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Risk of transition from occasional neck/back pain to long-duration activity limiting neck/ back pain; The influence of poor work ability and sleep disturbances

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ABSTRACT

Objectives: The prevalence of neck/back pain (NBP) is high worldwide. Limited number of studies have investigated workers with occasional NBP regarding the risk of developing long-duration activity limiting NBP (LNBP). The objectives were to assess (1) the effect of poor work ability and sleep disturbances in persons with occasional NBP on the risk of LNBP, (2) the interaction effect of these exposures.

Design: Prospective cohort study based on three subsamples from the Stockholm Public Health Cohort

Settings*:* The working population in Stockholm County

Participants*:* Persons aged 18–60, and reporting occasional NBP pain the past 6 months at baseline year 2010 (n=16,460).

Measures*:* Work ability was assessed with items from the Work Ability Index, perceived mental and/or physical work ability. Sleep disturbances were self-reported current mild/severe disturbances. The outcome in year 2014 was reporting NBP the previous 6 months, occurring ≥ couple of days per week and resulting in decreased work ability/restricted other daily activities. The additive effect of having both poor work ability and sleep disturbances was modelled with a dummy variable, including both exposures. Poisson log linear regression was used to calculate the risk ratios (RR) and 95% confidence intervals (95%CI).

Results: Poor work ability and sleep disturbances were independent risk factors for LNBP; adjusted RR 1.7;(95%CI:1.4-2.0) and 1.4;(95%CI:1.2-1.5) respectively. No additive interaction was observed.

Conclusion: Workers with occasional NBP who have poor work ability and/or sleep disturbances are at risk of developing long-duration activity limiting NBP. Having both conditions does not exceed the additive risk.

ARTICLE SUMMARY

Strengths and limitations of this study

- A longitudinal design and the exposures were measured at baseline and the outcome at follow-up four years later, thus the temporality has been taken care of.
- Large study population securing statistical power
- A comprehensive control of confounding factors increases the possibility of causality
- The main possible limitation is the misclassification of the exposures and the outcome and would, if any, result in an underestimation of the results.

INTRODUCTION

Despite decades of research aiming to understand how to prevent and treat activity limiting or disabling neck and/or back pain (LNBP), these health conditions seem to increase over time and are the leading causes of disability globally[1, 2]. Preventive measures are necessary in order to reduce the burden of disease in society and require a knowledge of modifiable risk factors. A recent systemic review of risk factors for the onset of "first episode" neck pain concludes that personal, as well as work-related factors play a role in the development of neck pain, some of which are modifiable while others are no [3]. Another systematic review concludes that physical activity may reduce the risk of long-duration low back pain, [4] while the evidence of risk factors for recurrence of low back pain,[5] and neck pain,[6] is sparse. Most people experience recurrent occasional short duration NBP, and it is necessary to identify the factors involved in the transition to long-duration and activity limiting pain conditions in order to address these in prevention measures.

Self-perceived work ability is a concept which has been widely studied in occupational settings, often as a predictor of future sickness absence,[7, 8], but it has also been shown to be associated with outcomes such as health-related production loss,[9] and work turnover [10] . A frequently used measurement is the Work Ability Index (WAI) and its subscales. WAI consists of seven items including two about perceived work ability in relation to physical and mental work demands[11]. Ahlstrom et al.,[12] used both the full WAI and the single item WAI-S; "current work ability compared with the lifetime best", and found that both were associated with sickness absenteeism over a 12 month-period . Lundin et al. found that this single WAI item had an excellent ability to predict long-term sickens absence, and also that the two items covering perceived mental and physical work ability had acceptable predictive ability[13].

Little is known about the impact of perceived work ability on the development of NBP. A recent clinical study of primary care patients with low back pain found an association between higher work ability measured with the WAI item "current work ability compared with the lifetime best" and improvement in work ability , pain and quality of life at follow up[14] , but other than this, the topic appears to have escaped scientific investigation despite the construct's connection to future ill-health.

It is well established that impaired sleep increases the risk of several health problems of varying severity, for instance all-cause cardiopulmonary mortality, respiratory tract infections, hypertension as well as depression[15-17] Current evidence suggests that sleep disturbances are a risk factor for the onset of NBP [18], as well as a prognostic factor in subacute or long-lasting pain conditions,[19, 20], and for sickness absence[21]. Hypothesizing that poor work ability and sleep disturbances are independent risk factors for the development of long-lasting LNBP, it is possible that having both factors results in a synergistic effect.

Few studies have focused on workers with occasional NBP and their risk of LNBP. We have previously studied job strain and sleep disturbances,[22, 23] regarding the risk of LNBP and have found that high job strain (high job demands/low job control) and active jobs (high job demands/high job control) as well as sleep disturbances were independent risk factors, but the estimates were modest for both conditions. The results also indicated that sleep disturbances may modify the association between high job strain and long-duration activity limiting neck pain, [22], but this was not the case for back pain[23]. In another study, also based on workers with occasional neck pain, work-related and leisure time physical activity were assessed for the risk of long-duration activity limiting neck pain, but no associations were found[24].

In summary, there is some evidence that poor perceived work ability and sleep disturbances contribute both to the onset of and the recovery from pain conditions but little is known about the transitions from occasional pain to long-duration pain that affects daily activities which includes the spectra from minor restrictions to full work disability. The primary aim of this study was, to assess the effect of poor mental and/or poor physical work ability and sleep disturbances respectively in persons with occasional NBP, for the risk of developing LNBP. A secondary aim was to assess the additive interaction effect between these two exposures.

