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Are Job Strain and Sleep Disturbances Prognostic Factors for Neck/Shoulder/Arm Pain? A Cohort Study of a General Population of Working Age in Sweden

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ABSTRACT (word count 253)

Background: It is proposed that workers exposed to job strain are at risk of stress-related diseases such as neck/shoulder/arm (NSAP) pain. One factor that may influence the impact of job strain on the prognosis of NSAP is sleep disturbances.

Aim: To study if job strain and sleep disturbances are prognostic factors for the development of troublesome NSAP, and to determine whether sleep disturbances is an effect measure modifier in the association between job strain and troublesome NSAP.

Methods: A population-based cohort of individuals with occasional NSAP (n = 6,979) answered surveys in 2006 and 2010. Logistic regressions were used to assess the associations between the exposures; job strain, active and passive job and sleep disturbances, and the development of troublesome NSAP. Stratified analysis was used to assess potential effect measure modification.

Results: The odds ratios for developing troublesome NSAP were in individuals exposed to active job 1.3 (95% CI 1.1–1.5); passive job 1.2 (95% CI 0.9–1.4); job strain 1.5 (95% CI 1.0–2.4); mild sleep disturbances 1.4 (95% CI 1.3–1.6); and severe sleep disturbances 2.2 (95% CI 1.6–3.0). Job strain and an active job situation were associated with persistent or troublesome NSAP in individuals with sleep disturbances, but not in individuals with no sleep disturbances.

Conclusion: Job strain and an active job situation as well as sleep disturbances are all independent prognostic factors that should be taken into account when implementing preventive measures meant to minimize the risk of troublesome neck/shoulder/arm pain among individuals of the general working-age population.

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Strengths and limitations to the study

- This study adds new information to the limited body of knowledge about factors that are of importance for the risk of developing troublesome neck/shoulder/arm pain (NSAP) among individuals of the general working-age population who report occasional pain at baseline.
- The strength of the current study lies in its prospective design based on a general population of working age and in that prognostic factors were assessed prior to the outcome.
- A further strength is the complete study sample and that several potential confounders were taken into account, even though we cannot rule out the risk of unmeasured or residual confounding.
- A limitation of the study is that we have no information about the duration of the exposures prior to baseline or about the presence of the exposures during the four-year follow-up period. This may limit the interpretation of the results.

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INTRODUCTION (word count 3326)

The prevalence of musculoskeletal pain is overall high.[1] Among workers neck/shoulder/arm pain (NSAP) is common causing personal suffering and an economic burden for society. [2-4] NSAP may be seen as a recurrent disorder that follows a course and remissions, exacerbations, and prior pain episodes seem to increase the risk of subsequent pain episodes.[5-7] Although most people will experience neck pain to some degree in their lifetimes, not everybody will experience chronic or troublesome neck pain.[8] Several determinants of the course of pain in the neck/shoulder have been suggested. Results from a cohort study in Sweden on the long-term prognosis of neck/shoulder pain showed that biomechanical exposure such as manual handling ≥50N and working with one's hands above the shoulder level negatively influence the prognosis.[9] Further, individuals who miss work, taking sick leave because of neck pain , seem to be at greater risk for subsequent episodes of lost time at work and prolonged disability.[7] Studying modifiable prognostic determinants of NSAP is important because it may help prevent severe conditions and promote recovery. A recent study of people who experience occasional neck pain reported that social factors, such as economic stress and family income, were associated with a poor prognosis (i.e., development of troublesome neck pain).[10] Work-related factors—physical, as well as psychosocial—are considered important for the course of neck/shoulder pain.[7 11] One important psychosocial model for neck/shoulder pain is the job strain model,[12-15] where job strain is described as a combination of high psychological job demands with low job decision latitude. The model further defines a combination of high job demands and high job control as an active job situation and a combination of low job control and low job demands as a passive job situation. It has been proposed that workers exposed to job strain face an increased risk of psychological strain and stress-related disease associated with unhealthy

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lifestyle factors that may also affect the prognosis of neck pain.[16-18] Recent research, however, has yielded contradictory results; some studies report a strong association between job strain and the prognosis and risk of NSAP, [19-20] while others report no associations.[8 21]According to a recent review, several studies on job strain and NSAP are cross-sectional; thus, no assessment of temporality can be made. [22]

Several factors most likely modify the trajectory from occasional to troublesome NSAP. One debated condition that may be associated with the impact of job strain is exhaustion [16] in terms of prolonged fatigue and sleep disturbances.[12] While sleep is considered an important part of physical restoration, curtailment of sleep by itself may be associated with the prognosis of musculoskeletal pain. Diverse associations between work-related psychosocial factors and sleep disturbances have been shown.[23-26]However, few studies explore whether sleep disturbances play a role as an effect measure modifier for the association between job strain and the prognosis of NSAP.[12 23]

To our knowledge, no longitudinal study has investigated the effects of exposure to job strain, and sleep disturbances in a general population of working age reporting occasional NSAP at baseline. We therefore sought to study whether these conditions are prognostic factors for the development of troublesome NSAP. We further sought to study whether sleep disturbances act as an effect measure modifier in the association between job strain and troublesome NSAP.

METHODS

Study design

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This longitudinal cohort study is based on the Stockholm Public Health Cohort, (n=25,167), a population-based cohort set up by the Stockholm County Council to gather information about the determinants and consequences of significant contributors to the burden of disease.[27]

Study population

Participants aged 18-84 years were selected using area-stratified random samples of the Stockholm population, an. urban region including 24 municipalities with approximately 1.4 million inhabitants (2002). Details about the data collection have been reported elsewhere.[27] Selected individuals (n = 56,634) received a baseline postal or Web-based questionnaire in 2006. Sixty-one percent of those (n = 34,707) answered the questionnaire. In 2010, a total of 25,167 of those who answered the baseline questionnaire also answered a follow-up questionnaire, and members of this group constitute Stockholm Public Health Cohort 06/10 (SPHC 06/10). For the purpose of the current study, those aged 61 years and under at baseline in SPHC 06/10 were included in order to limit the study to people of working age, given that the follow-up time was four years and the official retirement age in Sweden is 65. Those with missing data on the questions on high job demands, low job control, and sleep were excluded from the cohort (n = 1,212). In addition, those who reported no NSAP or more frequent than occasional at baseline were excluded (n = 3,789; Fig 1). Thus, the study population comprised people who reported occasional NSAP at baseline (n = 6,979). Occasional pain was indicated if participants responded to the question "During the previous six months, have you experienced pain in neck, shoulder and/or arms?" with either "Yes, a couple of days in the last six months" or "Yes, a couple of days each month."

Insert Fig 1 about here

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Figure 1 Flowchart of inclusion process

Questionnaires

Baseline data included questions regarding demographic characteristics, physical and psychological health, physical and psychosocial work environment, lifestyle factors, socioeconomics, social relations, and sick leave. These questions were included in the 2006 survey, as reported elsewhere.[27]

The potential prognostic factors of interest in this study were self-reported combinations of job demands and job control (job strain, active and passive job) and sleep disturbances — all reported at baseline.

The Job strain model

Job demands and job control were categorized according to the job strain model and analysed as follows: (i) low strain (low job demands and high job control), (ii) active job (high job demands and high job control), (iii) passive job (low job demands and low job control) and (iiii) job strain (high job demands and low job control) (Fig 2).

Four questions in the baseline questionnaire were used for this purpose; two questions about job demands and two about job control. The original instrument Job Content Questionnaire (JQC) has five items on job demand and nine on job control.[28-29]The use of a partial scale compared to a complete, multi-item job-demands-and-control instrument has been reported to be feasible, exhibiting high correlations to a complete instrument (Pearson's correlation coefficient, r = 0.76–0.88); in addition, it has also been determined that such a partial instrument assesses the same underlying concepts as the complete instrument.[30] To test the internal consistency of the four questions used for job strain in the current study, Cronbach's

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alpha was calculated for job demands (α = 0.53) and job control (α = 0.77).

The two questions used to measure job demands were:

(a) "Do you have enough time to complete your assignments at work?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never)

(b) "Are there contradictory demands involved in your job?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never).

The two questions used to measure job control were:

(c) "Are you free to decide what needs to be done at work?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never).

(d) "Are you free to decide how your work is to be carried out?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never).

Persons with an active job situation had a combination of high job demands (question a =no, b= yes) and high job control (question c=yes, d=yes). Those with a passive job situation a combination of low job demands (question a=yes, b=no) and low job control (question c=no, d=no) and persons with job strain a combination of high job demands(question a=no, b=yes) and low control (question c=no, d=no)

Insert fig 2 about here

Figure 2 The job strain model [14]

Sleep disturbances

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Sleep disturbances were assessed with the question "Do you have difficulty sleeping?" The response options were no; yes, somewhat (classified as mild sleep disturbances); and yes, severe (classified as severe sleep disturbances). The question has been included in the Stockholm Public Health surveys since 2002 in order to longitudinally determine the prevalence of such disturbances among the population.[31]

Outcome

The outcome of troublesome neck/shoulder/arm pain (NSAP) was based on two questions in the follow-up survey, conducted in 2010. Participants who answered "*yes*" to both of the following questions were defined as experiencing troublesome NSAP: "During the last six months, have you felt pain in your neck or upper back and/or shoulder or arms? If so, have these restricted your work capacity or hindered you in daily activities to some degree or to a high degree?"

Potential confounders

Potential confounders were chosen from the baseline survey and guided by knowledge from prior research, as well as by clinical considerations.[7 32] The potential confounders were age (continuous and five categories), smoking habits (daily/not daily), alcohol consumption (at least one glass of alcohol during a period of 12 months (yes/no), back pain the previous six months (no pain, two days in total, on average two days per month, two days per week, every day), socioeconomic class (unskilled and semiskilled worker, skilled worker, assistant non manual employee, employed/self-employed/professional), support at work from superior (yes/no), support at work from colleagues (yes/no), main physical workload in the past 12 months (sedentary, light, moderate, heavy), time spent on household work per day (almost no

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time, approx. 30 minutes, 1–2 hours, 3–5 hours, > 5 hours), economic stress based on the question "Did it happen that during the past 12 months you ran out of salary/money and had to borrow from relatives or friends in order to pay for food or rent?" (yes/no), country of birth (Sweden, elsewhere), and leisure physical activity level (sedentary, < 2 hours); (Table 1).

Statistical analyses

Numbers and proportions (%) for the variables were used to describe the baseline characteristics. Logistic regression models were used to assess associations between the prognostic factors and the outcome. Results are presented as odds ratios (OR), along with 95% confidence intervals (95% CI).

Crude associations between (i) active job (high job demands/ control) (ii) passive job (low job control/ demands) and (iii) job strain, as discrete factors on one hand, and troublesome NSAP, on the other, were calculated. Low strain (high job control/ low job demands) served as the reference category. We also calculated crude associations between sleep disturbances (mild, severe, and none) and troublesome NSAP.

Two regression models were built for the analyses: one with the four levels of job strain - (low strain, active job, passive job, and job strain) - and one with the three levels of sleep disturbances (none, mild, severe). For each of the two regression models, potential confounding factors were added to the crude regression model, one at a time. If a factor changed the crude OR by 10% or more, it was considered a confounder and was entered into the final model, in accordance with Rothman et al.[33] Finally, we stratified the analyses on the categories of job strain and troublesome NSAP by sleep disturbances/no sleep

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disturbances in a crude and adjusted model in order to study whether the effect of job strain was modified by sleep disturbances.

The final adjusted model for the exposures active job, passive job and job strain included the confounders' socioeconomic class, work load and support at work from one's superior. In the final adjusted model for sleep disturbances, we included economic stress. .

Statistical analyses were run using STATA® statistical software system version 11. This study was approved by the Regional Ethical Review Board in Stockholm, Sweden (Diary nr. 2013/497-32).

RESULTS

The characteristics of the study population who experience occasional NSAP (n = 6,979) stratified by the categories of the job strain model at baseline are presented in Table 1. Sixty-one percent (n = 4,260) of the cohort was women, and 57% (n = 4,006) fell within the age span 18–44 years. Of the cohort, 1,003 people (14%) reported an active job situation at baseline in 2006, 518 (7%) reported a passive job situation and 100 (2%) reported job strain. In total, 2,137 (31%) reported severe sleep disturbances at baseline. Twenty-four percent (n = 1,659) of the cohort reported troublesome NSAP at follow-up (2010).

We found that job strain and an active job situation at baseline were independently associated with reporting troublesome NSAP at follow-up (Table 2). The adjusted analyses showed an OR of 1.3 (95% CI 1.1–1.5) for active job, 1.2 (95% CI 0.9–1.4) for passive job, and 1.5 (95% CI 1.0–2.4) for job strain, compared to the reference category low strain.

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Sleep disturbances at baseline were associated with troublesome NSAP at follow-up (Table 2). The adjusted analysis yielded an OR of 1.4 (95% CI 1.3–1.6) for mild sleep disturbances and an OR of 2.2 (95% CI 1.6–3.0) for severe sleep disturbances, compared to the reference category no sleep disturbances.

Insert Table 2 here

Table 3 shows the results of the stratified analysis. In the stratum *no* sleep disturbances, the adjusted ORs for the association between active and passive job at baseline and troublesome NSAP at follow-up were 1.1 (95% CI 0.9-1.4) and 1.2 (95%CI 0.9–1.6), respectively and for job strain: OR 1.2 (95% CI 0.6-2.1). For the stratum sleep disturbances, the adjusted ORs between active and passive job at baseline and troublesome NSAP at follow-up were 1.3 (95% CI 1.0–1.7) and 1.0 (95% CI 0.7–1.5), respectively. The OR for job strain was 1.8 (95% CI 1.0–3.5).

Insert Table 3 here

DISCUSSION

The results of the current study indicate that an active job situation (high job demands/control) and job strain, as well as sleep disturbances, are all important risk factors for developing troublesome neck/shoulder/ arm pain (NSAP) for individuals of the general working-age population who experience occasional NSAP at baseline. Further, sleep disturbances seem to modify the prognostic effect of an active job situation and job strain. As

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sleep disturbances and NSAP are common complaints in society, the findings of the current study are important from a public-health perspective.

The study population included individuals who reported occasional NSAP at baseline, of whom, some subsequently developed troublesome pain. Such a prognostic approach in longitudinal studies of the general population is, to date, scarce.[22]Job strain is a critical psychosocial work-related factor in the development of harmful work stress and is associated with the risk of several disorders.[17 34-35] However, not all studies recognize job strain as a prognostic factor for NSAP.[9 22 26] The discrepancy may owe to sources of bias, different study designs, or varied study populations, but results may also depend on each case's definition of neck/shoulder pain.[22]

Sleep is considered vital to the recovery of body and mind and has been linked to a state of altered metabolism—changes that, in turn may be linked to conditions such as diabetes and cardiovascular disease.[36-37] In addition, the metabolic changes that result from sleep disturbance are similar to those seen in relation to stress.[36-37] The present study suggests that sleep disturbances act as an effect measure modifier between the prognosis of troublesome NSAP and the impact of job strain. However, Canivet et al. investigated sleep disturbances as a possible mediating factor in the pathway between job strain and chronic musculoskeletal pain but found that no such association was present.[12] A recent literature review [25] concludes that strong evidence associates especially high demands at work (active job) with severe sleep disturbances. The modifying effect of sleep disturbances in the present study may have different explanations, but since we cannot be sure of the temporality between the onsets of job strain and sleep disturbances, we can only speculate on the associations. It may be that sleep disturbance is a confounder as well as an effect measure modifier.

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Furthermore it may be that sleep disturbance is a mediator in the causal pathway between job strain and troublesome NSAP. If a biological interaction is present, the risk of developing troublesome NSAP for a person who experiences both job strain and sleeping disturbances may be higher than the sum of the effects of the two exposures.

Strengths and limitations of the study

The strength of the current study lies in its prospective design based on a general population of working age and in that prognostic factors were assessed prior to the outcome. A further strength is the complete study sample; moreover, several potential confounders were taken into account, even though we cannot rule out the risk of unmeasured or residual confounding.

We used job strain to assess work-related stress, which is a well-recognized model.[14] [15] A frequently used questionnaire developed to measure the construct job strain is the Job Content Questionnaire (JCQ), [28] which comprises five items addressing job demands and nine addressing control. In Stockholm Public Health Cohort 06/10, on which the current study is based, four items from the JCQ were used. Using four items to measure the constructs was judged feasible based on a study that reported a consistent high agreement between partial scales measuring job strain and a complete survey.[30] A potential limitation of our study is that the lower sensitivity of a shorter scale may result in an increased risk of non-differential misclassification of exposure (i.e., in this case, the prognostic factors, resulting in a dilution of the true effect). However, the sensitivity of the shorter scales was reported to be high ($r > 0.94$). [30] In addition, low sensitivity of the exposure measure is mainly a problem when the exposure is common, and this is not the case with job strain.

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Exposure to sleep disturbances was relatively common (31%) in our study. Sleep disturbances were investigated with a single question in the current study; the single question may lead to a misclassification of this exposure. However, we have no reason to believe that that such a misclassification should be differential and no reason to believe that, if it is, this would lead to a dilution of a true effect.

We used logistic regression for the analyses of the associations in this study. Since the outcome (i.e., troublesome NSAP) is relatively common, the calculated OR is probably higher than a corresponding relative risk (RR), and the results should not be interpreted as such. We have no information about the duration of the exposures prior to baseline or about the presence of the exposures during the four-year follow-up period. This may limit the interpretation of the results.

Selection bias is a potential threat to validity and may be present if the loss to follow-up differs among participants exposed and unexposed *and* if the loss to follow-up is also related to the outcome. [33]Additional analyses showed that the proportion of those exposed to job strain and sleeping disturbances differed only marginally between those who completed the follow-up and those who did not. Accordingly, selection bias may not be a problem in this study.

Job strain may be one of several important psychosocial factors that influence various disorders and distress — among others, troublesome NSAP. In addition it is recently reported that there seem to be an association between stress-related factors—such as high job demands and job strain — and an overall unhealthy lifestyle.[17] In summary, our results indicate that job strain and sleep disturbances may have an impact on the risk that occasional NSAP will

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develop into troublesome. It is important for employers and caregivers to take both reported job strain and sleep disturbances into account when implementing measures meant to minimize the risk of troublesome NSAP in workers. Still, additional large prospective studies are needed to confirm the results of our study and also to identify other modifiable prognostic factors for this public-health problem.

CONCLUSION

Job strain, an active job situation and sleep disturbances are all independent prognostic factors that should be taken into account when implementing preventive measures meant to minimize the risk of troublesome neck/shoulder/arm pain among individuals of the general working-age population. Further, we suggest that sleep disturbances is an effect measure modifier in the association between job strain and troublesome neck/shoulder/arm pain.

