, elbow/forearm, hand/wrist, and low back after introduction of new workstations (new chairs, furniture, and hand support) and buildings, alternative work schedules, and less keying.[16 19] A randomised controlled intervention study showed that a comprehensive ergonomics programme (education in ergonomics, adjusted desk and chair, use of armrest, changed screen height, new office furniture, short rest pauses, and relaxed postures) was significantly associated with reduced discomfort scores in the neck, shoulder, and upper back region at the two month follow up, but only a tendency of an association was present at the 10 month follow up.[12]

Intervention studies with a shorter follow up period (6–8 weeks) have shown that by taking regular breaks, the perceived overall recovery from complaints was increased,[20] and by using two arm supports instead of one, the muscle activity of the musculus trapezius, the subjective discomfort, and the angle of wrist extension were reduced.[21] Furthermore, an individually placed screen height and distance from the user reduced self-reported eyestrain, musculoskeletal, and headache related symptoms.[22]

Theoretically, absence of a risk factor could be a prognostic factor for musculoskeletal symptoms, but it is not known whether the mechanisms inducing increased and decreased symptoms are the same.

The main hypothesis in this study was that favourable ergonomic conditions and factors related to work technique are prognostic factors for office workers with musculoskeletal symptoms. It was further expected that the benefit from recommended ergonomic conditions and factors related to work technique was greater for subjects with very intensive monotonous repetitive computer work. Thus, the aim of the study was to study self-reported ergonomic factors and factors related to work technique as possible prognostic factors for musculoskeletal symptoms in the neck/shoulder, elbow/hand, and low back region among office workers, and more specifically in a subgroup with very intensive monotonous repetitive computer work.

SUBJECTS AND METHODS

Population

A baseline questionnaire concerning physical and psychosocial working conditions and health status was given to 5033 office workers in Denmark in the beginning of 1999; 69% responded.[5 6] A follow up questionnaire primarily consisting of health outcomes was mailed at the end of 2000 to 3471 respondents, whose home address was received. Of those, 108 respondents had changed home address and were not traceable through postal service registers at the time of follow up. Thus 3363 respondents were finally assumed to have received the follow up questionnaire; 2576 subjects responded, corresponding to a response rate of 77%.

The analyses in the present paper were performed on subjects with at least eight days of symptoms at baseline. Thus, at baseline 1292 subjects reported symptoms in the neck/shoulder, 746 subjects reported symptoms in the elbow/hand, and 939 subjects reported symptoms in the low back (table 1). Furthermore, stratified analyses on subjects with highly monotonous and repetitive computer work were performed. This group was defined as those who were either repeating the same finger, hand, or arm movements many times per minute for at least 75% of the work time and/or repeating the same work tasks many times per hour for at least 75% of the work time. This subgroup consisted of 709 subjects with symptoms in the neck/shoulder, 405 subjects with symptoms in the elbow/hand, and 526 subjects with symptoms in the low back at baseline (table 1).

Outcome variables

Questionnaires in the baseline and the follow up study contained items regarding musculoskeletal symptoms (troubles, aches or pain, here denoted as symptoms) according to a modified version of the Nordic questionnaire.[23]

The outcome variable was defined as the difference in self-reported frequency of days with musculoskeletal symptoms during the last 12 months, reported at baseline and at follow up. A case was defined as a subject who reported a lower frequency of symptoms at follow up than at baseline. Symptoms were assessed separately in three regions: (1) neck/right shoulder; (2) right elbow/right hand; and (3) low back.

Exposure variables

The ergonomic exposure parameters at baseline consisted of six questions about the workstation: (1) whether the chair had been individually adjusted (yes or no); (2) whether the table had been individually adjusted (yes or no); (3) whether there was enough space to rest the arms on the desk in front of the keyboard (yes or no); (4) whether the upper line of the mostly used screen was below eye height (yes or no); (5) how much of the work time was spent standing up at the desk (six categories dichotomised to ''never'' or ''seldom–100% of the time''); and (6) how often they were disturbed by glare/reflection from the screen (four categories dichotomised to ''every day–several times a week'' or ''now and then–never'').

Other variables related to work technique were: (1) how often they had influence on when to take a rest pause (five categories dichotomised to ''always–often'' or ''sometimes–never''); and (2) how often they had influence on their speed of work (five categories dichotomised to ''always–often'' or ''sometimes–never'').

