Eur Spine J (2007) 16:2083–2091
DOI 10.1007/s00586-007-0481-0

ORIGINAL ARTICLE

The influence of work-related exposures on the prognosis of neck/shoulder pain

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Received: 1 February 2007 / Revised: 29 June 2007 / Accepted: 2 August 2007 / Published online: 25 August 2007

Abstract To determine associations between work-related exposures and the prognosis of self-reported neck/shoulder pain. This prospective cohort study was based on 803 working subjects who reported neck/shoulder pain at baseline. The proportion of subjects who 5–6 years later were symptom-free was calculated. Data concerning work-related biomechanical, psychosocial, and organizational exposures were collected at baseline. The Cox regression analyses were used to calculate the relative chances (RC) of being symptom-free at the end of the study for single exposures, and also for up to three simultaneous work-related exposures. Adjustments were made for sex and age. Only 36% of the subjects were symptom-free 5–6 years later. The relative chance for being symptom-free at the end of the study was 1.32 (95% CI = 0.99–1.74) for subjects who were exposed to *sitting* ≥75% of the working time and 1.53 (95% CI = 1.02–2.29) for subjects who were exposed to *job strain*, i.e., the combination of *high demands* and *low decision latitude*. The relative chance of being symptom-free at the end of the study was 0.61 (95% CI = 0.40–0.94) for subjects with at least two out of three simultaneous biomechanical exposures at work; *manual handling*, *working with the hands above shoulder level*, and *working with vibrating tools*. In a heterogeneous population with moderate nonspecific neck/shoulder pain, sedentary work enhanced the chance of being symptom-free 5–6 years later, whereas simultaneous exposures to at least two of *manual handling*, *working with hands above shoulder level* and *working with vibrating tools* were associated with a lower chance of being symptom-free at the end of the study. This could imply that subjects with neck/shoulder pain should avoid such simultaneous exposures.

Keywords Disability · Epidemiology · Occupational health · Prospective studies

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Introduction

Neck/shoulder disorders are common in Western society, causing major medical and socio-economic problems [11, 13]. Approximately two out of three individuals will at some time during their lives experience at least one episode of pain in their neck or shoulders [22]. The prognosis for those suffering from neck/shoulder pain is relatively poor. Not more than about the half of the subjects with neck/shoulder pain are pain-free after 1–5 years [2, 4, 6, 13, 14, 19, 21, 23, 32, 34].

Many studies investigate the influence of individual-related factors on the prognosis of neck/shoulder pain, e.g., the level of pain-intensity [34]. Work-related exposures could also influence the prognosis, since they are involved

in the development of neck/shoulder pain, e.g., manual handling, low decision latitude, and high mental demands [4, 9]. Contradictory results have been found concerning the influence of work-related biomechanical, psychosocial and organizational exposures on the prognosis of neck/shoulder pain [1, 3, 4, 16, 23]. Moreover, detailed information on the levels of exposure, or the combinations of exposures that influence the prognosis is still lacking [2, 5]. The aim of the present study was to examine associations between work-related exposures and the prognosis of neck/shoulder pain.

Subjects and methods

Subjects

The study population consisted of the cases and the controls from a population-based case-control study on neck/shoulder- and low-back pain with a 5- to 6-year follow up, the MUSIC-Norrtälje study [8, 9, 24, 33, 38]. The baseline study was performed between 1994 and 1997. The follow-up was done in 2000–2001; all cases and controls, who still lived in Sweden, were invited to participate (n = 2,812). Subjects examined in 1994 and 1995 received a self-administered questionnaire in 2000, and subjects examined in 1996 and 1997 received their questionnaire in 2001. Inclusion criteria for the present study were: (1) having self-reported neck/shoulder pain at baseline (as defined below), and (2) employment[1] at baseline. In all, 1,044 subjects fulfilled these criteria. Of the 1,044 subjects with self-reported neck/shoulder pain at baseline, 844 returned their questionnaires. Due to internal missing values for the outcome variable, i.e., being symptom-free at the end of the study, 41 of the responders could not be classified at the follow-up and were excluded from the analyses. Thus, 803 subjects were included in the study, giving a response rate of 77%.