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Competing Interest: None declared.

Contributors' statement

All authors contributed to the design of the study and to the interpretation of the results. ERB and ES conducted the statistical analyses. ERB wrote the first version of the manuscript. All the authors critically revised different versions of the manuscript. All authors read the final version of the manuscript.

Data sharing statement

No additional data available

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Table 1. Baseline socio-demographic and psychosocial characteristics in the study population of people with occasional neck, shoulder and/or arm pain (n = 6,979).

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	Low strain (n = 5,358)		Active job (n = 1,003)		Passive job (n = 518)		Job strain (n = 100)	
	n	%	N	%	n	%	n	%
Age								
18–44	2,981	***56***	613	***61***	348	***67***	64	***64***
45–61	2,377	***44***	390	***39***	170	***33***	36	***36***
Gender								
Men	2,145	***40***	384	***38***	158	***30***	32	***32***
Women	3,213	***60***	619	***62***	360	***70***	68	***68***
Country of birth								
Sweden	4,600	***86***	899	***90***	404	***78***	83	***83***
Elsewhere	758	***14***	104	***10***	114	***22***	17	***17***
Socioeconomic class*								
Unskilled and semiskilled workers	656	***13***	64	***7***	162	***34***	33	***35***
Skilled workers	611	***12***	62	***6***	76	***16***	11	***11***
Assistant non-manual employees	778	***15***	107	***11***	108	***23***	12	***12***
Intermediate non-manual employees	1,358	***26***	321	***33***	90	***19***	24	***24***
Employed/self-employed professionals, servants and executives	1,265	***24***	331	***34***	29	***6***	10	***10***
Self-employed (other than professionals)	492	***10***	84	***9***	8	***2***	4	***4***
Sleep disturbances								
None or mild	3,861	***72***	601	***60***	326	***63***	54	***54***
Severe	1,497	***28***	402	***40***	192	***37***	46	***46***
Work load								
Sedentary	2,207	***41***	464	***46***	192	***37***	36	**36**
Light, low	1,572	***29***	272	***27***	119	***23***	18	**18**
Moderately heavy	1,156	***22***	192	***19***	149	***29***	18	**18**
Heavy	409	***8***	74	***7***	56	***11***	27	**27**

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Low support at work from superior	458	***18***	321	***32***	183	***35***	69	***69***
Low support at work from colleagues	622	***9***	150	***15***	71	***14***	20	***20***
Economic stress (yes)	367	*7*	77	***8***	73	***14***	16	***16***
Household work								
>10 hr/week	2,135	***40***	456	***45***	183	***36***	39	***39***
Co-morbidity LBP								
Yes, a few days per month or more often	3,318	***62***	648	***65***	345	***67***	67	***67***
Daily smoker (yes)	702	***13***	121	***12***	79	***15***	13	***13***
Alcohol (yes, sometime during last 12 months)	4,945	***93***	949	***95***	458	***89***	87	***87***
Leisure physical activity level								
Sedentary < 2hr/week	477	***9***	102	***10***	83	***16***	18	***18***
Active ≥2 hr/week	4,877	***91***	895	***89***	432	***84***	81	***81***

*Socioeconomic class: Based on occupation and education Economic stress ("Did it happen that during the past 12 months you ran out of salary/money and had to borrow from relatives and friends in order to pay for food or rent?)

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Table 2. The associations between an active job (high job demands/control) and passive job (low job control/demands), job strain and sleep disturbances on the risk of developing troublesome neck/shoulder/arm pain presented as crude and adjusted odds ratios (OR) and 95% confidence intervals (95% CI).

Exposure	**No.exp. Cases (total)**	**Crude OR (95% CI)**	**P**	**Adjusted OR (95% CI)**	**p**
Low strain (reference)	1,219 (4,023)	1	-	1	-
Active job	257 (725)	1.2 (1.0–1.4)	0.05	1.3* (1.1–1.5)	0.006
Passive job	145 (356)	1.3 (1.1–1.6)	0.004	1.2* (0.9–1.4)	0.2
Job strain	38 (62)	2.0 (1.3–3.0)	0.001	1.5* (1.0–2.4)	0.06
No sleep disturbance (reference)	1,035 (3,697)	1		1	
Mild sleep disturbance	547 (1,358)	1.4 (1.3–1.6)	<0.00	1.4 □ (1.3–1.6)	<0.00
Severe sleep disturbance	77 (111)	2.5 (1.8–3.3)	<0.00	2.2 □ (1.6–3.0)	<0.00

*Adjusted for socio-economic class, work load and support from superior, □ adjusted for economic stress

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Table 3. The associations between an active job (high job demands/control), passive job (low job control/demands) and job strain and troublesome neck, shoulder and/or arm pain, stratified for *no* sleep disturbances/ sleep disturbances, presented as crude and adjusted odds ratios (OR) and 95% confidence intervals (95% CI).

	No sleep disturbances				Sleep disturbances			
Exposure	**No. exp. Cases (total)**	**Crude OR (95% CI)**	**Adjusted* OR (95% CI)**	**P**	**No. exp. Cases**	**Crude OR (95% CI)**	**Adjusted* OR (95% CI)**	**p**
Low strain (reference)	808 (3,775)	1	1		411 (1,467)	1	1	
Active job	129 (587)	1.0 (0.8–1.3)	1.1 (0.9–1.4)	0.3	128 (395)	1.2 (1.0-1.6)	1.3 (1.0–1.7)	0.02
Passive job	83 (316)	1.3 (1.0–1.7)	1.2 (0.9–1.6)	0.2	62 (185)	1.3 (0.9–1.8)	1.0 (0.7–1.5)	0.9
Job strain	15 (54)	1.4 (0.8–2.6)	1.2 (0.6–2.1)	0.7	23 (46)	2.6 (1.4–4.6)	1.8 (1.0–3.5)	0.07

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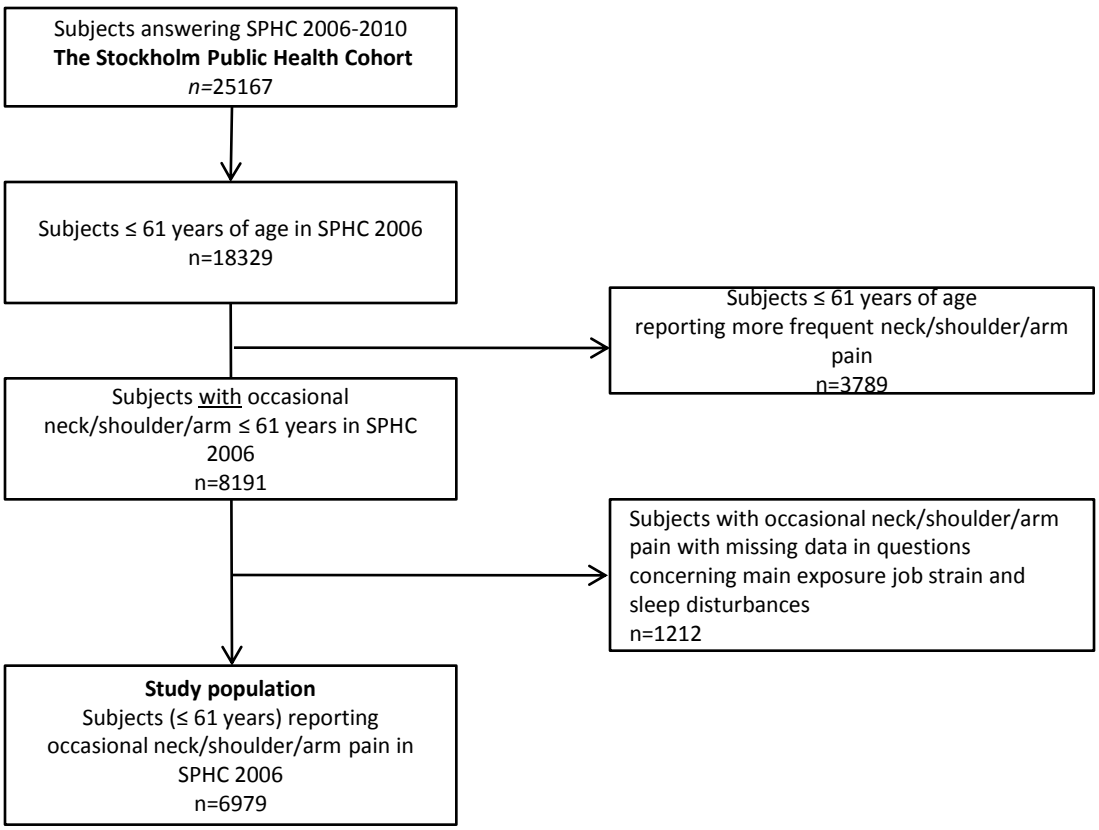
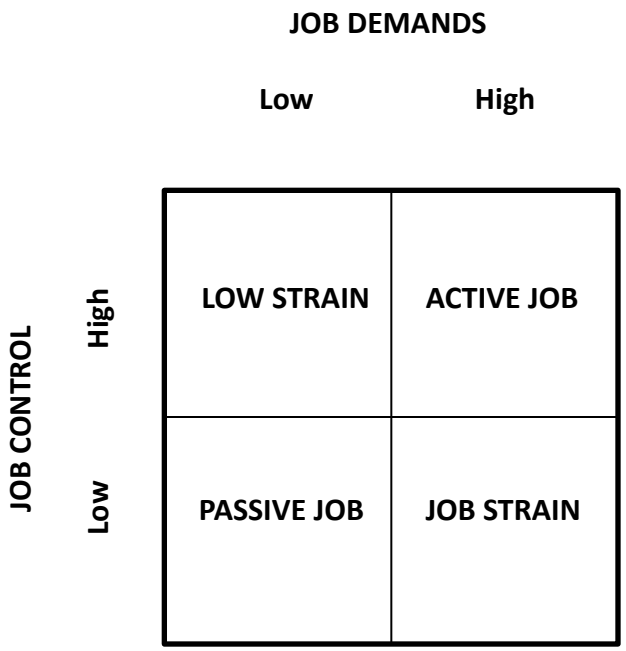

Subjects answering SPHC 2006-2010
The Stockholm Public Health Cohort
n=25167
Subjects ≤ 61 years of age in SPHC 2006
n=18329
Subjects ≤ 61 years of age reporting more frequent neck/shoulder/arm pain
n=3789
Subjects with occasional neck/shoulder/arm ≤ 61 years in SPHC 2006
n=8191
Subjects with occasional neck/shoulder/arm pain with missing data in questions concerning main exposure job strain and sleep disturbances
n=1212
Study population
Subjects (≤ 61 years) reporting occasional neck/shoulder/arm pain in SPHC 2006
n=6979


JOB DEMANDS
Low
High
JOB CONTROL
High
Low
LOW STRAIN
ACTIVE JOB
PASSIVE JOB
JOB STRAIN

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1 a)Cohort study – in title and in abstract b) This is done in the abstract with headings	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2 This is summarised in the introduction part of the manuscript. Page 2-3.	Explain the scientific background and rationale for the investigation being reported
Objectives	3 The objectives are stated at page 3, line 20-25	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4 The study design is presented at the first line in the method section, Page 3, line 3-6	Present key elements of study design early in the paper
Setting	5 This is presented in the methods section Page 4, line 8-15	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6 a) This is presented in the method section; Page 4 , line 15-23 and page 5, line1-2 b) Exposed are n= 6979 and unexposed n=1212. This is presented in a flow chart. Figure 1.	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	Outcomes, exposures, potential predictors, potential confounders are presented in the method section page 5, line 5 to page 8, line 37	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/	8	For each variable of interest, give sources of data and

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measurement	This is presented for all outcomes, potential predictors, confounders in the method section page 5, line 5 to page 8, line3*	details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9 Selection bias; page 13, line 12-17, page 14, 12-16 Confounding bias, page 9, line 18-21, page 13,line 8-10	Describe any efforts to address potential sources of bias
Study size	10 This is presented in flow-chart, Fig 1	Explain how the study size was arrived at
Quantitative variables	11 Page 7, line 1-14,Page 8, line 5 – Page 9, line 3	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12 a)Page 9, line 5 – Page 10, line 5 b) Page 9, line 21-24 c) Figure 1 and page 14, line 12-16 d) Figure 1 e) No sensitivity analysis was performed e)	(*a*) Describe all statistical methods, including those used to control for confounding (*b*) Describe any methods used to examine subgroups and interactions (*c*) Explain how missing data were addressed (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy (*e*) Describe any sensitivity analyses
Results		
Participants	13* See flow-chart –Figure 1	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14* a) b)Se table 1-3 and flow-chart Fig 1 c) Page 5, line 6-22	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15* Page 8, line 5-10, Page 10, line 12-18	*Cohort study*—Report numbers of outcome events or summary measures over time *Case-control study*—Report numbers in each exposure category, or summary measures of exposure

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		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16 Table 2 and 3 Page 10, line 20 – page 11, line 5 b) N/A c)N/A	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17 Table 3 Page 11, line 8-14	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18 Page 11, line 19-23	Summarise key results with reference to study objectives
Limitations	19 Page 13, line7-Page 14, line 17	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20 Page 14, line 19 – Page 14 line 3 Page 15, line 6-11	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21 Page 11, line 19-23 Page 12, line 1-2 Page 14, line 24	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22 Page 15, line 13-15	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

Continued on next page

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*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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BMJ Open

Are job Strain and Sleep Disturbances Prognostic Factors for Neck/Shoulder/Arm pain? A Cohort Study of a General Population of Working Age in Sweden

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Are job strain and sleep disturbances prognostic factors for neck/shoulder/arm pain? A cohort study of a general population of working age in Sweden

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ABSTRACT (word count 221)

Objective The study whether job strain and sleep disturbances among persons with *occasional* NSAP are prognostic factors for having experienced at least one episode of *troublesome* NSAP; and to determine whether sleep disturbances modify the association between job strain and troublesome NSAP.

Design Prospective cohort study

Setting Stockholm, Sweden

Participants A population-based cohort of individuals with occasional NSAP (n = 6,979) who answered surveys in 2006 and 2010.

Outcome measures Report of at least one episode of troublesome NSAP in 2010

Results: The odds ratios for troublesome NSAP at follow-up were in individuals exposed to passive jobs 1.2 (95% CI 0.9–1.4); to active jobs 1.3 (95% CI 1.1–1.5); to high strain 1.5 (95% CI 1.0–2.4); to mild sleep disturbances 1.4 (95% CI 1.3–1.6); and to severe sleep disturbances 2.2 (95% CI 1.6–3.0). High strain and active jobs were associated with having experienced at least one episode of troublesome NSAP the previous six months in persons with sleep disturbances, but not in individuals without sleep disturbances.

Conclusion: Our results indicate that high strain, active jobs and sleep disturbances are prognostic factors that should be taken into account when implementing preventive measures to minimize the risk of troublesome NSAP among people of working age. We suggest that sleep disturbances may modify the association between job strain and troublesome neck/shoulder/arm pain.

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Strengths and limitations

- This study adds new information to the limited knowledge about factors of importance for the risk of episodes of *troublesome* neck/shoulder/arm pain (NSAP) among working-age individuals who report *occasional* neck pain.
- Strength lies in its prospective design based on a general population of working age and the fact that prognostic factors were assessed prior to the outcome.
- A further strength is the complete study sample and that several potential confounders were taken into account, even though unmeasured or residual confounding cannot be ruled out.
- A limitation of the study is that we lack information about the duration of the exposures prior to baseline or about their occurrence during the four-year follow-up period. This may limit interpretation of the results.

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INTRODUCTION

The prevalence of musculoskeletal pain is overall high.[1] Among workers neck/shoulder/arm pain (NSAP) is common, causing personal suffering and an economic burden for society.[2-4] NSAP is a recurrent disorder that follows a course. Remissions, exacerbations, and prior pain episodes seem to increase the risk of subsequent pain episodes.[5-7] Although most people will experience neck pain to some degree, not everybody will experience chronic or troublesome neck pain.[8] Studying modifiable prognostic determinants of NSAP is important because it may help prevent severe conditions and promote recovery. Several determinants of the course of pain in the neck/shoulder have been suggested. Results from a cohort study in Sweden on the long-term prognosis of neck/shoulder pain showed that biomechanical exposure such as manual handling ≥50N and working with one's hands above shoulder level negatively influences the prognosis.[9] Further, individuals who take sick leave because of neck pain, seem to be prone to subsequent episodes of lost time at work and prolonged disability.[7] A recent study of persons with occasional neck pain reported that social factors such as economic stress and family income are associated with an increased risk of development of troublesome neck pain.[10] In addition, work-related factors—physical, psychological and psychosocial—are considered important for the course of neck/shoulder pain.[7 11] One widely-used work-related model for various disorders is the job strain model, also known as the "demand-control model".[12-15] Here high strain is described as a combination of high psychological job demands with low job decision latitude. This extensively studied model[14 16] further defines a combination of high job demands and high job control as an active job situation, and a combination of low job control and low job demands as a passive job situation. It has been proposed that workers exposed to job strain face an increased risk of psychological strain and stress-related diseases.[16-18] Recent

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research, however, has yielded contradictory results; some studies report a strong association between high strain and the prognosis of NSAP,[19-20] while others report no associations.[8 21] According to a recent review, several studies on job strain and NSAP are cross-sectional; thus, no assessment of temporality can be made.[22]

Several factors most likely modify the association between job strain and the trajectory from *occasional* NSAP to *troublesome.* One debated condition which may be associated with the impact of job strain is exhaustion [17] in terms of prolonged fatigue and sleep disturbances.[12] While sleep is considered an important part of physical restoration, curtailment of sleep by itself may be associated with the prognosis of musculoskeletal pain. Diverse associations between work-related psychological as well as psychosocial factors and sleep disturbances have been shown.[23-26] However, few studies explore whether sleep disturbances play a role as an effect-measure modifier for the association between job strain and the risk of developing NSAP.[12 23]

To our knowledge, no longitudinal study has investigated the effects of the exposures job strain and sleep disturbances in a general population of working age reporting occasional NSAP at baseline. We therefore sought to study whether these conditions are prognostic factors for having experienced at least one episode of troublesome NSAP during the previous six months. We further sought to explore whether an association between job strain and troublesome NSAP is modified by sleep disturbances.

METHODS

Study design

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This longitudinal cohort study is based on the Stockholm Public Health Cohort, (n=25,167), a population-based cohort set up by the Stockholm County Council to gather information about the determinants and consequences of significant contributors to the burden of disease.[27] The study was approved by the Regional Ethical Review Board in Stockholm, Sweden (Diary nr. 2013/497-32).