Furthermore, duration of work time with the computer (four categories) and two individual factors (gender and age) were included in the analyses.

Statistical analyses

Associations between ergonomic exposure variables reported at baseline and reduced frequency of symptoms at follow up in the neck/shoulder, elbow/hand, and low back were analysed. All analyses were performed on the group of all office workers and on the subgroup of subjects with monotonous repetitive computer work. Unadjusted odds ratios (OR) for all exposure variables and ORs adjusted for all other factors were calculated. All factors from the univariate analyses with a p value <0.25 (either in the whole group of office workers or in the subgroup of monotonous repetitive computer work) were included in a backwards stepwise multivariate logistic regression analysis for the relevant body region. Factors with the largest likelihood ratio probability were omitted first, until $p < 0.10$ for the remaining factors in the model. In the final models all exposure factors with $p < 0.10$ in at least one of the regions were included. Adjustment for gender and age was performed in all the multiple regression analyses. The final regression model was recalculated using only those respondents that did not change workplace between baseline and follow up. The procedures proc FREQ, MEAN, and GENMOD were used in SAS (version 8.2). Values of $p < 0.10$ were considered significant and ORs were presented with 90% CI (confidence intervals).

RESULTS

In total, 39%, 47%, and 51% of the symptomatic subjects at baseline (respondents with at least eight days of symptoms)

Table 1 Respondents with a reduced frequency of musculoskeletal symptoms at follow up

Less days of musculoskeletal symptoms during last 12 months	Total			Women			Men		
	N	%	N_{total}	N	%	N_{total}	N	%	N_{total}
All office workers									
Neck/shoulder	500	39	1292	344	34	1002	156	54	290
Elbow/hand	382	51	746	264	47	562	118	64	184
Low back	440	47	939	307	43	715	133	59	224
Workers with monotonous repetitive computer work									
Neck/shoulder	245	35	709	205	32	634	40	53	75
Elbow/hand	190	47	405	161	45	361	29	66	44
Low back	221	42	526	193	41	470	28	50	56

All respondents with at least eight days of musculoskeletal symptoms during the last 12 months at baseline were included.

Table 2 Unadjusted and adjusted odds ratios (OR) of all factors at baseline for a lower frequency of neck/shoulder symptom days at follow up

	Unadjusted ORs for each factor						ORs for each factor adjusted for all other factors					
	All computer workers			Repetitive work			All computer workers			Repetitive work		
Factors	p	OR	90% CI	p	OR	90% CI	p	Adj. OR	90% CI	p	Adj. OR	90% CI
Gender	**<0.0001**			**0.0004**			**<0.0001**			**0.01**		
Women		0.45	0.36–0.56		0.42	0.28–0.63		0.51	0.38–0.67		0.44	0.27–0.74
Age	0.72			0.42			0.50			0.33		
40–49 y		1.02	0.81–1.29		1.24	0.89–1.73		0.96	0.73–1.27		1.28	0.87–1.88
30–39 y		1.17	0.92–1.49		1.35	0.97–1.88		1.19	0.89–1.59		1.43	0.96–2.13
18–29 y		1.07	0.74–1.55		1.38	0.87–2.17		1.33	0.85–2.06		1.61	0.94–2.77
% of work time at computer	**0.0001**			**0.006**			**0.08**			0.70		
75%		1.70	1.34–2.15		1.70	1.16–2.49		1.46	1.08–1.96		1.23	0.79–1.92
50%		1.39	1.06–1.81		1.70	0.93–3.10		1.05	0.74–1.49		1.31	0.61–2.80
0–25%		2.01	1.43–2.83		3.15	1.52–6.51		1.62	1.05–2.52		1.71	0.63–4.64
Adjusted chair	0.12			0.25			0.40			0.31		
Yes		1.33	0.98–1.82		1.31	0.89–1.93		1.22	0.83–1.80		1.38	0.81–2.35
Adjusted desk	0.44			0.64			0.88			0.78		
Yes		1.13	0.87–1.48		1.12	0.75–1.68		1.03	0.72–1.49		0.90	0.50–1.65
Space for resting the arms in front of keyboard	0.49			0.89			0.40			0.60		
Yes		0.91	0.74–1.13		0.97	0.69–1.36		0.85	0.64–1.14		0.87	0.56–1.34
Upper line on screen below eye height	0.38			0.53			0.70			0.35		
Yes		1.11	0.91–1.37		1.11	0.84–1.47		1.06	0.83–1.36		1.20	0.86–1.68
Standing work posture	0.20			0.48			0.86			0.85		
Seldom–all the time		0.86	0.71–1.04		0.88	0.66–1.18		0.97	0.75–1.26		1.05	0.70–1.56
Glare/reflection	0.38			0.68			0.23			0.87		
Now and then–never		1.13	0.90–1.42		0.92	0.68–1.26		1.22	0.93–1.60		1.04	0.72–1.51
Pauses	**0.0008**			**0.009**			0.98			0.68		
Large influence		1.47	1.22–1.78		1.53	1.17–2.01		1.00	0.76–1.32		1.11	0.74–1.67
Speed of work	**0.01**			**0.03**			0.63			0.36		
Large influence		1.35	1.11–1.63		1.43	1.10–1.86		1.08	0.84–1.38		1.22	0.86–1.72