Definition of neck/shoulder pain at baseline

At baseline, the level of pain intensity and the level of pain-related disability in the neck/shoulder region were assessed using the questions and rating scales described by von Korff [39]. Three questions covered the level of pain intensity in the neck/shoulder region: (1) current pain, (2) worst pain experienced during the previous 6 months, and (3) average pain during the previous 6 months. For each question the rating was made on an 11-point scale, where 0 meant "no pain" and 10 meant "pain as bad as it could be". The average of the ratings from these three questions was calculated for each subject and was defined as the *pain intensity score*. Another three questions were about pain-related disability due to neck/shoulder pain. These three questions covered the past 6 months and asked how much the pain had affected (1) everyday activities, (2) social and family activities, and (3) the ability to work (including domestic work) [39]. These ratings were also made on an 11-point scale, where 0 meant "not affected at all" and 10 meant "impossible to continue with these activities". For each subject, the average of the ratings from these three questions was calculated and defined as the *pain-related disability score*. Subjects with *pain intensity score* ≥3 and/or *pain-related disability score* ≥1 were defined as having neck/shoulder pain.

Methods

Work-related exposures at baseline

At baseline, data concerning work-related biomechanical, psychosocial, and organizational exposures were collected by means of task-oriented interviews (i_1 and i_2) and self-administered questionnaires (q_1 and q_2).

In the interview concerning biomechanical exposures (i_1), each subject was asked to specify the various work tasks performed during *a typical working day* and also the time spent on each task [37]. Four biomechanical exposures were analyzed: (1) *manual handling* ≥50 N[2] ≥60 min/day (i_1); (2) *working with hands above shoulder level* ≥30 min/day (i_1); (3) *working with vibrating tools* ≥60 min/day (q_1); and 4) *sitting* ≥75% *of the working time* (i_1). The cut-off points for classifying subjects as exposed or unexposed were used in previous reports from the MUSIC-Norrtälje study [9, 33]. The exposure variables analyzed have previously been considered to be sufficiently reliable [17, 28, 35–37].

In the interview concerning psychosocial exposures (i_2), each subject was asked to describe his or her *typical working day* in sufficient detail so that the interviewer could quantify the requirements of each work task and was able to create a profile of the total work engagement [30]. The questionnaire concerning psychosocial exposures (q_2) included several items on social relations and support in the workplace. It also incorporated questions from the Swedish version of the demand/control model by Karasek and Theorell, in order to assess psychosocial demands and decision latitude [15, 27]. Nine psychosocial exposures were analyzed: (1) low demands in relation to competence ($q_2 + i_2$); (2) few opportunities to learn and develop at

[1] Working at least 17 h/week.

[2] Newton

work ($q_2 + i_2$); (3) high mental demands; (4) low decision latitude; (5) job strain, i.e., the combination of high mental demands and low decision latitude (q_2); (6) poor general support at work (q_2); (7) low meaningfulness (q_2); (8) high time pressure (q_2); and (9) high hindrances at work ($q_2 + i_2$). The cut-off points for classifying subjects as exposed or unexposed were based on previous reports from the MUSIC-Norrtälje study [9, 33].

Three organizational exposures were identified: (1) non-fixed salary (q_2); (2) night work/shift work (q_2); and (3) solitary work (i_2). Subjects that answered, "yes" to these questions were classified as exposed, and subjects that answered "no" were classified as unexposed.

Outcome

The follow-up questionnaire contained the same questions about the level of pain intensity and the level of pain-related disability in the neck/shoulder region as was used in the baseline questionnaire. For each subject, a *pain intensity score* and a *pain-related disability score* at the end of the study was calculated in a corresponding way as was made at baseline. A subject with a *pain intensity score* <3 and a *pain-related disability score* <1 at the end of the study was considered to be symptom-free from neck/shoulder pain.

Data treatment and statistical analyses

Initially, subjects with a four and a 5-year follow-up period were grouped together ($n = 27$ and $n = 457$, respectively). The proportion of subjects who were symptom-free at the end of the study was calculated separately for those with a 5-year and for those with a 6-year follow-up period and a z test for differences in proportions was used to ascertain whether the two proportions differed.

To determine the association between each separate work-related exposure and the outcome of interest, that is, being symptom-free at the end of the study, univariate Cox regression analysis was applied. For each exposure, the relative chance of being symptom-free at the end of the study (a cumulative incidence ratio) was calculated along with the corresponding 95% confidence intervals (95% CI). Exposures with $P \leq 0.10$ were considered as potential predictors and were included in a multivariate Cox regression model. In both the univariate and the multivariate models, adjustments were made for sex and age (continuous), and a constant time variable was applied. Moreover, the interaction term between sex and age was included in the multivariate Cox regression model if $P \leq 0.10$. The reference category for all analyses was the unexposed group.