Study population

Participants aged 18-84 years were selected using area-stratified random samples of the Stockholm population, an. urban region including 24 municipalities with approximately 1.4 million inhabitants (2002). Details about the data collection have been reported elsewhere.[27] Randomly selected individuals (n = 56,634) (18-84 yrs old) after stratification for gender and residential area received a baseline postal or web-based questionnaire in 2006. Sixty-one percent of these (n = 34,707) answered the questionnaire. A total of 25,167 of those who answered the baseline questionnaire answered a follow-up questionnaire in 2010, and members of this group constitute Stockholm Public Health Cohort 06/10 (SPHC 06/10). For the present purpose, only those aged 61 years and below at baseline in SPHC 06/10 were included in order to limit the study to persons of working age, since the follow-up time was four years and the official retirement age in Sweden is 65. Those with missing data on the questions on high job demands, low job control, and sleep were excluded from the cohort (n = 1,212). In addition, those who reported no NSAP or more frequent than occasional at baseline were excluded (n = 3,789; Fig 1). Thus, the study population comprises persons who reported occasional NSAP at baseline (n = 6,979). Occasional pain was indicated if participants responded to the question “During the previous six months, have you experienced pain in neck, shoulder and/or arms?” with either “Yes, a couple of days in the last six months” or “Yes, a couple of days each month.”

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Insert Fig 1 about here

Figure 1 Flowchart of inclusion process

Questionnaires

Baseline data was elicited with questions regarding demographic characteristics, physical and psychological health, physical and psychosocial work environment, lifestyle factors, socioeconomics, social relations, and sick leave. These questions were included in the 2006 survey, as reported elsewhere.[27]

The potential prognostic factors studied were self-reported job strain; combinations of job demands and job control (high strain, active and passive jobs) and sleep disturbances – reported at baseline.

The Job strain model

Job demands and job control were categorized according to the job strain model and analysed as follows: (i) low strain (low job demands and high job control), (ii) active jobs (high job demands and high job control), (iii) passive jobs (low job demands and low job control) and (iiii) high strain (high job demands and low job control) (Fig 2). Four questions in the baseline questionnaire were used for this purpose; two about job demands and two about job control. The original Job Content Questionnaire (JQC) has five items on job demand and nine on job control.[28-29] The use of a partial scale compared to a complete, multi-item job-demands-and-control instrument is reportedly feasible, exhibiting high correlations to a complete instrument (Pearson's correlation coefficient, r = 0.76–0.88); in addition, the present partial instrument assesses the same underlying concepts as the complete instrument.[30] To

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test the internal consistency of the four questions used for job strain in the present study, Cronbach's alpha was calculated for job demands (α = 0.53) and job control (α = 0.77).

The two questions used to measure job demands were:

(a) "Do you have enough time to complete your assignments at work?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never)

(b) "Are there contradictory demands involved in your job?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never).

The two questions used to measure job control were:

(c) "Are you free to decide what needs to be done at work?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never).

(d) "Are you free to decide how your work is to be carried out?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never).

Persons with an active job situation had a combination of high job demands (question a =no, b= yes) and high job control (question c=yes, d=yes). Those with a passive job situation had a combination of low job demands (question a=yes, b=no) and low job control (question c=no, d=no) and persons with job strain a combination of high job demands (question a=no, b=yes) and low control (question c=no, d=no).

Insert fig 2 about here

Figure 2 The job strain model [14]

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Sleep disturbances

Sleep disturbances were assessed with the question "Do you have difficulty sleeping?" The response options were no; yes, somewhat (classified as mild sleep disturbances); and yes, severe (classified as severe sleep disturbances). The question has been included in the Stockholm Public Health surveys since 2002, to determine longitudinally the prevalence of such disturbances among the population.[31]

Outcome

The outcome of having experienced an episode of troublesome neck/shoulder/arm pain (NSAP) during the previous six months – was based on two questions in the 2010 follow-up survey. Participants who answered "yes" to both of the following questions were defined as experiencing troublesome NSAP: "During the last six months, have you felt pain in your neck or upper back and/or shoulder or arms? If so, have these restricted your work capacity or hindered you in daily activities to some degree or to a high degree?"

Potential confounders

Potential confounders were chosen from the baseline survey and guided by knowledge from prior research, and by clinical considerations.[7 32] The potential confounders were age (continuous and <44/>45 years), sex (men/women) smoking habits (daily/not daily), alcohol consumption (sometime during a period of 12 months /no), back pain the previous six months (yes; more than two days), socioeconomic class (unskilled and semiskilled workers, skilled workers, assistant non manual employee, intermediate non-manual employees employed/ self-employed/professional), low support at work from superior (yes), low support at work from colleagues (yes), main physical workload in the past 12 months (sedentary, light, moderately heavy, heavy), time spent on household work per day (yes > 5 hours),

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economic stress based on the question "Did it happen that during the past 12 months you ran out of salary/money and had to borrow from relatives or friends in order to pay for food or rent?" (yes), country of birth (Sweden, elsewhere), and leisure physical activity level (sedentary < 2 hours per week/active ≥ 2 hours per week), sleep disturbances (none or mild/severe) ; (Table 1).

Job strain (low strain, active and passive jobs and high strain) was tested regarding confounding in the sleep-disturbances model; sleep disturbances were considered to be potentially in the causal pathway between job strain and episodes of troublesome NSAP.

Statistical analysis

Numbers and proportions (%) for the variables were used to describe the baseline characteristics. Logistic regression models were used to assess associations between the prognostic factors and the outcome. Results are presented as odds ratios (OR), along with 95% confidence intervals (95% CI).

Crude associations between (i) active jobs (high job demands/ control) (ii) passive jobs (low job control/ demands) and (iii) high strain, as discrete factors on one hand, and as a new episode of troublesome NSAP, on the other, were calculated. Low strain (high job control/ low job demands) served as the reference category. We also calculated crude associations between sleep disturbances (mild, severe, and none) and troublesome NSAP.

Two regression models were built for the analyses: one with the four levels of job strain - (low strain, active jobs, passive jobs, and high strain) - and one with the three levels of sleep disturbances (none, mild, severe). For each of the two regression models, potential

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confounding factors were added one at a time to the crude regression model,. If a factor changed the crude OR by 10% or more, it was considered a confounder and was entered into the final model, in accordance with Rothman et al.[33] Finally, we stratified the analyses of job strain and troublesome NSAP by sleep disturbances/no sleep disturbances in a crude and adjusted model in order to study whether the effect of job strain was modified by sleep disturbances.

The final adjusted model for the exposures active jobs, passive jobs and high strain included the confounders socioeconomic class, work load and support at work from one's superior. In the final adjusted model for sleep disturbances, we included economic stress.

Statistical analyses used the STATA® statistical software system version 11.

RESULTS

The characteristics of the study population who experience occasional NSAP at baseline (n = 6,979) stratified by the categories of the job strain model are presented in Table 1. Sixty-one percent (n = 4,260) of the cohort were women, and 57% (n = 4,006) were aged 18–44 years. Of the cohort, 1,003 persons (14%) reported active jobs at baseline in 2006, 518 (7%) reported passive jobs in 2010 and 100 (2%) reported high strain. In total, 2,137 (31%) reported severe sleep disturbances at baseline. Twenty-four percent (n = 1,659) of the cohort reported troublesome NSAP at follow-up (2010).

After control for confounding, high strain and active jobs at baseline were associated with at least one episode of troublesome NSAP experienced during the six months prior to follow-up in 2010 (Table 2). The adjusted analyses showed an OR of 1.3 (95% CI 1.1–1.5) for active

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jobs, 1.2 (95% CI 0.9–1.4) for passive jobs, and 1.5 (95% CI 1.0–2.4) for high strain, compared to the reference category low strain.

Sleep disturbances at baseline were associated with at least one episode of NSAP during the previous six months reported at follow-up (Table 2). The adjusted analysis yielded an OR of 1.4 (95% CI 1.3–1.6) for mild sleep disturbances and an OR of 2.2 (95% CI 1.6–3.0) for severe sleep disturbances, compared to the reference category no sleep disturbances.

Insert Table 2 here

Table 3 shows the results of the stratified analysis. In the stratum *no* sleep disturbances, the adjusted ORs for the association between active and passive jobs at baseline and troublesome NSAP at follow-up were 1.1 (95% CI 0.9-1.4) and 1.2 (95%CI 0.9–1.6), respectively, and for high strain: OR 1.2 (95% CI 0.6-2.1). For the stratum sleep disturbances, the adjusted ORs between active and passive jobs at baseline and troublesome NSAP at follow-up were 1.3 (95% CI 1.0–1.7) and 1.0 (95% CI 0.7–1.5), respectively. The OR for high strain was 1.8 (95% CI 1.0–3.5).

Insert Table 3 here

DISCUSSION

The present results indicate that active jobs (high job demands/high job control) and high strain (high job demand/low job control), and sleep disturbances, are factors that may be important for having experienced at least one episode of troublesome neck/shoulder/arm pain

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(NSAP) during the six months prior to follow-up in persons of working age with occasional NSAP. Further, sleep disturbances seem to modify the prognostic effect of an active job situation and in addition a high strain situation. As sleep disturbances and NSAP are common complaints, our findings are important from a public-health perspective.

The study population included individuals who reported *occasional* NSAP at baseline, of whom some subsequently experienced at least one period of *troublesome* pain at follow-up. Such a prognostic approach in longitudinal studies of the general population has, to date been but little used.[22] Job strain is a critical psychosocial work-related factor in the development of harmful work stress and is associated with the risk of several disorders.[18 34-35] However, not all studies recognize job strain as a prognostic factor for NSAP.[9 22 26] The discrepancy may be explained by sources of bias, different study designs, or varied study populations; but results may also depend on differing definitions of neck/shoulder pain.[22]

Sleep is considered vital to the recovery of body and mind and has been linked to a state of altered metabolism—changes that, in turn may be linked to e.g. diabetes and cardiovascular disease.[36-37] In addition, the metabolic changes that result from sleep disturbance are similar to those related to stress.[36-37] The present study suggests that sleep disturbances act as a modifier between the prognosis of troublesome NSAP and the impact of job strain. However, Canivet et al. investigated sleep disturbances as a possible mediating factor in the pathway between job strain and chronic musculoskeletal pain but found no such association. [12] A recent literature review [25] concludes that strong evidence associates especially high demands at work (active jobs) with severe sleep disturbances. The modifying effect of sleep disturbances we found may have different explanations, but since we cannot be sure of the temporality between the onsets of high strain and sleep disturbances, we can only speculate on

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the associations. It may be that sleep disturbance is a confounder as well as an effect-measure modifier. Further, it may be that sleep disturbance is a mediator in the causal pathway between high strain and new periods of troublesome NSAP. If a causal interaction is present, the risk of developing troublesome NSAP for a person who experiences both high strain or active jobs and sleeping disturbances may be higher than the sum of the effects of the two exposures.

Strengths and limitations of the study

The strength of the study lies in its prospective design based on a general population of working age and on the fact that prognostic factors were assessed prior to the outcome. A further strength is the complete study sample; moreover, several potential confounders were taken into account, even though we cannot rule out the risk of unmeasured or residual confounding, for instance from other psychosocial factors like catastrophizing and somatization.[38]

The well-recognized job strain model was used to assess work-related stress.[14][15] A frequently-used questionnaire developed to measure the construct job strain is the Job Content Questionnaire (JCQ), [28] which comprises five items addressing job demands and nine addressing control. In Stockholm Public Health Cohort 06/10, on which the present study is based, four items from the JCQ were used to measure the constructs. This was judged feasible based on a reported of consistently high agreement between partial scales measuring job strain and a complete survey.[30]

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A potential limitation is that the lower sensitivity of a shorter scale may increase the risk of non-differential misclassification of exposure (i.e. in this case, the prognostic factors, resulting in a dilution of the true effect). However, the sensitivity of the shorter scales was reported to be high ($r > 0.94$). [30] In addition, low sensitivity of the exposure measure is mainly a problem when the exposure is common, and this is not the case with job strain.

Sleep disturbances were relatively common (31%). They were investigated with a single question, and this may lead to misclassification of this exposure and differential misclassification, thus a dilution of a true effect.

We used logistic regression for the analyses of the associations in the study. Since the outcome (i.e.troublesome NSAP) is relatively common, the calculated OR might be higher than a corresponding relative risk (RR), and the results should not be interpreted as such. We lack information about the duration of the exposures prior to baseline or about the presence of the exposures during the four-year follow-up period. This may limit the interpretation of the results.

Selection bias is a potential threat to validity and may be present if the loss to follow-up differs among participants exposed and unexposed *and* if the loss is also related to the outcome. [33] Additional analyses showed that the proportion of those exposed to job strain and sleeping disturbances differed only marginally between those who completed the follow-up and those who did not. Accordingly, selection bias may not be a problem in this study. Job strain may be one of several important factors that influence various disorders and distress — among others, troublesome NSAP. In addition it has been reported recently that there

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seems to be an association between stress-related factors such as high job demands and high strain and an overall unhealthy lifestyle.[18]

In summary, our results indicate that high strain, active jobs and sleep disturbances may be of importance for the prognosis of occasional NSAP, in that these factors are associated with episodes of troublesome NSAP. It is important for employers and caregivers to take reported high strain, active jobs and sleep disturbances into account when implementing measures to minimize the risk of troublesome NSAP in workers. Still, additional large prospective studies are needed to confirm our results and also to identify other modifiable prognostic factors for this public-health problem.

CONCLUSION

Our results indicate that high strain, active jobs and sleep disturbances are prognostic factors that should be taken into account when implementing preventive measures to minimize the risk of troublesome neck/shoulder/arm pain among people of working age. Further, we suggest that sleep disturbances may modify the association between job strain and troublesome neck/shoulder/arm pain.

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Contributors' statement

All five authors contributed to the design of the study and to the interpretation of the results. ERB and ES conducted the statistical analyses. ERB wrote the first version of the manuscript. All the authors critically revised different versions of the manuscript and all read the final version.

Data sharing statement

No additional data available

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Table 1. Baseline sociodemographic and psychosocial characteristics in the study population of persons with *occasional* neck, shoulder and/or arm pain at baseline (n = 6,979).

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	Low strain (n = 5,358)		Active jobs (n = 1,003)		Passive jobs (n = 518)		High strain (n = 100)	
	N	%	N	%	n	%	n	%
Age								
18–44	2,981	***56***	613	***61***	348	***67***	64	***64***
45–61	2,377	***44***	390	***39***	170	***33***	36	***36***
Sex								
Men	2,145	***40***	384	***38***	158	***30***	32	***32***
Women	3,213	***60***	619	***62***	360	***70***	68	***68***
Country of birth								
Sweden	4,600	***86***	899	***90***	404	***78***	83	***83***
Elsewhere	758	***14***	104	***10***	114	***22***	17	***17***
Socioeconomic class*								
Unskilled and semiskilled workers	656	***13***	64	***7***	162	***34***	33	***35***
Skilled workers	611	***12***	62	***6***	76	***16***	11	***11***
Assistant non-manual employees	778	***15***	107	***11***	108	***23***	12	***12***
Intermediate non-manual employees	1,358	***26***	321	***33***	90	***19***	24	***24***
Employed/self-employed professionals, civil servants and executives	1,265	***24***	331	***34***	29	***6***	10	***10***
Self-employed (other than professionals)	492	***10***	84	***9***	8	***2***	4	***4***
Sleep disturbances								
None or mild	3,861	***72***	601	***60***	326	***63***	54	***54***
Severe	1,497	***28***	402	***40***	192	***37***	46	***46***
Work load								
Sedentary	2,207	***41***	464	***46***	192	***37***	36	**36**
Light	1,572	***29***	272	***27***	119	***23***	18	**18**
Moderately heavy	1,156	***22***	192	***19***	149	***29***	18	**18**
Heavy	409	***8***	74	***7***	56	***11***	27	**27**

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Low support at work from superior (yes)	458	***18***	321	***32***	183	***35***	69	***69***
Low support at work from colleagues (yes)	622	***9***	150	***15***	71	***14***	20	***20***
Economic stress (yes)ǂ	367	***7***	77	***8***	73	***14***	16	***16***
Household work								
>5 hrs./week	2,135	***40***	456	***45***	183	***36***	39	***39***
Co-morbidity LBP								
Yes, 2 days or more often during previous six months	3,318	***62***	648	***65***	345	***67***	67	***67***
Smoking habits (daily)	702	***13***	121	***12***	79	***15***	13	***13***
Alcohol (yes, sometime during last 12 months)	4,945	***93***	949	***95***	458	***89***	87	***87***
Leisure physical activity level								
Sedentary < 2hr/week	477	***9***	102	***10***	83	***16***	18	***18***
Active ≥2 hrs./week	4,877	***91***	895	***89***	432	***84***	81	***81***

*Socioeconomic class: based on occupation and education ǂ Economic stress ("Did it happen that during the past 12 months you ran out of salary/money and had to borrow from relatives and friends in order to pay for food or rent?)

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Table 2. Associations between active jobs (high job demands/high control) and passive jobs (low job control/low job demands), high strain (high job demands/low job control) and sleep disturbances and the risk of experiencing at least one episode of *troublesome* neck/shoulder/arm pain. The associations are presented as crude and adjusted odds ratios (OR) and 95% confidence intervals (95% CI).

Exposure	No.exp. Cases (total)	Crude OR (95% CI)	P	Adjusted OR (95% CI)	p
Low strain (reference)	1,219 (4,023)	1	-	1	-
Active jobs	257 (725)	1.2 (1.0–1.4)	0.05	1.3* (1.1–1.5)	0.006
Passive jobs	145 (356)	1.3 (1.1–1.6)	0.004	1.2* (0.9–1.4)	0.2
High strain	38 (62)	2.0 (1.3–3.0)	0.001	1.5* (1.0–2.4)	0.06
No sleep disturbance (reference)	1,035 (3,697)	1		1	
Mild sleep disturbance	547 (1,358)	1.4 (1.3–1.6)	<0.00	1.4 ǂ (1.3–1.6)	<0.00
Severe sleep disturbance	77 (111)	2.5 (1.8–3.3)	<0.00	2.2 ǂ (1.6–3.0)	<0.00

*Adjusted for socio-economic class, work load and support from superior, ǂ adjusted for economic stress

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Table 3. Associations between active jobs (high job demands/high job control), passive jobs (low job control/low job demands), high strain (high job demands/low control) and troublesome neck, shoulder and/or arm pain, stratified for *no* sleep disturbances/ sleep disturbances, presented as crude and adjusted odds ratios (OR) and 95% confidence intervals (95% CI).