reported a reduced frequency of symptom days in the neck/shoulder, low back, or elbow/hand region, respectively (table 1). For the subgroup with monotonous repetitive computer work, 35%, 42%, and 47% of the symptomatic subjects at baseline reported a reduced frequency of symptoms in the neck/shoulder, low back, or elbow/hand region, respectively (table 1). In all regions a higher percentage of men compared to women had reduced symptoms.

From the univariate analyses (tables 2–4), three of the ergonomic factors were selected for the multiple regression analyses ($p < 0.25$). These were "adjusted chair", "screen height below eye height", and "not being disturbed by glare/reflection". Both factors related to work technique and work time with the computer were also associated with fewer symptoms at a significance level of $p < 0.25$. Even though the variable "standing at work" for all three body regions had $p < 0.25$ it was not included in the further analyses for any of the regions, as it showed the opposite association as expected according to our hypothesis. When adjusting for all other factors, most of the associations became weaker (tables 2–4).

In the final logistic regression models for the group of all office workers, work time with the computer was a prognostic factor for symptoms in the neck/shoulder and elbow/hand, and a large influence on the speed of work was a prognostic factor for low back symptoms ($p < 0.10$, table 5). For subjects with monotonous repetitive computer work only work time with the computer predicted fewer symptoms and only in the elbow/hand region. However, the ORs for this subgroup of computer users did not differ to a large extent from the whole group of office workers. None of the ORs changed markedly when subjects who had changed workplace before the follow up study were excluded (not shown in table).

DISCUSSION

Only few ergonomic variables were prognostic factors for musculoskeletal symptoms in the univariate analyses, whereas variables related to work technique (large influence on pauses and on the speed of work) and working no more than 75% of the work time at the computer predicted fewer symptoms. In the final multivariate logistic regression models, four factors were included as they all predicted fewer symptoms in at least one of the models after logistic backwards regression analysis, where all other factors were eliminated. However, after combining these four factors in all six final models, two of the variables, "influence on pauses" and "disturbed by glare/reflection", were not significantly associated with fewer symptoms. Only "work time with the computer" predicted fewer neck/shoulder and elbow/hand symptoms and "influence on the speed of work" predicted fewer back symptoms. The OR for working less than 25% of the time at the computer was high for elbow/

Table 3 Unadjusted and adjusted odds ratios of all factors at baseline for a lower frequency of elbow/hand symptom days at follow up