In jobs with high physical workload, different biomechanical exposures often occur simultaneously [1]. For this reason, subjects simultaneously exposed to one, two, or three of the biomechanical exposures m*anual handling* ≥50N ≥60 min/day, w*orking with hands above shoulder level* ≥30 min/day, and *working with vibrating tools* ≥60 min/day were compared to those unexposed to all of these three. The relative chances of being symptom-free at the end of the study and the corresponding 95% confidence intervals were calculated by means of Cox regression analysis adjusted for sex and age, and a constant time variable was applied. The interaction term between sex and age was included in this model if $P \leq 0.10$. All analyses were made using the statistical package SPSS for Windows (SPSS Inc., Version 13.0; Chicago, IL, USA).

Results

Of the 1,044 subjects with self-reported neck/shoulder pain at baseline, 803 subjects were included in the study. The 241 non-responders were similar to the responding subjects concerning sex, age, socio-economic status, pain intensity score and pain-related disability score (Table 1). A total of 140 different job titles were represented.

Three percent of the 803 subjects were followed up 4 years after their baseline investigation, 57% after 5 years, and 40% after 6 years. For the total group of subjects, the proportion of symptom-free subjects at the end of the study was 36%. The proportion of symptom-free subjects did not differ between those with a 5-year follow-up period (35%) and those with a 6-year follow-up (39%).

At baseline, the mean pain intensity score in the study group was 4.4 and the mean pain-related disability score was 2.2 (Table 1). The 75% percentile for the pain intensity score was 5.6. For pain-related disability it was 3.0. Less than 10% of the subjects had a neck/shoulder pain-intensity level above 7.

At the follow-up, 140 subjects (17%) had stopped working. Among them, 30 subjects were symptom-free at the end of the study. The proportion of symptom-free subjects at the end of the study was lower ($P < 0.001$) among those that had stopped working (21%) compared to those still at work, 263 out of 663, (40%) ($P < 0.001$).

Influence of work-related exposures

After adjusting for sex and age, three exposures were associated with being symptom-free at the end of the study ($P \leq 0.10$ in the univariate Cox regression analyses: *manual handling* ≥50 N ≥60 min/day, *sitting* ≥75% *of the*

Table 1 Demographics and illness-related data of the subjects included in the study (n = 803) and the non-responders (n = 241)

Total (n)		Subjects included in the study n (%) 803	Non-responders n (%) 241
Demographic data			
Women		524 (65%)	154 (64%)
Men		279 (35%)	87 (36%)
Mean age (SD)		42 (SD = 10)	40 (SD = 10)
Socio-economic status[a] at baseline			
Blue-collar workers		161 (57%)	148 (61%)
White-collar workers		274 (34%)	75 (31%)
Self-employed or employer		40 (5%)	12 (5%)
Labor-market programs		28 (4%)	6 (3%)
Illness-related data at baseline			
Sought medical care	No	315 (39%)	116 (48%)
Yes, due to neck/shoulder pain		216 (27%)	64 (27%)
Yes, due to low-back pain		218 (27%)	51 (21%)
Yes, due to neck/shoulder and low-back pain		54 (7%)	10 (4%)
Neck/shoulder pain intensity score ≥3 and neck/shoulder pain-related disability score ≥1		455 (57%)	139 (58%)
Neck/shoulder pain intensity score ≥3 and neck/shoulder pain-related disability score <1		194 (24%)	71 (29%)
Neck/shoulder pain intensity score <3 and neck/shoulder pain-related disability score ≥1		148 (19%)	31 (13%)
Neck/shoulder pain intensity score (0–10)	Mean (SD)	4.4 (1.9)	4.4 (1.8)
	Median (range)[b]	4.3 (1.0–8.0)	4.3 (1.0–8.0)
Neck/shoulder pain-related disability score (0–10)	Mean (SD)	2.2 (2.0)	1.9 (1.8)
	Median (Range)[b]	1.7 (0.0–6.3)	1.3 (0.0–6.0)

SD standard deviation

[a] Based on the combination of job title and education level. Job titles were categorized with the three-digit Nordic occupational classification (NYK), which follows the recommendations of the three digit International classification (ISCO)

[b] P05-P95

working time, and *job strain* (Table 2). These exposures were included in a multivariate model.