	No sleep disturbances				Sleep disturbances			
Exposure	**No. exp. Cases (total)**	**Crude OR (95% CI)**	**Adjusted* OR (95% CI)**	**P**	**No. exp. Cases**	**Crude OR (95% CI)**	**Adjusted* OR (95% CI)**	**p**
Low strain (reference)	808 (3,775)	1	1		411 (1,467)	1	1	
Active jobs	129 (587)	1.0 (0.8–1.3)	1.1 (0.9–1.4)	0.3	128 (395)	1.2 (1.0-1.6)	1.3 (1.0–1.7)	0.02
Passive jobs	83 (316)	1.3 (1.0–1.7)	1.2 (0.9–1.6)	0.2	62 (185)	1.3 (0.9–1.8)	1.0 (0.7–1.5)	0.9
High strain	15 (54)	1.4 (0.8–2.6)	1.2 (0.6–2.1)	0.7	23 (46)	2.6 (1.4–4.6)	1.8 (1.0–3.5)	0.07

*Adjusted for adjusted for economic stress

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Are job strain and sleep disturbances prognostic factors for neck/shoulder/arm pain? A cohort study of a general population of working age in Sweden

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ABSTRACT (word count 221)

Objective The study whether job strain and sleep disturbances among persons with *occasional* NSAP are prognostic factors for having experienced at least one episode of *troublesome* NSAP; and to determine whether sleep disturbances modify the association between job strain and troublesome NSAP.

Design Prospective cohort study

Setting Sweden

Participants A population-based cohort of individuals with occasional NSAP (n = 6,979) answered surveys in 2006 and 2010.

Outcome measures Report of at least one episode of troublesome NSAP in 2010

Results: The odds ratios for troublesome NSAP at follow-up were in individuals exposed to passive jobs 1.2 (95% CI 0.9–1.4); to active jobs 1.3 (95% CI 1.1–1.5); to high strain 1.5 (95% CI 1.0–2.4); to mild sleep disturbances 1.4 (95% CI 1.3–1.6); and to severe sleep disturbances 2.2 (95% CI 1.6–3.0). High strain and active jobs were associated with having experienced at least one episode of troublesome NSAP the previous six months in persons with sleep disturbances, but not in individuals without sleep disturbances.

Conclusion: Our results indicate that high strain, active jobs and sleep disturbances are prognostic factors that should be taken into account when implementing preventive measures to minimize the risk of troublesome NSAP among people of working age. We suggest that sleep disturbances may modify the association between job strain and troublesome neck/shoulder/arm pain.

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Strengths and limitations

- This study adds new information to the limited knowledge about factors of importance for the risk of episodes of *troublesome* neck/shoulder/arm pain (NSAP) among working-age individuals who report *occasional* neck pain.
- Strength lies in its prospective design based on a general population of working age and the fact that prognostic factors were assessed prior to the outcome.
- A further strength is the complete study sample and that several potential confounders were taken into account, even though unmeasured or residual confounding cannot be ruled out.
- A limitation of the study is that we lack information about the duration of the exposures prior to baseline or about their occurrence during the four-year follow-up period. This may limit interpretation of the results.

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INTRODUCTION

The prevalence of musculoskeletal pain is overall high.[1] Among workers neck/shoulder/arm pain (NSAP) is common, causing personal suffering and an economic burden for society.[2-4] NSAP is a recurrent disorder that follows a course. Remissions, exacerbations, and prior pain episodes seem to increase the risk of subsequent pain episodes.[5-7] Although most people will experience neck pain to some degree, not everybody will experience chronic or troublesome neck pain.[8] Studying modifiable prognostic determinants of NSAP is important because it may help prevent severe conditions and promote recovery. Several determinants of the course of pain in the neck/shoulder have been suggested. Results from a cohort study in Sweden on the long-term prognosis of neck/shoulder pain showed that biomechanical exposure such as manual handling ≥50N and working with one's hands above shoulder level negatively influences the prognosis.[9] Further, individuals who take sick leave because of neck pain, seem to be prone to subsequent episodes of lost time at work and prolonged disability.[7] A recent study of persons with occasional neck pain reported that social factors such as economic stress and family income are associated with an increased risk of development of troublesome neck pain.[10] In addition, work-related factors—physical, psychological and psychosocial—are considered important for the course of neck/shoulder pain.[7 11] One widely-used work-related model for various disorders is the job strain model, also known as the "demand-control model".[12-15] Here high strain is described as a combination of high psychological job demands with low job decision latitude. This extensively studied model[14 16] further defines a combination of high job demands and high job control as an active job situation, and a combination of low job control and low job demands as a passive job situation. It has been proposed that workers exposed to job strain face an increased risk of psychological strain and stress-related diseases.[16-18] Recent

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research, however, has yielded contradictory results; some studies report a strong association between high strain and the prognosis of NSAP,[19-20] while others report no associations.[8 21] According to a recent review, several studies on job strain and NSAP are cross-sectional; thus, no assessment of temporality can be made.[22]

Several factors most likely modify the association between job strain and the trajectory from *occasional* NSAP to *troublesome.* One debated condition which may be associated with the impact of job strain is exhaustion [17] in terms of prolonged fatigue and sleep disturbances.[12] While sleep is considered an important part of physical restoration, curtailment of sleep by itself may be associated with the prognosis of musculoskeletal pain. Diverse associations between work-related psychological as well as psychosocial factors and sleep disturbances have been shown.[23-26] However, few studies explore whether sleep disturbances play a role as an effect-measure modifier for the association between job strain and the risk of developing NSAP.[12 23]

To our knowledge, no longitudinal study has investigated the effects of the exposures job strain and sleep disturbances in a general population of working age reporting occasional NSAP at baseline. We therefore sought to study whether these conditions are prognostic factors for having experienced at least one episode of troublesome NSAP during the previous six months. We further sought to explore whether an association between job strain and troublesome NSAP is modified by sleep disturbances.

METHODS

Study design

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This longitudinal cohort study is based on the Stockholm Public Health Cohort, (n=25,167), a population-based cohort set up by the Stockholm County Council to gather information about the determinants and consequences of significant contributors to the burden of disease.[27] The study was approved by the Regional Ethical Review Board in Stockholm, Sweden (Diary nr. 2013/497-32).

Study population

Participants aged 18-84 years were selected using area-stratified random samples of the Stockholm population, an. urban region including 24 municipalities with approximately 1.4 million inhabitants (2002). Details about the data collection have been reported elsewhere.[27] Randomly selected individuals (n = 56,634) (18-84 yrs old) after stratification for gender and residential area received a baseline postal or web-based questionnaire in 2006. Sixty-one percent of these (n = 34,707) answered the questionnaire. A total of 25,167 of those who answered the baseline questionnaire answered a follow-up questionnaire in 2010, and members of this group constitute Stockholm Public Health Cohort 06/10 (SPHC 06/10). For the present purpose, only those aged 61 years and below at baseline in SPHC 06/10 were included in order to limit the study to persons of working age, since the follow-up time was four years and the official retirement age in Sweden is 65. Those with missing data on the questions on high job demands, low job control, and sleep were excluded from the cohort (n = 1,212). In addition, those who reported no NSAP or more frequent than occasional at baseline were excluded (n = 3,789; Fig 1). Thus, the study population comprises persons who reported occasional NSAP at baseline (n = 6,979). Occasional pain was indicated if participants responded to the question “During the previous six months, have you experienced pain in neck, shoulder and/or arms?” with either “Yes, a couple of days in the last six months” or “Yes, a couple of days each month.”

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Insert Fig 1 about here

Figure 1 Flowchart of inclusion process

Questionnaires

Baseline data was elicited with questions regarding demographic characteristics, physical and psychological health, physical and psychosocial work environment, lifestyle factors, socioeconomics, social relations, and sick leave. These questions were included in the 2006 survey, as reported elsewhere.[27]

The potential prognostic factors studied were self-reported job strain; combinations of job demands and job control (high strain, active and passive jobs) and sleep disturbances – reported at baseline.

The Job strain model

Job demands and job control were categorized according to the job strain model and analysed as follows: (i) low strain (low job demands and high job control), (ii) active jobs (high job demands and high job control), (iii) passive jobs (low job demands and low job control) and (iiii) high strain (high job demands and low job control) (Fig 2). Four questions in the baseline questionnaire were used for this purpose; two about job demands and two about job control. The original Job Content Questionnaire (JQC) has five items on job demand and nine on job control.[28-29] The use of a partial scale compared to a complete, multi-item job-demands-and-control instrument is reportedly feasible, exhibiting high correlations to a complete instrument (Pearson's correlation coefficient, r = 0.76–0.88); in addition, the present partial instrument assesses the same underlying concepts as the complete instrument.[30] To

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test the internal consistency of the four questions used for job strain in the present study, Cronbach's alpha was calculated for job demands ($\alpha = 0.53$) and job control ($\alpha = 0.77$).

The two questions used to measure job demands were:

(a) "Do you have enough time to complete your assignments at work?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never)

(b) "Are there contradictory demands involved in your job?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never).

The two questions used to measure job control were:

(c) "Are you free to decide what needs to be done at work?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never).

(d) "Are you free to decide how your work is to be carried out?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never).

Persons with an active job situation had a combination of high job demands (question a =no, b= yes) and high job control (question c=yes, d=yes). Those with a passive job situation had a combination of low job demands (question a=yes, b=no) and low job control (question c=no, d=no) and persons with job strain a combination of high job demands (question a=no, b=yes) and low control (question c=no, d=no).

Insert fig 2 about here

Figure 2 The job strain model [14]

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Sleep disturbances

Sleep disturbances were assessed with the question "Do you have difficulty sleeping?" The response options were no; yes, somewhat (classified as mild sleep disturbances); and yes, severe (classified as severe sleep disturbances). The question has been included in the Stockholm Public Health surveys since 2002, to determine longitudinally the prevalence of such disturbances among the population.[31]

Outcome

The outcome of having experienced an episode of troublesome neck/shoulder/arm pain (NSAP) during the previous six months – was based on two questions in the 2010 follow-up survey. Participants who answered "yes" to both of the following questions were defined as experiencing troublesome NSAP: "During the last six months, have you felt pain in your neck or upper back and/or shoulder or arms? If so, have these restricted your work capacity or hindered you in daily activities to some degree or to a high degree?"

Potential confounders

Potential confounders were chosen from the baseline survey and guided by knowledge from prior research, and by clinical considerations.[7 32] The potential confounders were age (continuous and <44/>45 years), sex (men/women) smoking habits (daily/not daily), alcohol consumption (sometime during a period of 12 months /no), back pain the previous six months (yes; more than two days), socioeconomic class (unskilled and semiskilled workers, skilled workers, assistant non manual employee, intermediate non-manual employees employed/ self-employed/professional), low support at work from superior (yes), low support at work from colleagues (yes), main physical workload in the past 12 months (sedentary, light, moderately heavy, heavy), time spent on household work per day (yes > 5 hours),

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economic stress based on the question "Did it happen that during the past 12 months you ran out of salary/money and had to borrow from relatives or friends in order to pay for food or rent?" (yes), country of birth (Sweden, elsewhere), and leisure physical activity level (sedentary < 2 hours per week/active ≥ 2 hours per week), sleep disturbances (none or mild/severe) ; (Table 1).

Job strain (low strain, active and passive jobs and high strain) was tested regarding confounding in the sleep-disturbances model; sleep disturbances were considered to be potentially in the causal pathway between job strain and episodes of troublesome NSAP.

Statistical analysis

Numbers and proportions (%) for the variables were used to describe the baseline characteristics. Logistic regression models were used to assess associations between the prognostic factors and the outcome. Results are presented as odds ratios (OR), along with 95% confidence intervals (95% CI).

Crude associations between (i) active jobs (high job demands/ control) (ii) passive jobs (low job control/ demands) and (iii) high strain, as discrete factors on one hand, and as a new episode of troublesome NSAP, on the other, were calculated. Low strain (high job control/ low job demands) served as the reference category. We also calculated crude associations between sleep disturbances (mild, severe, and none) and troublesome NSAP.

Two regression models were built for the analyses: one with the four levels of job strain - (low strain, active jobs, passive jobs, and high strain) - and one with the three levels of sleep disturbances (none, mild, severe). For each of the two regression models, potential

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confounding factors were added one at a time to the crude regression model,. If a factor changed the crude OR by 10% or more, it was considered a confounder and was entered into the final model, in accordance with Rothman et al.[33] Finally, we stratified the analyses of job strain and troublesome NSAP by sleep disturbances/no sleep disturbances in a crude and adjusted model in order to study whether the effect of job strain was modified by sleep disturbances.

The final adjusted model for the exposures active jobs, passive jobs and high strain included the confounders socioeconomic class, work load and support at work from one's superior. In the final adjusted model for sleep disturbances, we included economic stress.

Statistical analyses used the STATA® statistical software system version 11.

RESULTS

The characteristics of the study population who experience occasional NSAP at baseline (n = 6,979) stratified by the categories of the job strain model are presented in Table 1. Sixty-one percent (n = 4,260) of the cohort were women, and 57% (n = 4,006) were aged 18–44 years. Of the cohort, 1,003 persons (14%) reported active jobs at baseline in 2006, 518 (7%) reported passive jobs in 2010 and 100 (2%) reported high strain. In total, 2,137 (31%) reported severe sleep disturbances at baseline. Twenty-four percent (n = 1,659) of the cohort reported troublesome NSAP at follow-up (2010).

After control for confounding, high strain and active jobs at baseline were associated with at least one episode of troublesome NSAP experienced during the six months prior to follow-up in 2010 (Table 2). The adjusted analyses showed an OR of 1.3 (95% CI 1.1–1.5) for active

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jobs, 1.2 (95% CI 0.9–1.4) for passive jobs, and 1.5 (95% CI 1.0–2.4) for high strain, compared to the reference category low strain.

Sleep disturbances at baseline were associated with at least one episode of NSAP during the previous six months reported at follow-up (Table 2). The adjusted analysis yielded an OR of 1.4 (95% CI 1.3–1.6) for mild sleep disturbances and an OR of 2.2 (95% CI 1.6–3.0) for severe sleep disturbances, compared to the reference category no sleep disturbances.

Insert Table 2 here

Table 3 shows the results of the stratified analysis. In the stratum *no* sleep disturbances, the adjusted ORs for the association between active and passive jobs at baseline and troublesome NSAP at follow-up were 1.1 (95% CI 0.9-1.4) and 1.2 (95%CI 0.9–1.6), respectively, and for high strain: OR 1.2 (95% CI 0.6-2.1). For the stratum sleep disturbances, the adjusted ORs between active and passive jobs at baseline and troublesome NSAP at follow-up were 1.3 (95% CI 1.0–1.7) and 1.0 (95% CI 0.7–1.5), respectively. The OR for high strain was 1.8 (95% CI 1.0–3.5).

Insert Table 3 here

DISCUSSION

The present results indicate that active jobs (high job demands/high job control) and high strain (high job demand/low job control), and sleep disturbances, are factors that may be important for having experienced at least one episode of troublesome neck/shoulder/arm pain

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(NSAP) during the six months prior to follow-up in persons of working age with occasional NSAP. Further, sleep disturbances seem to modify the prognostic effect of an active job situation and in addition a high strain situation. As sleep disturbances and NSAP are common complaints, our findings are important from a public-health perspective.

The study population included individuals who reported *occasional* NSAP at baseline, of whom some subsequently experienced at least one period of *troublesome* pain at follow-up. Such a prognostic approach in longitudinal studies of the general population has, to date been but little used.[22] Job strain is a critical psychosocial work-related factor in the development of harmful work stress and is associated with the risk of several disorders.[18 34-35] However, not all studies recognize job strain as a prognostic factor for NSAP.[9 22 26] The discrepancy may be explained by sources of bias, different study designs, or varied study populations; but results may also depend on differing definitions of neck/shoulder pain.[22]

Sleep is considered vital to the recovery of body and mind and has been linked to a state of altered metabolism—changes that, in turn may be linked to e.g. diabetes and cardiovascular disease.[36-37] In addition, the metabolic changes that result from sleep disturbance are similar to those related to stress.[36-37] The present study suggests that sleep disturbances act as a modifier between the prognosis of troublesome NSAP and the impact of job strain. However, Canivet et al. investigated sleep disturbances as a possible mediating factor in the pathway between job strain and chronic musculoskeletal pain but found no such association. [12] A recent literature review [25] concludes that strong evidence associates especially high demands at work (active jobs) with severe sleep disturbances. The modifying effect of sleep disturbances we found may have different explanations, but since we cannot be sure of the temporality between the onsets of high strain and sleep disturbances, we can only speculate on

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the associations. It may be that sleep disturbance is a confounder as well as an effect-measure modifier. Further, it may be that sleep disturbance is a mediator in the causal pathway between high strain and new periods of troublesome NSAP. If a causal interaction is present, the risk of developing troublesome NSAP for a person who experiences both high strain or active jobs and sleeping disturbances may be higher than the sum of the effects of the two exposures.

Strengths and limitations of the study

The strength of the study lies in its prospective design based on a general population of working age and on the fact that prognostic factors were assessed prior to the outcome. A further strength is the complete study sample; moreover, several potential confounders were taken into account, even though we cannot rule out the risk of unmeasured or residual confounding, for instance from other psychosocial factors like catastrophizing and somatization.[38]

The well-recognized job strain model was used to assess work-related stress.[14][15] A frequently-used questionnaire developed to measure the construct job strain is the Job Content Questionnaire (JCQ), [28] which comprises five items addressing job demands and nine addressing control. In Stockholm Public Health Cohort 06/10, on which the present study is based, four items from the JCQ were used to measure the constructs. This was judged feasible based on a reported of consistently high agreement between partial scales measuring job strain and a complete survey.[30]

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A potential limitation is that the lower sensitivity of a shorter scale may increase the risk of non-differential misclassification of exposure (i.e. in this case, the prognostic factors, resulting in a dilution of the true effect). However, the sensitivity of the shorter scales was reported to be high ($r > 0.94$). [30] In addition, low sensitivity of the exposure measure is mainly a problem when the exposure is common, and this is not the case with job strain.

Sleep disturbances were relatively common (31%). They were investigated with a single question, and this may lead to misclassification of this exposure and differential misclassification, thus a dilution of a true effect.

We used logistic regression for the analyses of the associations in the study. Since the outcome (i.e.troublesome NSAP) is relatively common, the calculated OR might be higher than a corresponding relative risk (RR), and the results should not be interpreted as such. We lack information about the duration of the exposures prior to baseline or about the presence of the exposures during the four-year follow-up period. This may limit the interpretation of the results.