	Unadjusted ORs for each factor						ORs for each factor adjusted for all other factors					
	All computer workers			Repetitive work			All computer workers			Repetitive work		
Factors	p	OR	90% CI	p	OR	90% CI	p	Adj. OR	90% CI	p	Adj. OR	90% CI
Gender	**<0.0001**			**0.007**			**0.03**			0.12		
Women		0.50	0.37–0.66		0.42	0.24–0.72		0.61	0.42–0.88		0.52	0.26–1.04
Age	0.48			0.39			0.48			0.36		
40–49 y		0.90	0.67–1.19		0.83	0.55–1.24		0.82	0.57–1.17		0.70	0.43–1.16
30–39 y		0.85	0.63–1.17		0.96	0.64–1.45		0.94	0.64–1.38		1.04	0.63–1.71
18–29 y		1.41	0.81–2.47		1.76	0.87–3.58		1.52	0.79–2.94		1.62	0.73–3.56
% of work time at computer	**<0.0001**			**0.02**			**0.02**			0.24		
75%		1.82	1.33–2.50		1.48	0.93–2.36		1.51	1.01–2.26		1.06	0.60–1.87
50%		1.52	1.09–2.12		1.44	0.66–3.13		1.45	0.92–2.29		2.99	0.93–9.61
0–25%		3.48	2.17–5.59		5.19	1.77–15.19		2.97	1.59–5.53		3.28	0.73–14.68
Adjusted chair	0.29			**0.09**			0.83			0.29		
Yes		1.28	0.88–1.87		1.66	1.01–2.73		1.07	0.63–1.82		1.62	0.77–3.41
Adjusted desk	0.86			0.49			0.87			0.62		
Yes		0.96	0.69–1.34		1.23	0.75–2.03		1.05	0.64–1.73		0.78	0.35–1.76
Space for resting the arms in front of keyboard	0.53			0.58			0.45			0.28		
Yes		0.90	0.69–1.19		1.15	0.76–1.74		1.19	0.81–1.75		1.45	0.82–2.55
Upper line on screen below eye height	0.32			0.92			0.41			0.54		
Yes		0.85	0.66–1.11		0.98	0.69–1.39		0.85	0.61–1.18		1.18	0.76–1.82
Standing work posture	0.06			0.48			0.36			0.73		
Seldom–all the time		0.75	0.58–0.96		0.85	0.58–1.24		0.82	0.58–1.16		0.89	0.52–1.52
Glare/reflection	0.39			0.29			0.13			0.16		
Now and then–never		0.86	0.65–1.15		0.79	0.54–1.14		0.72	0.51–1.03		0.68	0.43–1.07
Pauses	**0.009**			**0.02**			0.77			0.50		
Large influence		1.47	1.15–1.88		1.64	1.16–2.31		1.07	0.74–1.53		1.24	0.73–2.13
Speed of work	**0.03**			0.15			0.56			0.69		
Large influence		1.38	1.08–1.76		1.35	0.96–1.91		1.13	0.80–1.58		1.12	0.70–1.81

hand symptoms, whereas the association between influence on speed of work and low back symptoms was only moderate for all computer workers. For those with monotonous repetitive computer work, only working less than 25% of the work time predicted fewer neck/shoulder and elbow/hand symptoms. In general the ORs for this subgroup were similar to those for all office workers, indicating that the factors were neither stronger nor weaker associated with fewer symptoms.

General strengths and weaknesses of the study

The most important strength of this study is its prospective design, including measurements of the ergonomic exposure prior to having reduced symptoms. Compared to previous cross-sectional studies this gives the possibility of identifying predictors for improved health.

No selection bias regarding symptoms, gender, and age was observed, as the baseline prevalence of symptoms of those who responded at follow up was similar to the baseline prevalence of symptoms for all participants (including those who dropped out at follow up).[3 15] The same result was found when comparing age and gender of respondents and drop-outs at follow up.

It has previously been shown that those who change job are more likely to be relieved of their symptoms.[24] At the follow up it could not be confirmed whether exposure was still the same, as these questions were not included in the follow up questionnaire. Instead the final models were repeated including only those individuals, who had not changed job since baseline, and the odds ratio did not change markedly.

It is well known that self-reported exposure is often influenced by many factors, for example, the presence of musculoskeletal symptoms.[25 26] A possible misclassification may exist in epidemiological studies of prognostic factors for musculoskeletal symptoms within office work, as those having musculoskeletal troubles are more inclined and able to change their work place towards use of recommended ergonomic tools. However, we are not able to quantify this potential misclassification, which most likely will dilute the observed effects. The group of subjects performing monotonous repetitive computer work consisted mainly of a large group of employees in a call centre, who performed repetitive tasks with short cycle times. There is no doubt that this type of computer work is qualitatively different from many other types of computer work. However, the prognostic factors were similar to the factors for the whole group of office workers.