The results from the multivariate model, presented in Table 3, showed that subjects exposed to *job strain* had a higher chance of being symptom-free at the end of the study than unexposed subjects, with an adjusted RC of 1.53 (95% CI = 1.02–2.29). The relative chance to be symptom-free at the end of the study was also higher for the subjects exposed to *sitting ≥75% of the working time*, with an adjusted RC of 1.32 (95% CI = 0.99–1.74). In other words, these two groups had a 53 and 32% greater chance to be symptom-free at the end of the study than those of the corresponding unexposed groups, respectively. No interaction between sex and age was found.

Subjects simultaneously exposed to two or three of the biomechanical exposures *manual handling* ≥50 N ≥60 min/day, *working with hands above shoulder level* ≥30 min/day, and *working with vibrating tools* ≥60 min/day had a lower relative chance to be symptom-free at the end of the study, than those unexposed to all three of these exposures; the adjusted RC was 0.61 (95% CI = 0.40–0.94) (Table 4). In other words, the prognosis in this group was lower that in the corresponding unexposed group. No interaction between sex and age was found.

The three exposure variables included in this multivariate model were almost mutually exclusive to the fourth biomechanical exposure, *sitting ≥75% of the working time*. Of the subjects exposed to *manual handling* ≥50 N ≥60 min/day, *hands above shoulder level* ≥30 min/day, or *vibrating tools* ≥60 min/day, only 10% were also exposed to *sitting ≥75% of the working time.*

When analyzing men and women separately, there were no systematic differences between men and women concerning the direction and the magnitude of the chance estimates. For *job strain*, it was impossible to perform sex-separated analyses due to the low number of exposed men (n = 8).

Additional analyses

To test the possibility of the presence of a "healthy worker effect", the data were reanalysed taking into account the work status at the end of the study. Table 5 shows the

Table 2 Results of Cox regression analysis for the 803 subjects, comprising adjusted relative chance of being symptom-free from neck/shoulder pain at the end of the study (RC), 95% confidence intervals (95% CI), and *P* values

	RC[a]	95% CI	*P* value	Total number of subjects	Number of symptom-free subjects at the end of the study	(%)
Manual handling ≥50 N ≥60 min/day						
Unexposed	1.00			707	266	(38)
Exposed	0.69	0.47–1.03	0.072	95	27	(28)
Working with hands above shoulder level ≥30 min/day						
Unexposed	1.00			640	237	(37)
Exposed	0.85	0.63–1.14	0.266	163	56	(34)
Working with vibrating tools ≥60 min/day						
Unexposed	1.00			674	246	(36)
Exposed	0.79	0.56–1.12	0.182	129	47	(36)
Sitting ≥75% of the working time						
Unexposed	1.00			640	219	(34)
Exposed	1.28	0.98–1.68	0.068	163	74	(45)
Low demands in relation to competence						
Unexposed	1.00			532	192	(36)
Exposed	0.96	0.73–1.26	0.742	194	70	(36)
Few possibilities to learn and develop at work						
Unexposed	1.00			553	204	(37)
Exposed	1.02	0.79–1.33	0.870	225	82	(36)
High mental demands						
Unexposed	1.00			512	182	(36)
Exposed	1.10	0.86–1.41	0.461	247	94	(38)
Low decision latitude						
Unexposed	1.00			589	213	(36)
Exposed	1.08	0.82–1.42	0.586	178	70	(39)
Job strain: high mental demands and low decision latitude						
Unexposed	1.00			687	244	(36)
Exposed	1.48	0.99–2.21	0.056	54	27	(50)
Poor general support at work						
Unexposed	1.00			422	147	(35)
Exposed	1.11	0.88–1.41	0.370	337	130	(39)
Low meaningfulness						
Unexposed	1.00			649	234	(36)
Exposed	1.13	0.83–1.53	0.442	120	51	(43)
High time pressure						
Unexposed	1.00			631	233	(37)
Exposed	1.02	0.75–1.38	0.905	151	53	(35)
High degree of hindrances at work						
Unexposed	1.00			419	145	(35)
Exposed	1.10	0.87–1.40	0.422	333	125	(38)
Non-fixed salary						
Unexposed	1.00			664	237	(36)
Exposed	1.35	0.93–1.97	0.114	63	34	(54)
Night/Shift work						
Unexposed	1.00			579	220	(38)
Exposed	0.87	0.66–1.14	0.311	208	69	(33)
Solitary work						
Unexposed	1.00			699	252	(36)
Exposed	1.11	0.80–1.56	0.533	96	39	(41)

Also shown for each exposure category are the total number of subjects with neck/shoulder pain at baseline, and the number and proportion (%) of subjects being symptom-free at the end of the study