Selection bias is a potential threat to validity and may be present if the loss to follow-up differs among participants exposed and unexposed *and* if the loss is also related to the outcome. [33] Additional analyses showed that the proportion of those exposed to job strain and sleeping disturbances differed only marginally between those who completed the follow-up and those who did not. Accordingly, selection bias may not be a problem in this study.

Job strain may be one of several important factors that influence various disorders and distress — among others, troublesome NSAP. In addition it has been reported recently that there

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seems to be an association between stress-related factors such as high job demands and high strain and an overall unhealthy lifestyle.[18]

In summary, our results indicate that high strain, active jobs and sleep disturbances may be of importance for the prognosis of occasional NSAP, in that these factors are associated with episodes of troublesome NSAP. It is important for employers and caregivers to take reported high strain, active jobs and sleep disturbances into account when implementing measures to minimize the risk of troublesome NSAP in workers. Still, additional large prospective studies are needed to confirm our results and also to identify other modifiable prognostic factors for this public-health problem.

CONCLUSION

Our results indicate that high strain, active jobs and sleep disturbances are prognostic factors that should be taken into account when implementing preventive measures to minimize the risk of troublesome neck/shoulder/arm pain among people of working age. Further, we suggest that sleep disturbances may modify the association between job strain and troublesome neck/shoulder/arm pain.

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Contributors' statement

All five authors contributed to the design of the study and to the interpretation of the results. ERB and ES conducted the statistical analyses. ERB wrote the first version of the manuscript. All the authors critically revised different versions of the manuscript and all read the final version.

Data sharing statement

No additional data available

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Table 1. Baseline sociodemographic and psychosocial characteristics in the study population of persons with *occasional* neck, shoulder and/or arm pain at baseline (n = 6,979).

	Low strain (n = 5,358)		Active jobs (n = 1,003)		Passive jobs (n = 518)		High strain (n = 100)	
	N	%	N	%	n	%	n	%
Age								
18–44	2,981	***56***	613	***61***	348	***67***	64	***64***
45–61	2,377	***44***	390	***39***	170	***33***	36	***36***
Sex								
Men	2,145	***40***	384	***38***	158	***30***	32	***32***
Women	3,213	***60***	619	***62***	360	***70***	68	***68***
Country of birth								
Sweden	4,600	***86***	899	***90***	404	***78***	83	***83***
Elsewhere	758	***14***	104	***10***	114	***22***	17	***17***
Socioeconomic class*								
Unskilled and semiskilled workers	656	***13***	64	***7***	162	***34***	33	***35***
Skilled workers	611	***12***	62	***6***	76	***16***	11	***11***
Assistant non-manual employees	778	***15***	107	***11***	108	***23***	12	***12***
Intermediate non-manual employees	1,358	***26***	321	***33***	90	***19***	24	***24***
Employed/self-employed professionals, civil servants and executives	1,265	***24***	331	***34***	29	***6***	10	***10***
Self-employed (other than professionals)	492	***10***	84	***9***	8	***2***	4	***4***
Sleep disturbances								
None or mild	3,861	***72***	601	***60***	326	***63***	54	***54***
Severe	1,497	***28***	402	***40***	192	***37***	46	***46***
Work load								
Sedentary	2,207	***41***	464	***46***	192	***37***	36	**36**
Light	1,572	***29***	272	***27***	119	***23***	18	**18**

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Moderately heavy	1,156	***22***	192	***19***	149	***29***	18	**18**
Heavy	409	***8***	74	***7***	56	***11***	27	**27**
Low support at work from superior (yes)	458	***18***	321	***32***	183	***35***	69	***69***
Low support at work from colleagues (yes)	622	***9***	150	***15***	71	***14***	20	***20***
Economic stress (yes)ǂ	367	***7***	77	***8***	73	***14***	16	***16***
Household work								
>5 hrs./week	2,135	***40***	456	***45***	183	***36***	39	***39***
Co-morbidity LBP								
Yes, 2 days or more often during previous six months	3,318	***62***	648	***65***	345	***67***	67	***67***
Smoking habits (daily)	702	***13***	121	***12***	79	***15***	13	***13***
Alcohol (yes, sometime during last 12 months)	4,945	***93***	949	***95***	458	***89***	87	***87***
Leisure physical activity level								
Sedentary < 2hr/week	477	***9***	102	***10***	83	***16***	18	***18***
Active ≥2 hrs./week	4,877	***91***	895	***89***	432	***84***	81	***81***

*Socioeconomic class: based on occupation and education ǂ Economic stress ("Did it happen that during the past 12 months you ran out of salary/money and had to borrow from relatives and friends in order to pay for food or rent?)

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Table 2. Associations between active jobs (high job demands/high control) and passive jobs (low job control/low job demands), high strain (high job demands/low job control) and sleep disturbances and the risk of experiencing at least one episode of *troublesome* neck/shoulder/arm pain. The associations are presented as crude and adjusted odds ratios (OR) and 95% confidence intervals (95% CI).

Exposure	No.exp. Cases (total)	Crude OR (95% CI)	P	Adjusted OR (95% CI)	p
Low strain (reference)	1,219 (4,023)	1	-	1	-
Active jobs	257 (725)	1.2 (1.0–1.4)	0.05	1.3* (1.1–1.5)	0.006
Passive jobs	145 (356)	1.3 (1.1–1.6)	0.004	1.2* (0.9–1.4)	0.2
High strain	38 (62)	2.0 (1.3–3.0)	0.001	1.5* (1.0–2.4)	0.06
No sleep disturbance (reference)	1,035 (3,697)	1		1	
Mild sleep disturbance	547 (1,358)	1.4 (1.3–1.6)	<0.00	1.4 ǂ (1.3–1.6)	<0.00
Severe sleep disturbance	77 (111)	2.5 (1.8–3.3)	<0.00	2.2 ǂ (1.6–3.0)	<0.00

*Adjusted for socio-economic class, work load and support from superior, ǂ adjusted for economic stress

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Table 3. Associations between active jobs (high job demands/high job control), passive jobs (low job control/low job demands), high strain (high job demands/low control) and troublesome neck, shoulder and/or arm pain, stratified for *no* sleep disturbances/ sleep disturbances, presented as crude and adjusted odds ratios (OR) and 95% confidence intervals (95% CI).

	No sleep disturbances				Sleep disturbances			
Exposure	**No. exp. Cases (total)**	**Crude OR (95% CI)**	**Adjusted* OR (95% CI)**	**P**	**No. exp. Cases**	**Crude OR (95% CI)**	**Adjusted* OR (95% CI)**	**p**
Low strain (reference)	808 (3,775)	1	1		411 (1,467)	1	1	
Active jobs	129 (587)	1.0 (0.8–1.3)	1.1 (0.9–1.4)	0.3	128 (395)	1.2 (1.0-1.6)	1.3 (1.0–1.7)	0.02
Passive jobs	83 (316)	1.3 (1.0–1.7)	1.2 (0.9–1.6)	0.2	62 (185)	1.3 (0.9–1.8)	1.0 (0.7–1.5)	0.9
High strain	15 (54)	1.4 (0.8–2.6)	1.2 (0.6–2.1)	0.7	23 (46)	2.6 (1.4–4.6)	1.8 (1.0–3.5)	0.07

*Adjusted for adjusted for economic stress

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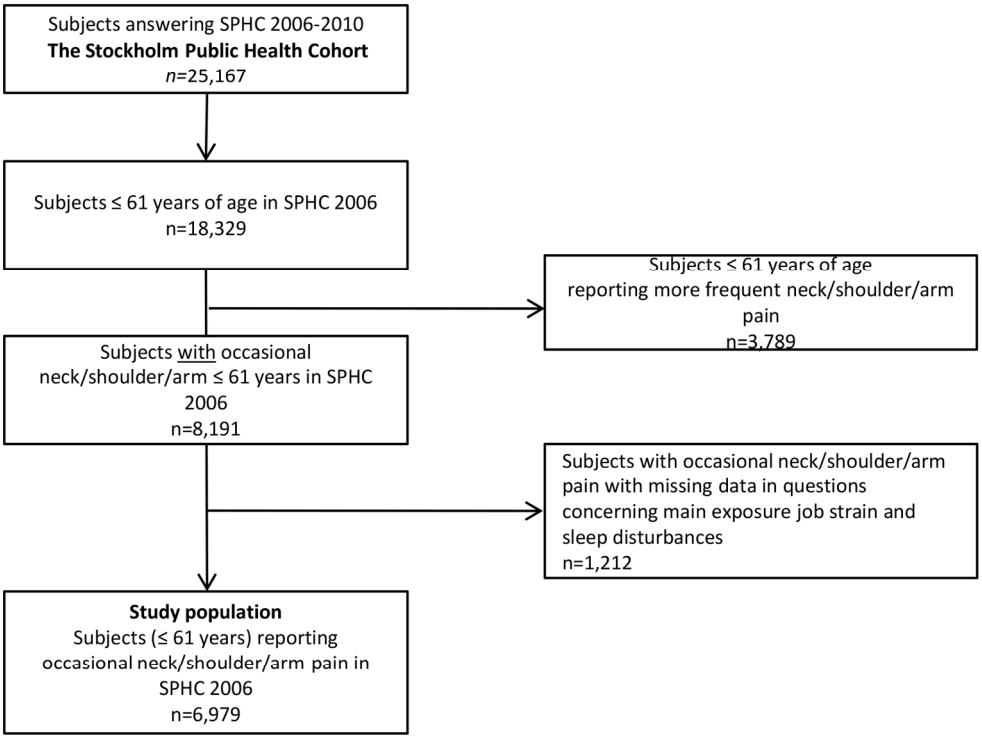

Figure 1 Flowchart of inclusion process
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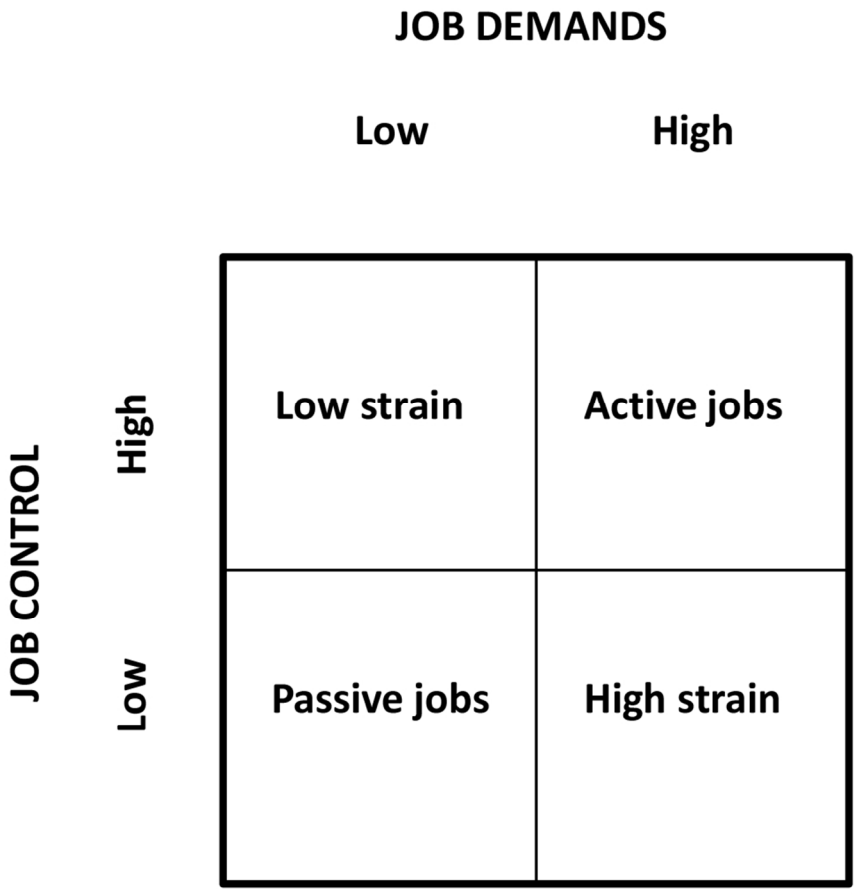

Figure 2 The job strain model [14]
95x92mm (300 x 300 DPI)

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1 a)Cohort study – in title and in abstract b) This is done in the abstract with headings	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2 This is summarised in the introduction part of the manuscript. Page 2-3.	Explain the scientific background and rationale for the investigation being reported
Objectives	3 The objectives are stated at page 3, line 20-25	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4 The study design is presented at the first line in the method section, Page 3, line 3-6	Present key elements of study design early in the paper
Setting	5 This is presented in the methods section Page 4, line 8-15	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6 a) This is presented in the method section; Page 4 , line 15-23 and page 5, line1-2 b) Exposed are n= 6979 and unexposed n=1212. This is presented in a flow chart. Figure 1.	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	Outcomes, exposures, potential predictors, potential confounders are presented in the method section page 5, line 5 to page 8, line 37	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/	8	For each variable of interest, give sources of data and

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measurement	This is presented for all outcomes, potential predictors, confounders in the method section page 5, line 5 to page 8, line3*	details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9 Selection bias; page 13, line 12-17, page 14, 12-16 Confounding bias, page 9, line 18-21, page 13,line 8-10	Describe any efforts to address potential sources of bias
Study size	10 This is presented in flow-chart, Fig 1	Explain how the study size was arrived at
Quantitative variables	11 Page 7, line 1-14,Page 8, line 5 – Page 9, line 3	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12 a)Page 9, line 5 – Page 10, line 5 b) Page 9, line 21-24 c) Figure 1 and page 14, line 12-16 d) Figure 1 e) No sensitivity analysis was performed e)	(*a*) Describe all statistical methods, including those used to control for confounding (*b*) Describe any methods used to examine subgroups and interactions (*c*) Explain how missing data were addressed (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy (*e*) Describe any sensitivity analyses
Results		
Participants	13* See flow-chart –Figure 1	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14* a) b)Se table 1-3 and flow-chart Fig 1 c) Page 5, line 6-22	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15* Page 8, line 5-10, Page 10, line 12-18	*Cohort study*—Report numbers of outcome events or summary measures over time *Case-control study*—Report numbers in each exposure category, or summary measures of exposure

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		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16 Table 2 and 3 Page 10, line 20 – page 11, line 5 b) N/A c)N/A	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17 Table 3 Page 11, line 8-14	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18 Page 11, line 19-23	Summarise key results with reference to study objectives
Limitations	19 Page 13, line7-Page 14, line 17	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20 Page 14, line 19 – Page 14 line 3 Page 15, line 6-11	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21 Page 11, line 19-23 Page 12, line 1-2 Page 14, line 24	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22 Page 15, line 13-15	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

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*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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BMJ Open

Are job Strain and Sleep Disturbances Prognostic Factors for Neck/Shoulder/Arm pain? A Cohort Study of a General Population of Working Age in Sweden

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Secondary Subject Heading:	Occupational and environmental medicine
Keywords:	Musculoskeletal disorders < ORTHOPAEDIC & TRAUMA SURGERY, SLEEP MEDICINE, PREVENTIVE MEDICINE, PRIMARY CARE, REHABILITATION MEDICINE, EPIDEMIOLOGY

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Manuscripts

Are job strain and sleep disturbances prognostic factors for neck/shoulder/arm pain? A cohort study of a general population of working age in Sweden

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Word count: 3350

Key words: musculoskeletal diseases, prevention, sleep, stress, work

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ABSTRACT (word count 234)

Objective To study whether job strain, i.e. psychological job demands and decision latitude and sleep disturbances among persons with *occasional* neck/shoulder/arm pain (NSAP) are prognostic factors for having experienced at least one episode of *troublesome* NSAP; and to determine whether sleep disturbances modify the association between job strain and troublesome NSAP.

Design Prospective cohort study

Setting Stockholm, Sweden

Participants A population-based cohort of individuals with occasional NSAP (n = 6,979) who answered surveys in 2006 and 2010.

Outcome measures Report of at least one episode of troublesome NSAP in 2010

Results: The odds ratios for troublesome NSAP at follow-up were in individuals exposed to passive jobs 1.2 (95% CI 0.9–1.4); to active jobs 1.3 (95% CI 1.1–1.5); to high strain 1.5 (95% CI 1.0–2.4); to mild sleep disturbances 1.4 (95% CI 1.3–1.6); and to severe sleep disturbances 2.2 (95% CI 1.6–3.0). High strain and active jobs were associated with having experienced at least one episode of troublesome NSAP the previous six months in persons with sleep disturbances, but not in individuals without sleep disturbances.

Conclusion: Our results indicate that high strain, active jobs and sleep disturbances are prognostic factors that should be taken into account when implementing preventive measures to minimize the risk of troublesome NSAP among people of working age. We suggest that sleep disturbances may modify the association between high strain and troublesome neck/shoulder/arm pain.

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Strengths and limitations

- This study adds new information to the limited knowledge about factors of importance for the risk of episodes of *troublesome* neck/shoulder/arm pain (NSAP) among working-age individuals who report *occasional* neck pain.
- Strength lies in its prospective design based on a general population of working age and the fact that prognostic factors were assessed prior to the outcome.
- A further strength is the complete study sample and that several potential confounders were taken into account, even though unmeasured or residual confounding cannot be ruled out.
- A limitation of the study is that we lack information about the duration of the exposures prior to baseline or about their occurrence during the four-year follow-up period. This may limit interpretation of the results.

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INTRODUCTION

The prevalence of musculoskeletal pain is overall high.[1] Among workers neck/shoulder/arm pain (NSAP) is common, causing personal suffering and an economic burden for society.[2-4] NSAP is a recurrent disorder that follows a course. Remissions, exacerbations, and prior pain episodes seem to increase the risk of subsequent pain episodes.[5-7] Although most people will experience neck pain to some degree, not everybody will experience chronic or troublesome neck pain.[8] Studying modifiable prognostic determinants of NSAP is important because it may help prevent severe conditions and promote recovery. Several determinants of the course of pain in the neck/shoulder have been suggested. Results from a cohort study in Sweden on the long-term prognosis of neck/shoulder pain showed that biomechanical exposure such as manual handling ≥50N and working with one's hands above shoulder level negatively influences the prognosis.[9] Further, individuals who take sick leave because of neck pain seem to be prone to subsequent episodes of lost time at work and prolonged disability.[7] A recent study of persons with occasional neck pain reported that social factors such as economic stress and family income are associated with an increased risk of development of troublesome neck pain.[10] In addition, work-related factors—physical, psychological and psychosocial—are considered important for the course of neck/shoulder pain.[7 11] One widely-used work-related model for various disorders is the job strain model, also known as the "demand-control model".[12-15] Here high strain is described as a combination of high psychological job demands with low job decision latitude. This extensively studied model[14 16] further defines a combination of high job demands and high job control as an active job situation, and a combination of low job control and low job demands as a passive job situation. It has been proposed that workers exposed to job strain

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face an increased risk of psychological strain and stress-related diseases.[16-18] Recent research, however, has yielded contradictory results; some studies report a strong association between high strain and the prognosis of NSAP,[19-20] while others report no associations.[8 21] According to a recent review, several studies on job strain and NSAP are cross-sectional; thus, no assessment of temporality can be made.[22]

Several factors most likely modify the association between job strain and the trajectory from *occasional* NSAP to *troublesome.* One debated condition which may be associated with the impact of job strain is exhaustion [17] in terms of prolonged fatigue and sleep disturbances.[12] While sleep is considered an important part of physical restoration, curtailment of sleep by itself may be associated with the prognosis of musculoskeletal pain. Diverse associations between work-related psychological as well as psychosocial factors and sleep disturbances have been shown.[23-26] However, few studies explore whether sleep disturbances play a role as an effect-measure modifier for the association between job strain and the risk of developing NSAP.[12 23]

To our knowledge, no longitudinal study has investigated the effects of the exposures job strain and sleep disturbances in a general population of working age reporting occasional NSAP at baseline. We therefore sought to study whether these conditions are prognostic factors for having experienced at least one episode of troublesome NSAP during the previous six months. We further sought to explore whether an association between job strain and troublesome NSAP is modified by sleep disturbances.