In the present study we do not know which recommendations the chairs and desks have been adjusted in accordance with, and which work postures they

Table 4 Unadjusted and adjusted odds ratios of all factors at baseline for a lower frequency of low back symptom days at follow up

	Unadjusted ORs for each factor						ORs for each factor adjusted for all other factors					
	All computer workers			Repetitive work			All computer workers			Repetitive work		
Factors	p	OR	90% CI	p	OR	90% CI	p	Adj. OR	90% CI	p	Adj. OR	90% CI
Gender	**<0.0001**			0.21			**0.01**			0.71		
Women		0.51	0.40–0.66		0.70	0.44–1.11		0.62	0.45–0.86		0.88	0.52–1.52
Age	0.84			0.29			0.63			0.44		
40–49 y		1.15	0.88–1.49		1.41	0.99–2.02		1.24	0.91–1.69		1.43	0.94–2.17
30–39 y		1.02	0.78–1.35		1.19	0.82–1.74		1.13	0.81–1.58		1.24	0.80–1.92
18–29 y		1.06	0.68–1.65		1.67	0.96–2.90		1.37	0.80–2.35		1.64	0.84–3.18
% of work time at computer	0.10			0.16			0.80			0.56		
75%		1.46	1.10–1.92		1.44	0.94–2.20		1.14	0.81–1.61		1.12	0.69–1.82
50%		1.25	0.93–1.69		0.60	0.30–1.23		1.13	0.77–1.67		0.55	0.22–1.37
0–25%		1.42	0.97–2.07		1.72	0.84–3.55		0.87	0.52–1.47		1.51	0.58–3.95
Adjusted chair	0.17			0.90			0.42			0.87		
Yes		1.30	0.95–1.79		1.03	0.69–1.54		1.22	0.82–1.82		0.95	0.56–1.60
Adjusted desk	0.36			0.28			0.56			0.42		
Yes		1.17	0.88–1.56		1.32	0.86–2.01		0.15	0.78–1.69		1.33	0.74–2.39
Space for resting the arms in front of keyboard	0.47			0.49			0.11			0.32		
Yes		0.90	0.70–1.15		0.86	0.60–1.23		0.73	0.54–1.01		0.76	0.48–1.20
Upper line on screen below eye height	0.17			0.68			**0.05**			0.21		
Yes		1.22	0.96–1.54		1.08	0.79–1.48		1.41	1.06–1.88		1.33	0.91–1.92
Standing work posture	0.07			0.26			0.16			0.33		
Seldom–all the time		0.78	0.62–0.98		0.80	0.58–1.11		0.78	0.58–1.04		0.77	0.49–1.20
Glare/reflection	**0.08**			0.11			0.28			0.22		
Now and then–never		1.31	1.02–1.69		1.40	1.00–1.96		1.22	0.90–1.65		1.34	0.90–1.99
Pauses	**0.03**			0.34			0.88			0.68		
Large influence		1.33	1.07–1.65		1.20	0.88–1.63		1.03	0.76–1.39		1.12	0.72–1.74
Speed of work	**0.002**			0.11			**0.04**			0.36		
Large influence		1.50	1.21–1.86		1.34	0.99–1.80		1.43	1.08–1.89		1.24	0.84–1.83

resulted in. We assumed that a non-adjusted chair/desk more often resulted in a non-optimal posture. Similarly, it was assumed that having a large influence on when to take a rest pause or on the speed of work, implied taking a rest pause or reducing the speed of work whenever it was needed. A positive effect of the chair was seen in the present study for the elbow/hand region in the univariate analyses, but not in the final model. As new desks and chairs today are easier to adjust than previously with respect to height, tilt, etc, thereby making it possible to match the anthropometry of the individual, we may already have had the positive health effects of the adjusted chairs and desks. In general, the working conditions were rated as good in the baseline questionnaire. The contrast between good and poor ergonomic conditions may therefore be too small to find any effect on musculoskeletal symptoms, but no conclusive interpretation can be made in this respect. Today a varied daily work posture is usually recommended, for which reason the frequency of adjustments becomes an important issue. Unfortunately, in the present study it was not possible to measure how frequently the chairs and especially the desks were adjusted.

The importance of the variable of whether there "was enough space to rest the arms in front of the keyboard" could be questioned. In a recent study of computer workers, half of the subjects reported they had space enough to rest their arms, but only half of them seemed to have their arms supported during work, as observed from video recordings.[27] However, arm supports are not preferred in all computer tasks, for example, touch typing or repetitive work as data entry work,[28] as they may interfere with rapid, accurate movements, may limit operator freedom of movement, and cause chairs to be placed away from the work surface. Thus, arm supports are not always regarded as a recommended ergonomic condition, and even in situations where they are, it may be questioned whether they are fully used or not.