[a] Adjusted for sex and age

Table 3 Results of a multivariate Cox regression model, comprising adjusted relative chance of being symptom-free from neck/shoulder pain at the end of the study (RC) and 95% confidence intervals (95% CI)

	RC[a]	95% CI
Manual handling ≥50 N ≥60 min/day		
Unexposed	1.00	
Exposed	0.78	0.51–1.18
Sitting ≥75% of the working time		
Unexposed	1.00	
Exposed	1.32	0.99–1.74
Job strain, the combination of high mental demands and low decision latitude		
Unexposed	1.00	
Exposed	1.53	1.02–2.29

[a] Adjusted for sex and age

stratified relative chances for being symptom-free at the end of the study for the variables included in the final model as well as for those simultaneously exposed to two or three of the biomechanical exposures *manual handling* ≥50 N ≥60 min/day, *working with hands above shoulder level* ≥30 min/day, and *working with vibrating tools* ≥60 min/day. The proportion of subjects that had stopped working at the end of the study ranged between 13% (*sitting ≥75% of the working time*) to 24% (*job strain*). For those that had stopped working the chances for being symptom-free at the end of the study was lower for all exposures compared to those still at work.

Discussion

In the study group of 803 working subjects with self-reported neck/shoulder pain, only 36% were symptom-free after a 5 to 6-year period. For subjects exposed to *sitting ≥75% of the working time* and for subjects exposed to *job strain*, the chances to be symptom-free at the end of the study were higher than for those unexposed to these factors. A lower chance to be symptom-free at the end of the study was found for subjects simultaneously exposed to at least two of the three biomechanical exposures *manual handling*, *work with hands above shoulder level*, *and work with vibrating tools* at baseline than for those unexposed to all of these three.

Proportion symptom-free subjects

Previously published cohort studies indicate that the prognosis is fairly poor for subjects suffering from neck/shoulder pain. The proportions of symptom-free subjects at follow-up varied largely between these studies and lies somewhere between 8 and 65% depending on the setting, time of follow-up, differences in study population, definition and body area studied, or other methodological differences between the studies [2, 4, 6, 12, 14, 19, 21, 23, 34]. The results of the present study in which a follow-up time of 5–6 years was used, were consistent with cohort studies with a follow-up time ≥1 year. In the present and above-mentioned cohort studies, subjects suffering from neck/shoulder pain were followed over a specified period of time and the proportion of symptom-free subjects at the end of the study was calculated. One should be aware that such study design, which consists in fact of two subsequent prevalence studies, could not describe the entire picture of the prognosis of neck/shoulder pain, since subjects in pain at the end of the study could have had symptom-free periods between the baseline and follow-up.

Table 4 Results of Cox regression analyses for three simultaneous biomechanical exposures: *manual handling* ≥50 N ≥ 60 min/day, *working with hands above shoulder level* ≥30 min/day, *and working with vibrating tools* ≥60 min/day, comprising adjusted relative chance of being symptom-free from neck/shoulder pain at the end of the study (RC) and 95% confidence intervals (95% CI), for increasing number of exposures

	RC[a]	95% CI	Subjects with neck/shoulder pain at baseline		
			Total	Symptom-free at the end of the study	(%)
Biomechanical exposures[b]					
0	1.00		525	196	(37)
1	0.89	0.68–1.18	187	71	(38)
2 or 3 simultaneous exposures	0.61	0.40–0.94	90	26	(29)

Also shown for each exposure category are the total number of subjects and the number and proportion (%) of subjects being symptom-free from neck/shoulder pain at the end of the study

[a] Adjusted for sex and age

[b] Included variables: *manual handling* ≥50 N ≥60 min/day, *working with hands above shoulder level* ≥30 min/day, and *working with vibrating tools* ≥60 min/day

Work-related exposures

Biomechanical exposures

Biomechanical exposures were found to have a moderate influence on the prognosis, a result in accordance with other prognostic studies on the associations between biomechanical exposures and neck or shoulder pain [4, 23, 32, 34]. However, there are other studies in which biomechanical exposures did not influence the prognosis at all [2, 14, 20].

In the present study, the only single biomechanical exposure that turned out to be associated with the outcome was *sitting during ≥75% of the working time*. In self-reports, the estimated time spent sitting at work have a higher precision than the estimates of other biomechanical exposures [17, 28, 35–37]. This is one possible explanation for why *sitting ≥75% of the working time* turned out to be significant in the univariate analyses while the other three biomechanical exposures did not. A low precision in exposure assessment has a dilutive effect on the chance estimates [25].