METHODS

Study design

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This longitudinal cohort study is based on the Stockholm Public Health Cohort, (n=25,167), a population-based cohort set up by the Stockholm County Council to gather information about the determinants and consequences of significant contributors to the burden of disease.[27] The study was approved by the Regional Ethical Review Board in Stockholm, Sweden (Diary nr. 2013/497-32).

Study population

Participants aged 18-84 years were selected using area-stratified random samples of the Stockholm population, an. urban region including 24 municipalities with approximately 1.4 million inhabitants (2002). Details about the data collection have been reported elsewhere.[27] Randomly selected individuals (n = 56,634) (18-84 yrs old) after stratification for gender and residential area received a baseline postal or web-based questionnaire in 2006. Sixty-one percent of these (n = 34,707) answered the questionnaire. A total of 25,167 of those who answered the baseline questionnaire answered a follow-up questionnaire in 2010, and members of this group constitute Stockholm Public Health Cohort 06/10 (SPHC 06/10). For the present purpose, only those aged 61 years and below at baseline in SPHC 06/10 were included in order to limit the study to persons of working age, since the follow-up time was four years and the official retirement age in Sweden is 65. Those with missing data on the questions on high job demands, low job control, and sleep were excluded from the cohort (n = 1,212). In addition, those who reported no NSAP or more frequent than occasional at baseline were excluded (n = 3,789; Fig 1). Thus, the study population comprises persons who reported occasional NSAP at baseline (n = 6,979). Occasional pain was indicated if participants responded to the question “During the previous six months, have you experienced pain in neck, shoulder and/or arms?” with either “Yes, a couple of days in the last six months” or “Yes, a couple of days each month.”

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Insert Fig 1 about here

Figure 1 Flowchart of inclusion process

Questionnaires

Baseline data was elicited with questions regarding demographic characteristics, physical and psychological health, physical and psychosocial work environment, lifestyle factors, socioeconomics, social relations, and sick leave. These questions were included in the 2006 survey, as reported elsewhere.[27]

The potential prognostic factors studied were self-reported job strain; combinations of job demands and job control (high strain, active and passive jobs) and sleep disturbances – reported at baseline.

The Job strain model

Job demands and job control were categorized according to the job strain model and analysed as follows: (i) low strain (low job demands and high job control), (ii) active jobs (high job demands and high job control), (iii) passive jobs (low job demands and low job control) and (iiii) high strain (high job demands and low job control) (Fig 2). Four questions in the baseline questionnaire were used for this purpose; two about job demands and two about job control. The original Job Content Questionnaire (JQC) has five items on job demand and nine on job control.[28-29] The use of a partial scale compared to a complete, multi-item job-demands-and-control instrument is reportedly feasible, exhibiting high correlations to a complete instrument (Pearson's correlation coefficient, r = 0.76–0.88); in addition, the present partial instrument assesses the same underlying concepts as the complete instrument.[30] To

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test the internal consistency of the four questions used for job strain in the present study, Cronbach's alpha was calculated for job demands ($\alpha = 0.53$) and job control ($\alpha = 0.77$).

The two questions used to measure job demands were:

(a) "Do you have enough time to complete your assignments at work?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never)

(b) "Are there contradictory demands involved in your job?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never).

The two questions used to measure job control were:

(c) "Are you free to decide what needs to be done at work?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never).

(d) "Are you free to decide how your work is to be carried out?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never).

Persons with an active job situation had a combination of high job demands (question a =no, b= yes) and high job control (question c=yes, d=yes). Those with a passive job situation had a combination of low job demands (question a=yes, b=no) and low job control (question c=no, d=no) and persons with job strain a combination of high job demands (question a=no, b=yes) and low control (question c=no, d=no).

Insert fig 2 about here

Figure 2 The job strain model [14]

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Sleep disturbances

Sleep disturbances were assessed with the question "Do you have difficulty sleeping?" The response options were no; yes, somewhat (classified as mild sleep disturbances); and yes, severe (classified as severe sleep disturbances). Mild and severe sleep disturbances were categorised as sleep disturbances in the stratified analysis. The question has been included in the Stockholm Public Health surveys since 2002, to determine longitudinally the prevalence of such disturbances among the population.[31]

Outcome

The outcome of having experienced an episode of troublesome neck/shoulder/arm pain (NSAP) during the previous six months – was based on two questions in the 2010 follow-up survey. Participants who answered "yes" to both of the following questions were defined as experiencing troublesome NSAP: "During the last six months, have you felt pain in your neck or upper back and/or shoulder or arms? If so, have these restricted your work capacity or hindered you in daily activities to some degree or to a high degree?"

Potential confounders

Potential confounders were chosen from the baseline survey and guided by knowledge from prior research, and by clinical considerations.[7 32] The potential confounders were age (continuous and 18-44/45-61 years), sex (men/women) smoking habits (daily), alcohol consumption (sometime during a period of 12 months), back pain the previous six months (yes; more than two days), socioeconomic class (unskilled and semiskilled workers, skilled workers, assistant non manual employee, intermediate non-manual employees employed/ self-employed/professional), low support at work from superior (yes), low support at work from colleagues (yes), main physical workload in the past 12 months (sedentary,

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light, moderately heavy, heavy), time spent on household work per day (yes > 5 hours), economic stress based on the question "Did it happen that during the past 12 months you ran out of salary/money and had to borrow from relatives or friends in order to pay for food or rent?" (yes), country of birth (Sweden, elsewhere), and leisure physical activity level (sedentary < 2 hours per week/active ≥ 2 hours per week), sleep disturbances (none or mild/severe) ; (Table 1).

Job strain (low strain, active and passive jobs and high strain) was tested regarding confounding in the sleep-disturbances model; sleep disturbances were considered to be potentially in the causal pathway between job strain and episodes of troublesome NSAP.

Statistical analysis

Numbers and proportions (%) for the variables were used to describe the baseline characteristics. Logistic regression models were used to assess associations between the prognostic factors and the outcome. Results are presented as odds ratios (OR), along with 95% confidence intervals (95% CI).

Crude associations between (i) active jobs (high job demands/ control) (ii) passive jobs (low job control/ demands) and (iii) high strain, as discrete factors on one hand, and as a new episode of troublesome NSAP, on the other, were calculated. Low strain (high job control/ low job demands) served as the reference category. We also calculated crude associations between sleep disturbances (mild, severe, and none) and troublesome NSAP.

Two regression models were built for the analyses: one with the four levels of job strain - (low strain, active jobs, passive jobs, and high strain) - and one with the three levels of sleep

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disturbances (none, mild, severe). For each of the two regression models, potential confounding factors were added one at a time to the crude regression model,. If a factor changed the crude OR by 10% or more, it was considered a confounder and was entered into the final model, in accordance with Rothman et al.[33] Finally, we stratified the analyses of job strain and troublesome NSAP by sleep disturbances/no sleep disturbances in a crude and adjusted model in order to study whether the effect of job strain was modified by sleep disturbances.

The final adjusted model for the exposures active jobs, passive jobs and high strain included the confounders socioeconomic class, work load and support at work from one's superior. In the final adjusted model for sleep disturbances, we included economic stress.

Statistical analyses used the STATA® statistical software system version 11.

RESULTS

The characteristics of the study population who experience occasional NSAP at baseline (n = 6,979) stratified by the categories of the job strain model are presented in Table 1. Sixty-one percent (n = 4,260) of the cohort were women, and 57% (n = 4,006) were aged 18–44 years. Mean age in women was 41 years (SD 11) and in men 42 (SD 11) and did not differ between low strain, passive or active jobs and high strain. Of the cohort, 1,003 persons (14%) reported active jobs at baseline in 2006, 518 (7%) reported passive jobs in 2010 and 100 (2%) reported high strain. In total, 2,137 (31%) reported severe sleep disturbances at baseline. Twenty-four percent (n = 1,659) of the cohort reported troublesome NSAP at follow-up (2010).

After control for confounding, high strain and active jobs at baseline were associated with at least one episode of troublesome NSAP experienced during the six months prior to follow-up

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in 2010 (Table 2). The adjusted analyses showed an OR of 1.3 (95% CI 1.1–1.5) for active jobs, 1.2 (95% CI 0.9–1.4) for passive jobs, and 1.5 (95% CI 1.0–2.4) for high strain, compared to the reference category low strain.

Sleep disturbances at baseline were associated with at least one episode of NSAP during the previous six months reported at follow-up (Table 2). The adjusted analysis yielded an OR of 1.4 (95% CI 1.3–1.6) for mild sleep disturbances and an OR of 2.2 (95% CI 1.6–3.0) for severe sleep disturbances, compared to the reference category no sleep disturbances.

Insert Table 2 here

Table 3 shows the results of the stratified analysis. In the stratum *no* sleep disturbances, the adjusted ORs for the association between active and passive jobs at baseline and troublesome NSAP at follow-up were 1.1 (95% CI 0.9-1.4) and 1.2 (95%CI 0.9–1.6), respectively, and for high strain: OR 1.2 (95% CI 0.6-2.1). For the stratum sleep disturbances, the adjusted ORs between active and passive jobs at baseline and troublesome NSAP at follow-up were 1.3 (95% CI 1.0–1.7) and 1.0 (95% CI 0.7–1.5), respectively. The OR for high strain was 1.8 (95% CI 1.0–3.5).

Insert Table 3 here

DISCUSSION

The present results indicate that active jobs (high job demands/high job control) and high strain (high job demand/low job control), and sleep disturbances, are factors that may be

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important for having experienced at least one episode of troublesome neck/shoulder/arm pain (NSAP) during the six months prior to follow-up in persons of working age with occasional NSAP. Further, sleep disturbances seem to modify the prognostic effect of an active job situation and in addition a high strain situation. As sleep disturbances and NSAP are common complaints, our findings are important from a public-health perspective.

The study population included individuals who reported *occasional* NSAP at baseline, of whom some subsequently experienced at least one period of *troublesome* pain at follow-up. Such a prognostic approach in longitudinal studies of the general population has, to date been but little used.[22] Job strain is a critical psychosocial work-related factor in the development of harmful work stress and is associated with the risk of several disorders.[18 34-35] However, not all studies recognize job strain as a prognostic factor for NSAP.[9 22 26] The discrepancy may be explained by sources of bias, different study designs, or varied study populations; but results may also depend on differing definitions of neck/shoulder pain.[22]

Sleep is considered vital to the recovery of body and mind and has been linked to a state of altered metabolism—changes that, in turn may be linked to e.g. diabetes and cardiovascular disease.[36-37] In addition, the metabolic changes that result from sleep disturbance are similar to those related to stress.[36-37] The present study suggests that sleep disturbances act as a modifier between the prognosis of troublesome NSAP and the impact of job strain. However, Canivet et al. investigated sleep disturbances as a possible mediating factor in the pathway between job strain and chronic musculoskeletal pain but found no such association. [12] A recent literature review [25] concludes that strong evidence associates especially high demands at work (active jobs) with severe sleep disturbances. The modifying effect of sleep disturbances we found may have different explanations, but since we cannot be sure of the

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temporality between the onsets of high strain and sleep disturbances, we can only speculate on the associations. It may be that sleep disturbance is a confounder as well as an effect-measure modifier. Further, it may be that sleep disturbance is a mediator in the causal pathway between high strain and new periods of troublesome NSAP. If a causal interaction is present, the risk of developing troublesome NSAP for a person who experiences both high strain or active jobs and sleeping disturbances may be higher than the sum of the effects of the two exposures.

Strengths and limitations of the study

The strength of the study lies in its prospective design based on a general population of working age and on the fact that prognostic factors were assessed prior to the outcome. A further strength is the complete study sample; moreover, several potential confounders were taken into account, even though we cannot rule out the risk of unmeasured or residual confounding, for instance from other psychosocial factors like catastrophizing and somatization.[38]

The well-recognized job strain model was used to assess work-related stress.[14][15] A frequently-used questionnaire developed to measure the construct job strain is the Job Content Questionnaire (JCQ), [28] which comprises five items addressing job demands and nine addressing control. In Stockholm Public Health Cohort 06/10, on which the present study is based, four items from the JCQ were used to measure the constructs. This was judged feasible based on a reported of consistently high agreement between partial scales measuring job strain and a complete survey.[30]

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A potential limitation is that the lower sensitivity of a shorter scale may increase the risk of non-differential misclassification of exposure (i.e. in this case, the prognostic factors, resulting in a dilution of the true effect). However, the sensitivity of the shorter scales was reported to be high ($r > 0.94$). [30] In addition, low sensitivity of the exposure measure is mainly a problem when the exposure is common, and this is not the case with job strain.

Sleep disturbances were relatively common (31%). They were investigated with a single question, and this may lead to misclassification of this exposure and differential misclassification, thus a dilution of a true effect.

We used logistic regression for the analyses of the associations in the study. Since the outcome (i.e.troublesome NSAP) is relatively common, the calculated OR might be higher than a corresponding relative risk (RR), and the results should not be interpreted as such. We lack information about the duration of the exposures prior to baseline or about the presence of the exposures during the four-year follow-up period. This may limit the interpretation of the results through a misclassification of exposure. Such a misclassification would most probably be non-differential. Some study participants classified as exposed at baseline might after a while be unexposed, and some study participants classified as unexposed at baseline may after a while be exposed, which might result in a dilution of a true association.

Selection bias is a potential threat to validity and may be present if the loss to follow-up differs among participants exposed and unexposed *and* if the loss is also related to the outcome. [33] Additional analyses showed that the proportion of those exposed to job strain and sleeping disturbances differed only marginally between those who completed the follow-up and those who did not. Accordingly, selection bias may not be a problem in this study.

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Job strain may be one of several important factors that influence various disorders and distress — among others, troublesome NSAP. In addition it has been reported recently that there seems to be an association between stress-related factors such as high job demands and high strain and an overall unhealthy lifestyle.[18]

In summary, our results indicate that high strain, active jobs and sleep disturbances may be of importance for the prognosis of occasional NSAP, in that these factors are associated with episodes of troublesome NSAP. It is important for employers and caregivers to take reported high strain, active jobs and sleep disturbances into account when implementing measures to minimize the risk of troublesome NSAP in workers. Still, additional large prospective studies are needed to confirm our results and also to identify other modifiable prognostic factors for this public-health problem.

CONCLUSION

Our results indicate that high strain, active jobs and sleep disturbances are prognostic factors that should be taken into account when implementing preventive measures to minimize the risk of troublesome neck/shoulder/arm pain among people of working age. Further, we suggest that sleep disturbances may modify the association between high strain and troublesome neck/shoulder/arm pain.

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All five authors (ERB, WG, JH, LH, ES) contributed to the design and content of the study and to the interpretation of the results. ERB and ES conducted the statistical analyses. All the authors (ERB, WG, JH, LH, ES) critically revised the different versions of the manuscript and all authors read the final version.

Data sharing statement

No additional data available

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Table 1. Baseline sociodemographic and psychosocial characteristics in the study population of persons wit *occasional* neck, shoulder and/or arm pain (NSAP) at baseline (n = 6,979).

	Low strain (n = 5,358)		Active jobs (n = 1,003)		Passive jobs (n = 518)		High strain (n = 100)	
	N	%	N	%	n	%	n	%
Age (yr)								
Age (yr) 18–44	2,981	***56***	613	***61***	348	***67***	64	***64***
Age (yr)45–61	2,377	***44***	390	***39***	170	***33***	36	***36***
Sex								
Men	2,145	***40***	384	***38***	158	***30***	32	***32***
Women	3,213	***60***	619	***62***	360	***70***	68	***68***
Country of birth								
Sweden	4,600	***86***	899	***90***	404	***78***	83	***83***
Elsewhere	758	***14***	104	***10***	114	***22***	17	***17***
Socioeconomic class*								
Unskilled and semiskilled workers	656	***13***	64	***7***	162	***34***	33	***35***
Skilled workers	611	***12***	62	***6***	76	***16***	11	***11***
Assistant non-manual employees	778	***15***	107	***11***	108	***23***	12	***12***
Intermediate non-manual employees	1,358	***26***	321	***33***	90	***19***	24	***24***
Employed/self-employed professionals, civil servants and executives	1,265	***24***	331	***34***	29	***6***	10	***10***
Self-employed (other than professionals)	492	***10***	84	***9***	8	***2***	4	***4***
Sleep disturbances								
None	3,861	***72***	601	***60***	326	***63***	54	***54***
Mild/Severe	1,497	***28***	402	***40***	192	***37***	46	***46***
Work load								
Sedentary	2,207	***41***	464	***46***	192	***37***	36	**36**
Light	1,572	***29***	272	***27***	119	***23***	18	**18**

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Moderately heavy	1,156	***22***	192	***19***	149	***29***	18	**18**
Heavy	409	***8***	74	***7***	56	***11***	27	**27**
Low support at work from superior (yes)	458	***18***	321	***32***	183	***35***	69	***69***
Low support at work from colleagues (yes)	622	***9***	150	***15***	71	***14***	20	***20***
Economic stress (yes)ǂ	367	***7***	77	***8***	73	***14***	16	***16***
Household work								
>5 hrs./week	2,135	***40***	456	***45***	183	***36***	39	***39***
Co-morbidity LBP								
Yes, 2 days or more often during previous six months	3,318	***62***	648	***65***	345	***67***	67	***67***
Smoking habits (daily)	702	***13***	121	***12***	79	***15***	13	***13***
Alcohol (yes, sometime during last 12 months)	4,945	***93***	949	***95***	458	***89***	87	***87***
Leisure physical activity level								
Sedentary < 2hr/week	477	***9***	102	***10***	83	***16***	18	***18***
Active ≥2 hrs./week	4,877	***91***	895	***89***	432	***84***	81	***81***

*Socioeconomic class: based on occupation and education ǂ Economic stress ("Did it happen that during the past 12 months you ran out of salary/money and had to borrow from relatives and friends in order to pay for food or rent?)