Outcome variables were self-reported, including "symptom frequency" that covers days of symptoms within the last 12 months, rated on a five point scale. This is a fairly easy question to answer, although recall bias may be a common problem in epidemiological studies. "Symptom frequency" is the most frequently used outcome variable in recent epidemiological and intervention studies,[3 12 14 29] which makes this variable easy to compare with other studies.

The results compared to other studies

Risk factors and prognostic factors for symptoms can be different as shown previously,[30] which might be due to different mechanisms—that is, a disease

Table 5 Final models: factors predicting a lower frequency of musculoskeletal symptom days at follow up adjusted for gender and age

	All office workers			Monotonous repetitive computer work		
Factors	**p**	**Adj. OR**	**90% CI**	**p**	**Adj. OR**	**90% CI**
Neck/shoulder						
% of work time at computer	**0.027**			0.11		
75%		**1.53**	**1.18–1.98**		1.48	0.99–2.22
50%		1.11	0.83–1.49		1.40	0.74–2.64
0–25%		**1.52**	**1.05–2.19**		**2.39**	**1.13–5.09**
Speed of work	0.61			0.40		
Large influence		1.07	0.83–1.33		1.17	0.86–1.59
Pauses	0.36			0.44		
Large influence		1.14	0.90–1.43		1.17	0.84–1.61
Glare/reflection	0.53			0.54		
Now and then–never		1.10	0.86–1.39		0.89	0.64–1.23
Elbow/hand						
% of work time at computer	**0.0014**			**0.09**		
75%		**1.68**	**1.20–2.36**		1.40	0.85–2.30
50%		1.39	0.96–2.00		1.74	0.74–4.07
0–25%		**2.99**	**1.78–5.02**		**4.14**	**1.35–12.72**
Speed of work	0.93			0.73		
Large influence		1.02	0.76–1.35		0.92	0.60–1.39
Pauses	0.38			0.25		
Large influence		1.17	0.87–1.58		1.34	0.88–2.06
Glare/reflection	0.11			0.12		
Now and then–never		0.75	0.55–1.01		0.69	0.47–1.02
Low back						
% of work time at computer	0.45			0.43		
75%		1.33	0.99–1.79		1.34	0.86–2.08
50%		1.08	0.78–1.51		0.68	0.32–1.42
0–25%		1.01	0.66–1.53		1.46	0.68–3.11
Speed of work	**0.027**			0.35		
Large influence		**1.39**	**1.09–1.77**		1.22	0.86–1.71
Pauses	0.93			0.80		
Large influence		1.01	0.78–1.31		1.06	0.74–1.51
Glare/reflection	0.27			0.15		
Now and then–never		1.19	0.92–1.56		1.36	0.96–1.93

Bold denotes significant associations ($p < 0.10$).

process may be provoked and deteriorated by certain conditions, whereas a relieved or comfort feeling may be experienced when having other conditions. However, in the present study the identified prognostic factors were almost the same factors found previously to be risk factors.

The study may support studies showing a positive health effect of reducing the duration of work time with the computer by taking rest pauses.[12 20] Another prognostic factor linked to the work technique, a high influence on the speed of work, has previously been supported in other studies.[1 31]

This study does not support previous studies showing a positive health effect of the classical ergonomic variables (adjusted chair, desk).[10 12] Even though arm support has previously been found to have a positive health effect on the neck, shoulder, arm and hand by reducing the static muscle activity in precision work,[10 12 21 32] and also on the low back,[16–18] arm support could not be verified as a prognostic factor in the present study. Neither could screen height (with the upper line of the screen below eye level), which in some studies has been shown to be a prognostic factor.[10 12 16] An individually placed screen (height and distance) has, on the other hand, been found to meet the need of individuals more sufficiently in relation to the capacity and condition of the eyes.[22]

A variation between a standing and a sitting posture was expected to be a prognostic factor, especially for the low back, as relieving factors for low back pain patients are lying down, walking around, and standing positions. This creates the least stress on the spinal tissues,[33 34] as the sitting posture has been found to increase the force on the intervertebral discs, increasing tension on ligaments and muscles during forward slumping.[35 36] But standing was not a prognostic factor for low back pain in the present study. In a recent review, "sitting-while-at-work" was not found to be a risk factor for low back pain compared to standing and lifting bending.[37] In a five year follow up study, people who had experienced low back pain more often changed from heavy physical jobs to sedentary jobs, thereby introducing a possible selection bias.[38] We do not know if there is a selection bias in the present study, so further studies are needed to study the true effect of varying between standing and sitting office work, especially as new desks today are more easily raised and lowered than previously, thereby giving the possibility for a varied work posture.