Those exposed to *sitting ≥75% of the working time* and those exposed to at least two of the three other biomechanical loads represented two extremes of working conditions. A sitting work position hampers the possibility of working with high forces and the possibility of performing prolonged work with hands above shoulder level. The increased chance of being symptom-free at the end of the study among those with a predominantly sitting work position was probably due to the lack of exposure to the other three biomechanical loads rather than to the sitting position itself.

Psychosocial exposures

Subjects exposed to *job strain* had a higher chance of being symptom-free at the end of the study than those who were not exposed. The relationship between *job strain* and the onset of neck/shoulder pain has been more widely studied than the relationship between *job strain* and recovery. There are some studies in more homogenous groups that have identified *job strain* as a risk factor or an effect-modifier for neck pain [10, 18, 26, 29, 31]. Previous reports from the MUSIC-Norrtälje study reported a lack of association between *job strain* and the onset of neck-shoulder pain, possibly due to low exposure prevalence or too low a contrast between exposed and unexposed subjects [8, 9, 33]. One earlier study reported a lack of association between *job strain* and the recurrence of neck or shoulder complaints [20].

One possible explanation of the unexpected results concerning *job strain* in the present study could be the presence of a "healthy worker effect". A "healthy worker effect" is defined as that those with adverse work conditions leave their jobs more often than those with better work conditions. When analysing risk factors, this could possibly lead to an underestimation of the risk estimates [25]. In the present study, some additional analyses were performed taking into account the work status at the end of the study. These analyses showed that those still at work and exposed to job strain had a higher chance for being symptom-free at the end of the study compared to those that had stopped working (Table 5). Thus, no healthy worker effect was present. Since we were not able to explain this counterintuitive result, further studies are needed in order to see whether the results from the present study were due purely to chance.

Organizational exposures

In the present study, none of the organizational exposures were associated with the outcome. One earlier study also found a lack of association between *night/shift work* and

Table 5 Results of univariate Cox regression analysis for the 803 subjects, stratified for work status at the end of the study

Exposure		Still at work at the end of the study RC[a] (95%CI) n = 663	Stopped working at the end of the study RC[a] (95%CI) n = 140
Manual handling ≥50 N ≥ 60 min/day		0.73 (0.5–1.1) (n = 80)	0.40 (0.1–1.7) (n = 15)
Sitting ≥75% of the working time		1.29 (0.9–1.7) (n = 141)	1.23 (0.5–3.1) (n = 22)
Job strain		1.59 (1.0–2.4) (n = 41)	1.28 (0.8–4.0) (n = 13)
Simultaneous biomechanical exposures[b]	2 or 3	0.62 (0.4–1.0) (n = 76)	0.51 (0.2–1.9) (n = 14)

Adjustments were made for sex and age. The relative chance of being symptom-free from neck/shoulder pain at the end of the study (RC), and 95% confidence intervals (95% CI). The number in parenthesis gives the number of exposed subjects (n)

[a] Adjusted for sex and age

[b] Included variables: *manual handling* ≥50 N ≥60 min/day, *working with hands above shoulder level* ≥30 min/day, and *working with vibrating tools* ≥60 min/day

persistent neck/shoulder pain [4], but to our knowledge no other prognostic studies have covered either *solitary work* or *non-fixed salary*.

Methodological considerations

Some of the strengths of this study are the considerable number of exposures that were measured, the prospective design and the high response rate. Moreover, population-based studies have the advantage of allowing many exposures to be studied simultaneously. On the other hand, one disadvantage of population-based studies is that "exposure noise" can arise when unexposed subjects (the comparison group) are exposed to other (harmful) exposures at the same time [7]. The decision to study simultaneous exposures both lowered exposure noise and created larger contrast.

The prospective design of the study made it possible to identify exposures that predicted the chance to be symptom-free at the end of the study *irrespective* of what happened during the follow-up period. However, additional analyses were performed in order to take into account and adjust for seeking medical care, sickness absence and participating in sports activity during the follow-up period. These adjustments did not influence the chance estimates (data not shown).

The present study showed that the condition of being exposed to "heavy work" is a predictor of poor outcome irrespective of the work status at the end of the study. However, the chance to become symptom-free ought to be better if the adverse exposures were eliminated, at least for some types of injuries. Further studies on the effect of the elimination of adverse work-related exposures on pain-intensity and pain-related disability are highly warranted, i.e., the effect of ergonomic interventions. In the present study, the small size of the study population and the fairly low exposure prevalence did not allow us to perform in-depth studies of the elimination of exposures or take into account the influence of the work settings at time of the follow-up.