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Table 2. Associations between active jobs (high job demands/high control) and passive jobs (low job control/low job demands), high strain (high job demands/low job control) and sleep disturbances and the risk of experiencing at least one episode of *troublesome* neck/shoulder/arm pain. The associations are presented as crude and adjusted odds ratios (OR) and 95% confidence intervals (95% CI).

Exposure	No.exp. Cases (total)	Crude OR (95% CI)	P	Adjusted OR (95% CI)	p
Low strain (reference)	1,219 (5,358)	1	-	1	-
Active jobs	257 (1,003)	1.2 (1.0–1.4)	0.04	1.3* (1.1–1.5)	0.01
Passive jobs	145 (518)	1.3 (1.1–1.6)	<0.001	1.2* (0.9–1.4)	ns
High strain	38 (100)	2.0 (1.3–3.0)	<0.01	1.5* (1.0–2.4)	ns
No sleep disturbance (reference)	1,035 (4,886)	1		1	
Mild sleep disturbance	547 (1,905)	1.4 (1.3–1.6)	<0.001	1.4 ǂ (1.3–1.6)	<0.001
Severe sleep disturbance	77 (188)	2.5 (1.8–3.3)	<0.001	2.2 ǂ (1.6–3.0)	<0.001

*Adjusted for socio-economic class, work load and support from superior, ǂ adjusted for economic stress ns=non significant

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Table 3. Associations between active jobs (high job demands/high job control), passive jobs (low job control/low job demands), high strain (high job demands/low control) and troublesome neck, shoulder and/or arm pain, stratified for *no* sleep disturbances/ sleep disturbances (mild/severe), presented as crude and adjusted odds ratios (OR) and 95% confidence intervals (95% CI).

	No sleep disturbances				Sleep disturbances			
Exposure	**No. exp. Cases (total)**	**Crude OR (95% CI)**	**Adjusted* OR (95% CI)**	**P**	**No. exp. Cases (total)**	**Crude OR (95% CI)**	**Adjusted* OR (95% CI)**	**p**
Low strain (reference)	808 (3,890)	1	1		411 (1,468)	1	1	
Active jobs	129 (597)	1.0 (0.8–1.3)	1.1 (0.9–1.4)	ns	128 (396)	1.2 (1.0-1.6)	1.3 (1.0–1.7)	0.02
Passive jobs	83 (336)	1.3 (1.0–1.7)	1.2 (0.9–1.6)	ns	62 (192)	1.3 (0.9–1.8)	1.0 (0.7–1.5)	ns
High strain	15 (54)	1.4 (0.8–2.6)	1.2 (0.6–2.1)	ns	23 (46)	2.6 (1.4–4.6)	1.8 (1.0–3.5)	ns

*Adjusted for adjusted for economic stress, ns=non significant

Figure legends

Figure 1 Flowchart of inclusion process

Figure 2 The job strain model

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Are job strain and sleep disturbances prognostic factors for neck/shoulder/arm pain? A cohort study of a general population of working age in Sweden

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ABSTRACT (word count 234)

Objective To study whether job strain, i.e. psychological job demands and decision latitude and sleep disturbances among persons with *occasional* neck/shoulder/arm pain (NSAP) are prognostic factors for having experienced at least one episode of *troublesome* NSAP; and to determine whether sleep disturbances modify the association between job strain and troublesome NSAP.

Design Prospective cohort study

Setting Stockholm, Sweden

Participants A population-based cohort of individuals with occasional NSAP (n = 6,979) who answered surveys in 2006 and 2010.

Outcome measures Report of at least one episode of troublesome NSAP in 2010

Results: The odds ratios for troublesome NSAP at follow-up were in individuals exposed to passive jobs 1.2 (95% CI 0.9–1.4); to active jobs 1.3 (95% CI 1.1–1.5); to high strain 1.5 (95% CI 1.0–2.4); to mild sleep disturbances 1.4 (95% CI 1.3–1.6); and to severe sleep disturbances 2.2 (95% CI 1.6–3.0). High strain and active jobs were associated with having experienced at least one episode of troublesome NSAP the previous six months in persons with sleep disturbances, but not in individuals without sleep disturbances.

Conclusion: Our results indicate that high strain, active jobs and sleep disturbances are prognostic factors that should be taken into account when implementing preventive measures to minimize the risk of troublesome NSAP among people of working age. We suggest that sleep disturbances may modify the association between high strain and troublesome neck/shoulder/arm pain.

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Strengths and limitations

- This study adds new information to the limited knowledge about factors of importance for the risk of episodes of *troublesome* neck/shoulder/arm pain (NSAP) among working-age individuals who report *occasional* neck pain.
- Strength lies in its prospective design based on a general population of working age and the fact that prognostic factors were assessed prior to the outcome.
- A further strength is the complete study sample and that several potential confounders were taken into account, even though unmeasured or residual confounding cannot be ruled out.
- A limitation of the study is that we lack information about the duration of the exposures prior to baseline or about their occurrence during the four-year follow-up period. This may limit interpretation of the results.

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INTRODUCTION

The prevalence of musculoskeletal pain is overall high.[1] Among workers neck/shoulder/arm pain (NSAP) is common, causing personal suffering and an economic burden for society.[2-4] NSAP is a recurrent disorder that follows a course. Remissions, exacerbations, and prior pain episodes seem to increase the risk of subsequent pain episodes.[5-7] Although most people will experience neck pain to some degree, not everybody will experience chronic or troublesome neck pain.[8] Studying modifiable prognostic determinants of NSAP is important because it may help prevent severe conditions and promote recovery. Several determinants of the course of pain in the neck/shoulder have been suggested. Results from a cohort study in Sweden on the long-term prognosis of neck/shoulder pain showed that biomechanical exposure such as manual handling ≥50N and working with one's hands above shoulder level negatively influences the prognosis.[9] Further, individuals who take sick leave because of neck pain seem to be prone to subsequent episodes of lost time at work and prolonged disability.[7] A recent study of persons with occasional neck pain reported that social factors such as economic stress and family income are associated with an increased risk of development of troublesome neck pain.[10] In addition, work-related factors—physical, psychological and psychosocial—are considered important for the course of neck/shoulder pain.[7 11] One widely-used work-related model for various disorders is the job strain model, also known as the "demand-control model".[12-15] Here high strain is described as a combination of high psychological job demands with low job decision latitude. This extensively studied model[14 16] further defines a combination of high job demands and high job control as an active job situation, and a combination of low job control and low job demands as a passive job situation. It has been proposed that workers exposed to job strain

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face an increased risk of psychological strain and stress-related diseases.[16-18] Recent research, however, has yielded contradictory results; some studies report a strong association between high strain and the prognosis of NSAP,[19-20] while others report no associations.[8 21] According to a recent review, several studies on job strain and NSAP are cross-sectional; thus, no assessment of temporality can be made.[22]

Several factors most likely modify the association between job strain and the trajectory from *occasional* NSAP to *troublesome.* One debated condition which may be associated with the impact of job strain is exhaustion [17] in terms of prolonged fatigue and sleep disturbances.[12] While sleep is considered an important part of physical restoration, curtailment of sleep by itself may be associated with the prognosis of musculoskeletal pain. Diverse associations between work-related psychological as well as psychosocial factors and sleep disturbances have been shown.[23-26] However, few studies explore whether sleep disturbances play a role as an effect-measure modifier for the association between job strain and the risk of developing NSAP.[12 23]

To our knowledge, no longitudinal study has investigated the effects of the exposures job strain and sleep disturbances in a general population of working age reporting occasional NSAP at baseline. We therefore sought to study whether these conditions are prognostic factors for having experienced at least one episode of troublesome NSAP during the previous six months. We further sought to explore whether an association between job strain and troublesome NSAP is modified by sleep disturbances.

METHODS

Study design

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This longitudinal cohort study is based on the Stockholm Public Health Cohort, (n=25,167), a population-based cohort set up by the Stockholm County Council to gather information about the determinants and consequences of significant contributors to the burden of disease.[27] The study was approved by the Regional Ethical Review Board in Stockholm, Sweden (Diary nr. 2013/497-32).

Study population

Participants aged 18-84 years were selected using area-stratified random samples of the Stockholm population, an. urban region including 24 municipalities with approximately 1.4 million inhabitants (2002). Details about the data collection have been reported elsewhere.[27] Randomly selected individuals (n = 56,634) (18-84 yrs old) after stratification for gender and residential area received a baseline postal or web-based questionnaire in 2006. Sixty-one percent of these (n = 34,707) answered the questionnaire. A total of 25,167 of those who answered the baseline questionnaire answered a follow-up questionnaire in 2010, and members of this group constitute Stockholm Public Health Cohort 06/10 (SPHC 06/10). For the present purpose, only those aged 61 years and below at baseline in SPHC 06/10 were included in order to limit the study to persons of working age, since the follow-up time was four years and the official retirement age in Sweden is 65. Those with missing data on the questions on high job demands, low job control, and sleep were excluded from the cohort (n = 1,212). In addition, those who reported no NSAP or more frequent than occasional at baseline were excluded (n = 3,789; Fig 1). Thus, the study population comprises persons who reported occasional NSAP at baseline (n = 6,979). Occasional pain was indicated if participants responded to the question “During the previous six months, have you experienced pain in neck, shoulder and/or arms?” with either “Yes, a couple of days in the last six months” or “Yes, a couple of days each month.”

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Insert Fig 1 about here

Figure 1 Flowchart of inclusion process

Questionnaires

Baseline data was elicited with questions regarding demographic characteristics, physical and psychological health, physical and psychosocial work environment, lifestyle factors, socioeconomics, social relations, and sick leave. These questions were included in the 2006 survey, as reported elsewhere.[27]

The potential prognostic factors studied were self-reported job strain; combinations of job demands and job control (high strain, active and passive jobs) and sleep disturbances – reported at baseline.

The Job strain model

Job demands and job control were categorized according to the job strain model and analysed as follows: (i) low strain (low job demands and high job control), (ii) active jobs (high job demands and high job control), (iii) passive jobs (low job demands and low job control) and (iiii) high strain (high job demands and low job control) (Fig 2). Four questions in the baseline questionnaire were used for this purpose; two about job demands and two about job control. The original Job Content Questionnaire (JQC) has five items on job demand and nine on job control.[28-29] The use of a partial scale compared to a complete, multi-item job-demands-and-control instrument is reportedly feasible, exhibiting high correlations to a complete instrument (Pearson's correlation coefficient, r = 0.76–0.88); in addition, the present partial instrument assesses the same underlying concepts as the complete instrument.[30] To

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test the internal consistency of the four questions used for job strain in the present study, Cronbach's alpha was calculated for job demands ($\alpha = 0.53$) and job control ($\alpha = 0.77$).

The two questions used to measure job demands were:

(a) "Do you have enough time to complete your assignments at work?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never)

(b) "Are there contradictory demands involved in your job?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never).

The two questions used to measure job control were:

(c) "Are you free to decide what needs to be done at work?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never).

(d) "Are you free to decide how your work is to be carried out?" The answers were dichotomized into yes (yes, usually/always; yes, sometimes) and no (no, rarely; no, never).

Persons with an active job situation had a combination of high job demands (question a =no, b= yes) and high job control (question c=yes, d=yes). Those with a passive job situation had a combination of low job demands (question a=yes, b=no) and low job control (question c=no, d=no) and persons with job strain a combination of high job demands (question a=no, b=yes) and low control (question c=no, d=no).

Insert fig 2 about here

Figure 2 The job strain model [14]

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Sleep disturbances

Sleep disturbances were assessed with the question "Do you have difficulty sleeping?" The response options were no; yes, somewhat (classified as mild sleep disturbances); and yes, severe (classified as severe sleep disturbances). Mild and severe sleep disturbances were categorised as sleep disturbances in the stratified analysis. The question has been included in the Stockholm Public Health surveys since 2002, to determine longitudinally the prevalence of such disturbances among the population.[31]

Outcome

The outcome of having experienced an episode of troublesome neck/shoulder/arm pain (NSAP) during the previous six months – was based on two questions in the 2010 follow-up survey. Participants who answered "yes" to both of the following questions were defined as experiencing troublesome NSAP: "During the last six months, have you felt pain in your neck or upper back and/or shoulder or arms? If so, have these restricted your work capacity or hindered you in daily activities to some degree or to a high degree?"

Potential confounders

Potential confounders were chosen from the baseline survey and guided by knowledge from prior research, and by clinical considerations.[7 32] The potential confounders were age (continuous and 18-44/45-61 years), sex (men/women) smoking habits (daily), alcohol consumption (sometime during a period of 12 months), back pain the previous six months (yes; more than two days), socioeconomic class (unskilled and semiskilled workers, skilled workers, assistant non manual employee, intermediate non-manual employees employed/ self-employed/professional), low support at work from superior (yes), low support at work from colleagues (yes), main physical workload in the past 12 months (sedentary,

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light, moderately heavy, heavy), time spent on household work per day (yes > 5 hours), economic stress based on the question "Did it happen that during the past 12 months you ran out of salary/money and had to borrow from relatives or friends in order to pay for food or rent?" (yes), country of birth (Sweden, elsewhere), and leisure physical activity level (sedentary < 2 hours per week/active ≥ 2 hours per week), sleep disturbances (none or mild/severe) ; (Table 1).

Job strain (low strain, active and passive jobs and high strain) was tested regarding confounding in the sleep-disturbances model; sleep disturbances were considered to be potentially in the causal pathway between job strain and episodes of troublesome NSAP.

Statistical analysis

Numbers and proportions (%) for the variables were used to describe the baseline characteristics. Logistic regression models were used to assess associations between the prognostic factors and the outcome. Results are presented as odds ratios (OR), along with 95% confidence intervals (95% CI).

Crude associations between (i) active jobs (high job demands/ control) (ii) passive jobs (low job control/ demands) and (iii) high strain, as discrete factors on one hand, and as a new episode of troublesome NSAP, on the other, were calculated. Low strain (high job control/ low job demands) served as the reference category. We also calculated crude associations between sleep disturbances (mild, severe, and none) and troublesome NSAP.

Two regression models were built for the analyses: one with the four levels of job strain - (low strain, active jobs, passive jobs, and high strain) - and one with the three levels of sleep

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disturbances (none, mild, severe). For each of the two regression models, potential confounding factors were added one at a time to the crude regression model,. If a factor changed the crude OR by 10% or more, it was considered a confounder and was entered into the final model, in accordance with Rothman et al.[33] Finally, we stratified the analyses of job strain and troublesome NSAP by sleep disturbances/no sleep disturbances in a crude and adjusted model in order to study whether the effect of job strain was modified by sleep disturbances.

The final adjusted model for the exposures active jobs, passive jobs and high strain included the confounders socioeconomic class, work load and support at work from one's superior. In the final adjusted model for sleep disturbances, we included economic stress.

Statistical analyses used the STATA® statistical software system version 11.

RESULTS

The characteristics of the study population who experience occasional NSAP at baseline (n = 6,979) stratified by the categories of the job strain model are presented in Table 1. Sixty-one percent (n = 4,260) of the cohort were women, and 57% (n = 4,006) were aged 18–44 years. Mean age in women was 41 years (SD 11) and in men 42 (SD 11) and did not differ between low strain, passive or active jobs and high strain. Of the cohort, 1,003 persons (14%) reported active jobs at baseline in 2006, 518 (7%) reported passive jobs in 2010 and 100 (2%) reported high strain. In total, 2,137 (31%) reported severe sleep disturbances at baseline. Twenty-four percent (n = 1,659) of the cohort reported troublesome NSAP at follow-up (2010).

After control for confounding, high strain and active jobs at baseline were associated with at least one episode of troublesome NSAP experienced during the six months prior to follow-up

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in 2010 (Table 2). The adjusted analyses showed an OR of 1.3 (95% CI 1.1–1.5) for active jobs, 1.2 (95% CI 0.9–1.4) for passive jobs, and 1.5 (95% CI 1.0–2.4) for high strain, compared to the reference category low strain.

Sleep disturbances at baseline were associated with at least one episode of NSAP during the previous six months reported at follow-up (Table 2). The adjusted analysis yielded an OR of 1.4 (95% CI 1.3–1.6) for mild sleep disturbances and an OR of 2.2 (95% CI 1.6–3.0) for severe sleep disturbances, compared to the reference category no sleep disturbances.

Insert Table 2 here

Table 3 shows the results of the stratified analysis. In the stratum *no* sleep disturbances, the adjusted ORs for the association between active and passive jobs at baseline and troublesome NSAP at follow-up were 1.1 (95% CI 0.9-1.4) and 1.2 (95%CI 0.9–1.6), respectively, and for high strain: OR 1.2 (95% CI 0.6-2.1). For the stratum sleep disturbances, the adjusted ORs between active and passive jobs at baseline and troublesome NSAP at follow-up were 1.3 (95% CI 1.0–1.7) and 1.0 (95% CI 0.7–1.5), respectively. The OR for high strain was 1.8 (95% CI 1.0–3.5).

Insert Table 3 here

DISCUSSION

The present results indicate that active jobs (high job demands/high job control) and high strain (high job demand/low job control), and sleep disturbances, are factors that may be

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important for having experienced at least one episode of troublesome neck/shoulder/arm pain (NSAP) during the six months prior to follow-up in persons of working age with occasional NSAP. Further, sleep disturbances seem to modify the prognostic effect of an active job situation and in addition a high strain situation. As sleep disturbances and NSAP are common complaints, our findings are important from a public-health perspective.