Concluding remarks

None of the classical ergonomic variables were prognostic factors for musculoskeletal symptoms. It remains unresolved whether this is due to no effect of classical ergonomics for the prognosis of symptoms, whether the exposure contrast was too small to detect an effect, or whether the questions used were unable to detect the relevant aspects of ergonomic conditions. Instead, not working all of the work time with the computer and a large influence on the speed of work were prognostic factors. For the subgroup with monotonous repetitive computer work, these factors were not stronger prognostic factors than for the whole group of office workers. Thus, when organising computer work, it seems important to consider both the duration of computer work and the employees' own influence on their speed of work.

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REFERENCES

1 **Andersen JH**, Kaergaard A, Mikkelsen S, *et al*. Risk factors in the onset of neck/shoulder pain in a prospective study of workers in industrial and service companies. *Occup Environ Med* 2003;**60**:649–54.
2 **Tittiranonda P**, Burastero S, Rempel D. Risk factors for musculoskeletal disorders among computer users. *Occup Med State Art Rev* 1999;**14**:17–38.
3 **Jensen C**. Development of neck and hand-wrist symptoms in relation to duration of computer use at work. *Scand J Work Environ Health* 2003;**29**:197–205.
4 **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.
5 **Jensen C**, Ryholt CU, Burr H, *et al*. Work-related psychosocial, physical and individual factors associated with musculoskeletal symptoms in computer users. *Work & Stress* 2002;**16**:107–20.
6 **Jensen C**, Finsen L, Søgaard K, *et al*. Musculoskeletal symptoms and duration of computer and mouse use. *Int J Ind Ergon* 2002;**30**:265–75.
7 **Blatter BM**, Bongers PM. Duration of computer use and mouse use in relation to musculoskeletal disorders of neck or upper limb. *Int J Ind Ergon* 2002;**30**:295–306.
8 **Punnett L**, Bergqvist U, Kjellberg A, eds. *National Institute for Working Life – Ergonomic expert committee document no 1. Visual display unit work and upper extremity musculoskeletal disorders. A review of epidemiological findings*. Solna: National Institute for Working Life, 1997.
9 **Gerr F**, Marcus M, Ortiz DJ, *et al*. Computer user's postures and associations with workstation characteristics. *Am Ind Hyg Assoc J* 2000;**61**:223–30.
10 **Marcus M**, Gerr F, Monteilh C, *et al*. A prospective study of computer users: II. Postural risk factors for musculoskeletal symptoms and disorders. *Am J Ind Med* 2002;**41**:236–49.
11 **Polanyi MFD**, Cole DC, Beaton DE, *et al*. Upper limb work-related musculoskeletal disorders among newspaper employees: cross-sectional survey results. *Am J Ind Med* 1997;**32**:620–8.
12 **Ketola R**, Toivonen R, Hakkanen M, *et al*. Effects of ergonomic intervention in work with video display units. *Scand J Work Environ Health* 2002;**28**:18–24.
13 **Demure B**, Mundt KA, Bigelow C, *et al*. Video display terminal workstation improvement program: II. Ergonomic intervention and reduction of musculoskeletal discomfort. *J Occup Environ Med* 2000;**42**:792–7.
14 **Demure B**, Luippold RS, 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.
15 **Juul-Kristensen B**, Søgaard K, Strøyer J, *et al*. Computer users' risk factors for developing shoulder, elbow and back symptoms – the 'BIT' study. *Scand J Work Environ Health* 2004;**30**:390–8.
16 **Aarås A**, Horgen G, Bjørset H-H, *et al*. Musculoskeletal, visual and psychosocial stress in VDU operators before and after multidisciplinary ergonomic interventions. *Appl Ergon* 1998;**39**:335–54.
17 **Aarås A**, Horgen G, Bjørset H-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.