In the present study, neck/shoulder pain was defined using a combination of self-reported pain and self-reported pain-related disability, an approach also used by others [2, 21]. Subjects were considered symptom-free at the end of the study, when they regained full functional capacity during this period and perceived no or very low levels of pain. We believe that in the present study the number of subjects with severe complaints was low, since only subjects that were still at work despite the presence of pain were included in the study . Thus the group studied consisted of subjects with "moderate" neck/shoulder pain intensity (mean 4.4). This group was also very homogeneous. This implies that the differences between the subjects in pain-intensity at baseline should not have influenced the relative chance estimates to a great extent. Possibly, the results could have been different in a population with more severe complaints, as the severity of the pain at baseline is of importance for the prognosis [21]. Additional studies are needed to examine this.

Conclusions

Only around one-third of the subjects with self-reported neck/shoulder pain were symptom-free after a 5–6 year period. In the present study, sedentary work enhanced the relative chance of being symptom-free 5–6 years later, while simultaneous exposure to at least two of *manual handling*, *working with the hands above shoulder level*, and *working with vibrating tools* was associated with a lower chance of being symptom-free at the end of the study. This could imply that subjects with neck/shoulder pain should avoid such simultaneous exposures.

Acknowledgments This study was supported by grants from the Swedish Council for Working Life and Social Research, the Center for Health Care Sciences, and Stockholm County Council. The authors would like to thank Linda Norrman for her help with the statistical analyses, as well as all collaborators in the MUSIC-Norrtälje study.

References

1. Andersen JH, Kaergaard A, Frost P et al. (2002) Physical, psychosocial, and individual risk factors for neck/shoulder pain with pressure tenderness in the muscles among workers performing monotonous, repetitive work. Spine 27:660–667
2. Bonde JP, Mikkelsen S, Andersen JH et al. (2003) Prognosis of shoulder tendonitis in repetitive work: a follow up study in a cohort of Danish industrial and service workers. Occup Environ Med 60:E8
3. Borghouts JA, Koes BW, Bouter LM (1998) The clinical course and prognostic factors of non-specific neck pain: a systematic review. Pain 77:1–13
4. Cassou B, Derriennic F, Monfort C et al (2002) Chronic neck and shoulder pain, age, and working conditions: longitudinal results from a large random sample in France. Occup Environ Med 59:537–544
5. Cole DC, Hudak PL (1996) Prognosis of nonspecific work-related musculoskeletal disorders of the neck and upper extremity. Am J Ind Med 29:657–668
6. Cote P, Cassidy JD, Carroll LJ et al (2004) The annual incidence and course of neck pain in the general population: a population-based cohort study. Pain 112:267–273
7. Devereux JJ, Buckle PW, Vlachonikolis IG (1999) Interactions between physical and psychosocial risk factors at work increase the risk of back disorders: an epidemiological approach. Occup Environ Med 56:343–353
8. Fredriksson K, Alfredsson L, Ahlberg G et al (2002) Work environment and neck and shoulder pain: the influence of exposure time. Results from a population based case-control study. Occup Environ Med 59:182–188