The study population included individuals who reported *occasional* NSAP at baseline, of whom some subsequently experienced at least one period of *troublesome* pain at follow-up. Such a prognostic approach in longitudinal studies of the general population has, to date been but little used.[22] Job strain is a critical psychosocial work-related factor in the development of harmful work stress and is associated with the risk of several disorders.[18 34-35] However, not all studies recognize job strain as a prognostic factor for NSAP.[9 22 26] The discrepancy may be explained by sources of bias, different study designs, or varied study populations; but results may also depend on differing definitions of neck/shoulder pain.[22]

Sleep is considered vital to the recovery of body and mind and has been linked to a state of altered metabolism—changes that, in turn may be linked to e.g. diabetes and cardiovascular disease.[36-37] In addition, the metabolic changes that result from sleep disturbance are similar to those related to stress.[36-37] The present study suggests that sleep disturbances act as a modifier between the prognosis of troublesome NSAP and the impact of job strain. However, Canivet et al. investigated sleep disturbances as a possible mediating factor in the pathway between job strain and chronic musculoskeletal pain but found no such association. [12] A recent literature review [25] concludes that strong evidence associates especially high demands at work (active jobs) with severe sleep disturbances. The modifying effect of sleep disturbances we found may have different explanations, but since we cannot be sure of the

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temporality between the onsets of high strain and sleep disturbances, we can only speculate on the associations. It may be that sleep disturbance is a confounder as well as an effect-measure modifier. Further, it may be that sleep disturbance is a mediator in the causal pathway between high strain and new periods of troublesome NSAP. If a causal interaction is present, the risk of developing troublesome NSAP for a person who experiences both high strain or active jobs and sleeping disturbances may be higher than the sum of the effects of the two exposures.

Strengths and limitations of the study

The strength of the study lies in its prospective design based on a general population of working age and on the fact that prognostic factors were assessed prior to the outcome. A further strength is the complete study sample; moreover, several potential confounders were taken into account, even though we cannot rule out the risk of unmeasured or residual confounding, for instance from other psychosocial factors like catastrophizing and somatization.[38]

The well-recognized job strain model was used to assess work-related stress.[14][15] A frequently-used questionnaire developed to measure the construct job strain is the Job Content Questionnaire (JCQ), [28] which comprises five items addressing job demands and nine addressing control. In Stockholm Public Health Cohort 06/10, on which the present study is based, four items from the JCQ were used to measure the constructs. This was judged feasible based on a reported of consistently high agreement between partial scales measuring job strain and a complete survey.[30]

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A potential limitation is that the lower sensitivity of a shorter scale may increase the risk of non-differential misclassification of exposure (i.e. in this case, the prognostic factors, resulting in a dilution of the true effect). However, the sensitivity of the shorter scales was reported to be high ($r > 0.94$). [30] In addition, low sensitivity of the exposure measure is mainly a problem when the exposure is common, and this is not the case with job strain.

Sleep disturbances were relatively common (31%). They were investigated with a single question, and this may lead to misclassification of this exposure and differential misclassification, thus a dilution of a true effect.

We used logistic regression for the analyses of the associations in the study. Since the outcome (i.e.troublesome NSAP) is relatively common, the calculated OR might be higher than a corresponding relative risk (RR), and the results should not be interpreted as such. We lack information about the duration of the exposures prior to baseline or about the presence of the exposures during the four-year follow-up period. This may limit the interpretation of the results through a misclassification of exposure. Such a misclassification would most probably be non-differential. Some study participants classified as exposed at baseline might after a while be unexposed, and some study participants classified as unexposed at baseline may after a while be exposed, which might result in a dilution of a true association.

Selection bias is a potential threat to validity and may be present if the loss to follow-up differs among participants exposed and unexposed *and* if the loss is also related to the outcome. [33] Additional analyses showed that the proportion of those exposed to job strain and sleeping disturbances differed only marginally between those who completed the follow-up and those who did not. Accordingly, selection bias may not be a problem in this study.

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Job strain may be one of several important factors that influence various disorders and distress — among others, troublesome NSAP. In addition it has been reported recently that there seems to be an association between stress-related factors such as high job demands and high strain and an overall unhealthy lifestyle.[18]

In summary, our results indicate that high strain, active jobs and sleep disturbances may be of importance for the prognosis of occasional NSAP, in that these factors are associated with episodes of troublesome NSAP. It is important for employers and caregivers to take reported high strain, active jobs and sleep disturbances into account when implementing measures to minimize the risk of troublesome NSAP in workers. Still, additional large prospective studies are needed to confirm our results and also to identify other modifiable prognostic factors for this public-health problem.

CONCLUSION

Our results indicate that high strain, active jobs and sleep disturbances are prognostic factors that should be taken into account when implementing preventive measures to minimize the risk of troublesome neck/shoulder/arm pain among people of working age. Further, we suggest that sleep disturbances may modify the association between high strain and troublesome neck/shoulder/arm pain.

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Competing Interest: None declared.

Contributors' statement

All five authors (ERB, WG, JH, LH, ES) contributed to the design and content of the study and to the interpretation of the results. ERB and ES conducted the statistical analyses. All the authors (ERB, WG, JH, LH, ES) critically revised the different versions of the manuscript and all authors read the final version.

Data sharing statement

No additional data available

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Table 1. Baseline sociodemographic and psychosocial characteristics in the study population of persons with *occasional* neck, shoulder and/or arm pain (NSAP) at baseline (n = 6,979).

	Low strain (n = 5,358)		Active jobs (n = 1,003)		Passive jobs (n = 518)		High strain (n = 100)	
	N	%	N	%	n	%	n	%
Age (yr)								
Age (yr) 18–44	2,981	***56***	613	***61***	348	***67***	64	***64***
Age (yr)45–61	2,377	***44***	390	***39***	170	***33***	36	***36***
Sex								
Men	2,145	***40***	384	***38***	158	***30***	32	***32***
Women	3,213	***60***	619	***62***	360	***70***	68	***68***
Country of birth								
Sweden	4,600	***86***	899	***90***	404	***78***	83	***83***
Elsewhere	758	***14***	104	***10***	114	***22***	17	***17***
Socioeconomic class*								
Unskilled and semiskilled workers	656	***13***	64	***7***	162	***34***	33	***35***
Skilled workers	611	***12***	62	***6***	76	***16***	11	***11***
Assistant non-manual employees	778	***15***	107	***11***	108	***23***	12	***12***
Intermediate non-manual employees	1,358	***26***	321	***33***	90	***19***	24	***24***
Employed/self-employed professionals, civil servants and executives	1,265	***24***	331	***34***	29	***6***	10	***10***
Self-employed (other than professionals)	492	***10***	84	***9***	8	***2***	4	***4***
Sleep disturbances								
None	3,861	***72***	601	***60***	326	***63***	54	***54***
Mild/Severe	1,497	***28***	402	***40***	192	***37***	46	***46***
Work load								
Sedentary	2,207	***41***	464	***46***	192	***37***	36	**36**
Light	1,572	***29***	272	***27***	119	***23***	18	**18**

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Moderately heavy	1,156	***22***	192	***19***	149	***29***	18	**18**
Heavy	409	***8***	74	***7***	56	***11***	27	**27**
Low support at work from superior (yes)	458	***18***	321	***32***	183	***35***	69	***69***
Low support at work from colleagues (yes)	622	***9***	150	***15***	71	***14***	20	***20***
Economic stress (yes)ǂ	367	***7***	77	***8***	73	***14***	16	***16***
Household work								
>5 hrs./week	2,135	***40***	456	***45***	183	***36***	39	***39***
Co-morbidity LBP								
Yes, 2 days or more often during previous six months	3,318	***62***	648	***65***	345	***67***	67	***67***
Smoking habits (daily)	702	***13***	121	***12***	79	***15***	13	***13***
Alcohol (yes, sometime during last 12 months)	4,945	***93***	949	***95***	458	***89***	87	***87***
Leisure physical activity level								
Sedentary < 2hr/week	477	***9***	102	***10***	83	***16***	18	***18***
Active ≥2 hrs./week	4,877	***91***	895	***89***	432	***84***	81	***81***

*Socioeconomic class: based on occupation and education ǂ Economic stress ("Did it happen that during the past 12 months you ran out of salary/money and had to borrow from relatives and friends in order to pay for food or rent?)

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Table 2. Associations between active jobs (high job demands/high control) and passive jobs (low job control/low job demands), high strain (high job demands/low job control) and sleep disturbances and the risk of experiencing at least one episode of *troublesome* neck/shoulder/arm pain. The associations are presented as crude and adjusted odds ratios (OR) and 95% confidence intervals (95% CI).

Exposure	No.exp. Cases (total)	Crude OR (95% CI)	P	Adjusted OR (95% CI)	p
Low strain (reference)	1,219 (5,358)	1	-	1	-
Active jobs	257 (1,003)	1.2 (1.0–1.4)	0.04	1.3* (1.1–1.5)	0.01
Passive jobs	145 (518)	1.3 (1.1–1.6)	<0.001	1.2* (0.9–1.4)	ns
High strain	38 (100)	2.0 (1.3–3.0)	<0.01	1.5* (1.0–2.4)	ns
No sleep disturbance (reference)	1,035 (4,886)	1		1	
Mild sleep disturbance	547 (1,905)	1.4 (1.3–1.6)	<0.001	1.4 ǂ (1.3–1.6)	<0.001
Severe sleep disturbance	77 (188)	2.5 (1.8–3.3)	<0.001	2.2 ǂ (1.6–3.0)	<0.001

*Adjusted for socio-economic class, work load and support from superior, ǂ adjusted for economic stress ns=non significant

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Table 3. Associations between active jobs (high job demands/high job control), passive jobs (low job control/low job demands), high strain (high job demands/low control) and troublesome neck, shoulder and/or arm pain, stratified for *no* sleep disturbances/ sleep disturbances (mild/severe), presented as crude and adjusted odds ratios (OR) and 95% confidence intervals (95% CI).

	No sleep disturbances				Sleep disturbances			
Exposure	**No. exp. Cases (total)**	**Crude OR (95% CI)**	**Adjusted* OR (95% CI)**	**P**	**No. exp. Cases (total)**	**Crude OR (95% CI)**	**Adjusted* OR (95% CI)**	**p**
Low strain (reference)	808 (3,890)	1	1		411 (1,468)	1	1	
Active jobs	129 (597)	1.0 (0.8–1.3)	1.1 (0.9–1.4)	ns	128 (396)	1.2 (1.0-1.6)	1.3 (1.0–1.7)	0.02
Passive jobs	83 (336)	1.3 (1.0–1.7)	1.2 (0.9–1.6)	ns	62 (192)	1.3 (0.9–1.8)	1.0 (0.7–1.5)	ns
High strain	15 (54)	1.4 (0.8–2.6)	1.2 (0.6–2.1)	ns	23 (46)	2.6 (1.4–4.6)	1.8 (1.0–3.5)	ns

*Adjusted for adjusted for economic stress, ns=non significant

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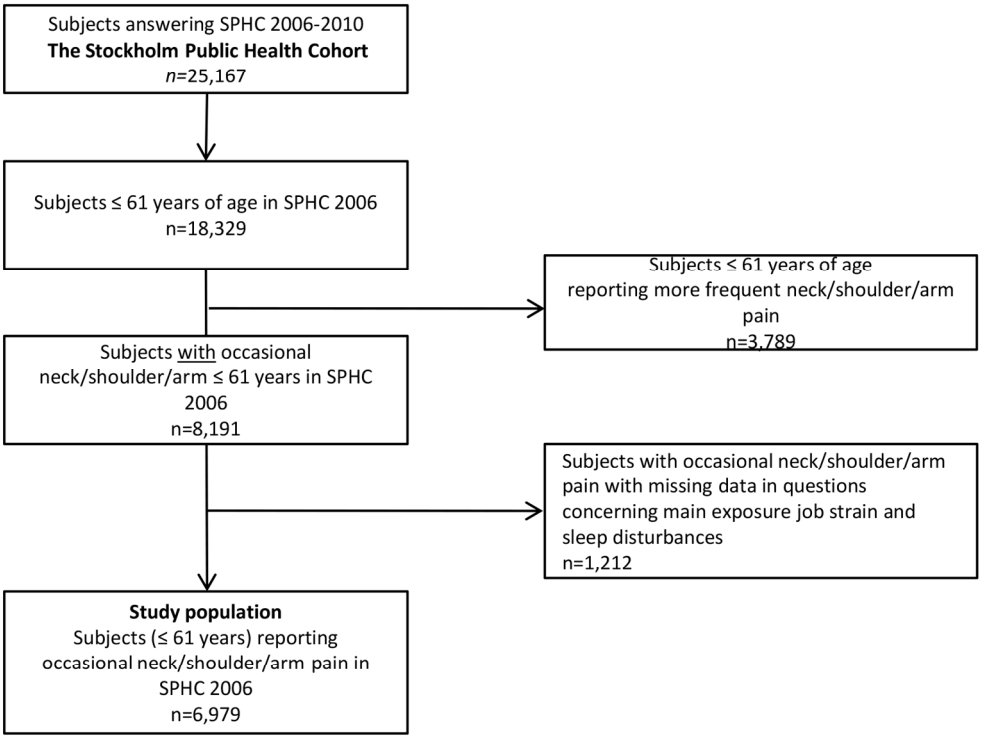

Figure 1 Flowchart of inclusion process
148x117mm (300 x 300 DPI)

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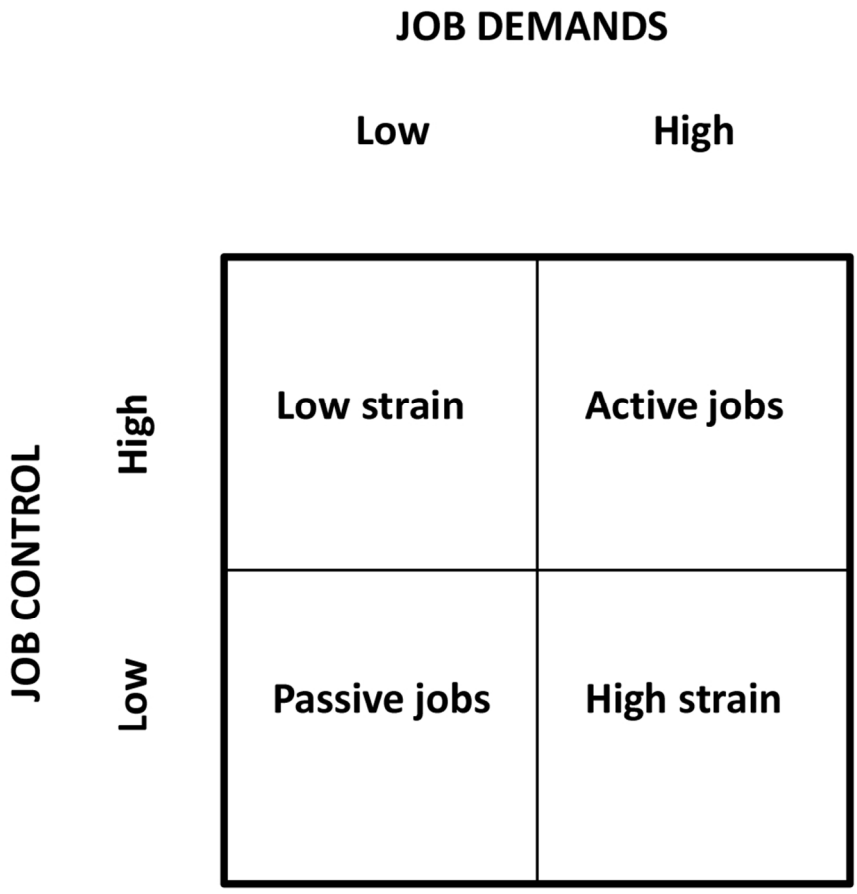

Figure 2 The job strain model [14]
95x92mm (300 x 300 DPI)

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STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1 a)Cohort study – in title and in abstract b) This is done in the abstract with headings	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2 This is summarised in the introduction part of the manuscript. Page 2-3.	Explain the scientific background and rationale for the investigation being reported
Objectives	3 The objectives are stated at page 3, line 20-25	State specific objectives, including any prespecified hypotheses
Methods		
Study design	4 The study design is presented at the first line in the method section, Page 3, line 3-6	Present key elements of study design early in the paper
Setting	5 This is presented in the methods section Page 4, line 8-15	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6 a) This is presented in the method section; Page 4 , line 15-23 and page 5, line1-2 b) Exposed are n= 6979 and unexposed n=1212. This is presented in a flow chart. Figure 1.	(*a*) *Cohort study*—Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up *Case-control study*—Give the eligibility criteria, and the sources and methods of case ascertainment and control selection. Give the rationale for the choice of cases and controls *Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants
		(*b*) *Cohort study*—For matched studies, give matching criteria and number of exposed and unexposed *Case-control study*—For matched studies, give matching criteria and the number of controls per case
Variables	Outcomes, exposures, potential predictors, potential confounders are presented in the method section page 5, line 5 to page 8, line 37	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/	8	For each variable of interest, give sources of data and

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measurement	This is presented for all outcomes, potential predictors, confounders in the method section page 5, line 5 to page 8, line3*	details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias	9 Selection bias; page 13, line 12-17, page 14, 12-16 Confounding bias, page 9, line 18-21, page 13,line 8-10	Describe any efforts to address potential sources of bias
Study size	10 This is presented in flow-chart, Fig 1	Explain how the study size was arrived at
Quantitative variables	11 Page 7, line 1-14,Page 8, line 5 – Page 9, line 3	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods	12 a)Page 9, line 5 – Page 10, line 5 b) Page 9, line 21-24 c) Figure 1 and page 14, line 12-16 d) Figure 1 e) No sensitivity analysis was performed e)	(*a*) Describe all statistical methods, including those used to control for confounding (*b*) Describe any methods used to examine subgroups and interactions (*c*) Explain how missing data were addressed (*d*) *Cohort study*—If applicable, explain how loss to follow-up was addressed *Case-control study*—If applicable, explain how matching of cases and controls was addressed *Cross-sectional study*—If applicable, describe analytical methods taking account of sampling strategy (*e*) Describe any sensitivity analyses
Results		
Participants	13* See flow-chart –Figure 1	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed (b) Give reasons for non-participation at each stage (c) Consider use of a flow diagram
Descriptive data	14* a) b)Se table 1-3 and flow-chart Fig 1 c) Page 5, line 6-22	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate number of participants with missing data for each variable of interest (c) *Cohort study*—Summarise follow-up time (eg, average and total amount)
Outcome data	15* Page 8, line 5-10, Page 10, line 12-18	*Cohort study*—Report numbers of outcome events or summary measures over time *Case-control study*—Report numbers in each exposure category, or summary measures of exposure

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		Cross-sectional study—Report numbers of outcome events or summary measures
Main results	16 Table 2 and 3 Page 10, line 20 – page 11, line 5 b) N/A c)N/A	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17 Table 3 Page 11, line 8-14	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results	18 Page 11, line 19-23	Summarise key results with reference to study objectives
Limitations	19 Page 13, line7-Page 14, line 17	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20 Page 14, line 19 – Page 14 line 3 Page 15, line 6-11	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21 Page 11, line 19-23 Page 12, line 1-2 Page 14, line 24	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22 Page 15, line 13-15	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

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*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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