18 **Aarås A**, Fostervold KI, Ro O, *et al*. Postural load during VDU work: a comparison between various work postures. *Ergonomics* 1997;**40**:1255–68.
19 **SHARP**. *Cumulative trauma disorders in claims follow-up study*, No.16-5-1993 Safety and Health Assessment and Research for Prevention. Washington State Department of Labor and Industries, 1993.
20 **Van den Heuvel SG**, de Looze MP, Hildebrandt VH, *et al*. Effects of software programs stimulating regular breaks and exercises on work-related neck and upper-limb disorders. *Scand J Work Environ Health* 2003;**29**:106–16.
21 **Lintula M**, Nevala-Puranen N, Louhevaara V. Effects of ergorest arm supports on muscle strain and wrist positions during the use of the mouse and keyboard in work with visual display units: a worksite intervention. *International Journal of Occupational Safety and Ergonomics* 2001;**7**:103–16.
22 **Jaschinski W**, Heuer H, Kylian H. A procedure to determine the individually comfortable position of visual displays relative to eyes. *Ergonomics* 1999;**42**:535–49.
23 **Kuorinka I**, Jonsson B, Kilbom Å, *et al*. Standardised Nordic questionnaires for the analysis of musculoskeletal symptoms. *Appl Ergon* 1987;**18**:233–7.
24 **Schibye B**, Skov T, Ekner D, *et al*. Musculoskeletal symptoms among sewing machine operators. *Scand J Work Environ Health* 1995;**21**:426–33.
25 **Mikkelsen S**, Butcher I, Andersen JH, *et al*. Factors influencing self-reported computer use compared to objectively measured computer use in the NUDATA study. The challenge of equity in safety and health at work [CD-ROM], 27th International Congress on Occupational Health, 23–28 February, ICOH, Iguassu Falls, Brazil, 2003:49.1.
26 **Thomsen JF**, Mikkelsen S, Prim Health Study Group. Do musculoskeletal symptoms influence reporting of ergonomic exposure? The challenge of equity in safety and health at work [CD-ROM], 27th International Congress on Occupational Health, 23–28 February, ICOH, Iguassu Falls, Brazil, 2003:46.1.
27 **Juul-Kristensen B**, Laursen B, Pilegaard M, *et al*. Physical workload during speech recognition and traditional computer work. *Ergonomics* 2002;**47**:119–33.
28 **Bendix T**, Jessen F. Wrist support during typing – a controlled, electromyographic study. *Appl Ergon* 1986;**17**:162–8.
29 **Kaergaard A**, Andersen JH, Rasmussen K, *et al*. Identification of neck-shoulder disorders in a 1 year follow-up study. Validation of a questionnaire-based method. *Pain* 2000;**86**:305–10.
30 **Borg V**, Kristensen TS, Burr H. Work environment and changes in self-rated health: a five year follow-up study. *Stress Med* 2000;**16**:37–47.
31 **Veiersted KB**, Westgaard RH. Development of trapezius myalgia among female workers performing light manual work. *Scand J Work Environ Health* 1993;**19**:277–83.
32 **Feng Y**, Grooten W, Wretenberg P, *et al*. Effects of arm support on shoulder and arm muscle activity during sedentary work. *Ergonomics* 1997;**40**:834–48.
33 **Biering-Sørensen F**. A prospective study of low back pain in a general population. II. Location, character, aggravating and relieving factors. *Scand J Rehabil Med* 1983;**15**:81–8.
34 **Carter JB**, Banister EW. Musculoskeletal problems in VDT work: a review. *Ergonomics* 1994;**37**:1623–48.
35 **Nachemson AL**. Disc pressure measurements. *Spine* 1981;**6**:93–7.
36 **Nachemson A**. Towards a better understanding of low-back pain: a review of the mechanics of the lumbar disc. *Rheumatology and Rehabilitation* 1975;**14**:129–43.
37 **Hartvigsen J**, Leboeuf-Yde C, Lings S, *et al*. Is sitting-while-at-work associated with low back pain? A systematic, critical review. *Scand J Public Health* 2000;**28**:230–9.
38 **Hartvigsen J**, Bakketeig LS, Leboeuf-Yde C, *et al*. The association between physical workload and low back pain clouded by the 'healthy worker' effect. *Spine* 2001;**26**:1788–93.