9. Grooten WJ, Wiktorin C, Norrman L et al (2004) Seeking care for neck/shoulder pain: a prospective study of work-related risk factors in a healthy population. J Occup Environ Med 46:138–146
10. Hannan LM, Monteilh CP, Gerr F et al (2005) Job strain and risk of musculoskeletal symptoms among a prospective cohort of occupational computer users. Scand J Work Environ Health 31:375–386
11. Hansson EK, Hansson TH (2005) The costs for persons sick-listed more than one month because of low back or neck problems. A two-year prospective study of Swedish patients. Eur Spine J 14:337–345
12. Hill J, Lewis M, Papageorgiou AC et al (2004) Predicting persistent neck pain: a 1-year follow-up of a population cohort. Spine 29:1648 –1654
13. Hoving JL, de Vet HC, Twisk JW et al (2004) Prognostic factors for neck pain in general practice. Pain 110:639–645
14. Juul-Kristensen B, Jensen C (2005) Self-reported workplace related ergonomic conditions as prognostic factors for musculoskeletal symptoms: the "BIT" follow up study on office workers. Occup Environ Med 62:188–194
15. Karasek RA (1979) Job demands, job decision latitude, and mental strain: implications for job redesign. Adminis Sci Quart 24:285–308
16. Kuijpers T, van der Windt DA, van der Heijden GJ et al (2004) Systematic review of prognostic cohort studies on shoulder disorders. Pain 109:420–431
17. Leijon O, Wiktorin C, Harenstam A et al (2002) Validity of a self-administered questionnaire for assessing physical work loads in a general population. J Occup Environ Med 44:724–735
18. Luime JJ, Koes BW, Hendriksen IJ et al (2004) Prevalence and incidence of shoulder pain in the general population; a systematic review. Scand J Rheumatol 33:73–81
19. Luime JJ, Koes BW, Miedem HS et al (2005) High incidence and recurrence of shoulder and neck pain in nursing home employees was demonstrated during a 2-year follow-up. J Clin Epidemiol 58:407–413
20. Luime JJ, Kuiper JI, Koes BW et al (2004) Work-related risk factors for the incidence and recurrence of shoulder and neck complaints among nursing-home and elderly-care workers. Scand J Work Environ Health 30:279–286
21. Macfarlane GJ, Hunt IM, Silman AJ (1998) Predictors of chronic shoulder pain: a population based prospective study. J Rheumatol 25:1612–1615
22. Makela M, Heliovaara M, Sievers K et al. (1991) Prevalence, determinants, and consequences of chronic neck pain in Finland. Am J Epidemiol 134:1356–1367
23. Miranda H, Viikari-Juntura E, Martikainen R et al. (2001) A prospective study of work related factors and physical exercise as predictors of shoulder pain. Occup Environ Med 58:528–534
24. Pernold G, Mortimer M, Wiktorin C et al. (2005) Neck/shoulder disorders in a general population. Natural course and influence of physical exercise: a 5-year follow-up. Spine 30:E363–E368
25. Rothman K, Greenland S (1998) Modern epidemiology. Lippincott-Raven, Philadelphia
26. Rugulies R, Krause N (2005) Job strain, iso-strain, and the incidence of low back and neck injuries. A 7.5-year prospective study of San Francisco transit operators. Soc Sci Med 61:27–39
27. Theorell T, Perski A, Akerstedt T et al (1988) Changes in job strain in relation to changes in physiological state. A longitudinal study. Scand J Work Environ Health 14:189–196
28. Torgen M, Alfredsson L, Koster M et al (1997) Reproducibility of a questionnaire for assessment of present and past physical activities. Int Arch Occup Environ Health 70:107–118
29. Wahlstrom J, Hagberg M, Toomingas A et al (2004) Perceived muscular tension, job strain, physical exposure, and associations with neck pain among VDU users; a prospective cohort study. Occup Environ Med 61:523–528
30. Waldenstrom M, Theorell T, Ahlberg G et al (2002) Assessment of psychological and social current working conditions in epidemiological studies: experiences from the MUSIC-Norrtalje study. Scand J Public Health 30:94–102
31. van den Heuvel SG, van der Beek AJ, Blatter BM et al (2005) Psychosocial work characteristics in relation to neck and upper limb symptoms. Pain 114:47–53
32. van der Windt DA, Koes BW, Boeke AJ et al (1996) Shoulder disorders in general practice: prognostic indicators of outcome. Br J Gen Pract 46:519–523
33. Wigaeus Tornqvist E, Kilbom A, Vingard E et al (2001) The influence on seeking care because of neck and shoulder disorders from work-related exposures. Epidemiology 12:537–545
34. Viikari-Juntura E, Martikainen R, Luukkonen R et al (2001) Longitudinal study on work related and individual risk factors affecting radiating neck pain. Occup Environ Med 58:345–352
35. Wiktorin C, Hjelm EW, Winkel J et al (1996) Reproducibility of a questionnaire for assessment of physical load during work and leisure time. Stockholm MUSIC I Study Group. MUSculoskeletal Intervention Center. J Occup Environ Med 38:190–201
36. Wiktorin C, Selin K, Ekenvall L et al (1996) Evaluation of perceived and self-reported manual forces exerted in occupational materials handling. Appl Ergon 27:231–239
37. Wiktorin C, Vingard E, Mortimer M et al. (1999) Interview versus questionnaire for assessing physical loads in the population-based MUSIC-Norrtalje Study. Am J Ind Med 35:441–455
38. Vingard E, Alfredsson L, Hagberg M et al (2000) To what extent do current and past physical and psychosocial occupational factors explain care-seeking for low back pain in a working population? Results from the Musculoskeletal Intervention Center-Norrtalje Study. Spine 25:493–500
39. Von Korff M, Ormel J, Keefe FJ et al (1992) Grading the severity of chronic pain. Pain 50:133–149