MATERIAL AND METHODS

Design, source and study population

A prospective cohort was formed based on three subsamples of the Stockholm Public Health Cohort; one recruited in year 2002 and followed up in year 2006, 2010 and 2014, one formed in 2006 and followed up in 2010 and 2014, and a third formed in 2010 and followed up in 2014. We used the 2010 and 2014 waves as baseline and follow-up respectively in all subsamples. The data used (i.e. the questions) were defined in the same way in these subsamples in 2010 and 2014.

Persons aged 18–60 who were participating in any of the three subsamples in 2010 were included if they reported NBP during the past six months up to a couple of days per month but not more often, and were responding to any of two items from the Work Ability Index (WAI); physical and mental capacity in relation to work demands (indicating that the persons were active in working life) at baseline.

Persons with sickness absence of more than 90 days during the past 12 months were excluded.

Exposures

The exposure self-perceived physical work ability and mental work ability in relation to work demands was measured with two questions from the WAI. The psychometric properties of this instrument have been tested,[25, 26], and it is considered stable at a group level, predictive and internally coherent. Physical work ability was measured with the question: "How do you rate your current work ability with respect to the physical demands of your work?" The answering alternatives were: "Very good", "Good", "Rather good"," Rather poor", and "Poor". The variable was dichotomised into poor work ability ("Moderate", "Rather poor" or "Poor"), and good work ability ("Very good" or "Rather good"). Mental

work ability was measured with the question: "How do you rate your current work ability with respect to the psychological and mental demands of your work?" The alternative response for mental work ability were the same as for physical work ability and the variable was dichotomised in the same way. The two items were then merged into "poor work ability" ("Rather good", "Rather poor", "Poor" in one or both of the items), whereas those scoring "Good" or "Very good" on both items, were categorised as having "Good work ability" (non-exposed).

The exposure sleep disturbances were defined as having responded "Yes mild" or "Yes severe" to the question "Do you have sleep disturbances?". Those responding "No" were classified as unexposed.

Outcome

The outcome LNBP was operationalised by the response from the 2014 questionnaire and was defined as having reported NBP during the past 6 months, occurring a couple of days per week or more often, and resulting in a decreased work ability/restricted other daily activities.

Confounding control

We controlled for several potential confounders, based on relevance and on the literature on risk factors for disabling NBP (table 1). For the work ability exposure, one model was run, adding sleep disturbances as a confounder, and similarly for the model sleep disturbances, one model was run adding work ability as a confounder.

Table 1. Description of the variables, tested as potential confounders

Variables	Operationalisation [1]
Age	Continuous and categorised in 5-year intervals
Sex	Man/Woman
Socioeconomic Status (SES)	Based on occupational class, classified according to the Swedish socioeconomic classification, developed by Statistics Sweden and retrieved from National Register in Sweden: A combination of current occupation and highest educational level (6 categories)
Body Mass Index	Continuous and categorised into Underweight <18.5, Normal weight 18.5–24.9, Overweight 25–29.9, Obese ≥ 30
Daily Smoking	Question: "Are you currently smoking daily or almost daily" Response alternatives: "Yes," "No"
Sedentary Leisure Time Activity	"State your average physical activity during the past 12 months"; Leisure time sitting; watching, TV, reading. The response alternatives were added up and categorised into <2 hrs/day, 2-3 hrs/day, and more than 3 hrs/day
Physical Activity	"State your physical activity (PA) during the past 12 months" categorised into Walking/cycling less than 20 min/day AND other leisure time PA less than 1 hr/week vs PA (walking/biking, other PA) exceeding these time durations

Household Composition	Three categories; adult living alone, adult living with other adult(s) with/ without children, adult living with children
Psychological Distress	Derived from the General Health Questionnaire (GHQ12) [27, 28] and categorized into < 3, 3–7 and > 7.
Long-standing illness	The question "Do you have any long-duration sickness, health problems as a result of an accident, handicap or other long-duration health problem?" Response alternatives: "Yes ","No"

[1] All variables were retrieved from the baseline questionnaire except Socioeconomic Status, which is retrieved from National Swedish Registers

Statistical Methods

Generalized Linear models with Poisson log linear regression was used to estimate the association between the exposures and the outcome. The results are presented as a risk ratio (RR) with 95% confidence intervals (CI). We ran four adjusted models. For work ability, the first model excluding and the second including sleep disturbances, and for sleep disturbances, one model excluding and the second including work ability. This was done since it might be argued that these factors act as mediators rather than confounders.

To assess whether the interaction between the two risk factors; poor work ability and sleep disturbances deviated from additivity regarding the risk of developing LNBP, we created a dummy variable: having poor work ability/no sleep disturbances, no poor work ability/ sleep disturbances, both poor work ability and sleep disturbances[29]. Having none of the conditions served as a reference, and this model was run in a Poisson log linear regression.

Factors potentially confounding the effect between the exposures and the outcome were added, one at the time, to each univariate model. If the crude estimate changed by 5% or more, the factor was considered a confounder and was included in the adjusted model. We also added a variable including the origin of the three subsamples, since, for two of the merged subsamples, the first and second follow-up wave respectively were used as baseline in our study.

To assess the potential selection bias, attrition analysis was conducted by comparing the prevalence of the main exposure, work ability, among those lost to follow-up and those with missing data on any of the outcome variables, with the prevalence of this exposure among those successfully followed.

IBM® SPSS Statistics version 25 was used.

Patient and Public Involvement

Patients or the public were not involved in the design or planning of the study.

RESULTS

The total study population was 16,460. Of those 11,276 were successfully followed up and 11,229 responded to the back/neck pain questions, which gives a follow-up rate of 68%, (figure 1).

Of the 16,460 participants, 1,989 (12%) reported poor work ability and 1,392 (8%) reported mild or severe sleep disturbances at baseline. A detailed description of the study population is displayed in table 2, and stratified into those with poor versus good work ability. Age and sex were relatively evenly distributed across the two groups. The most common occupations represented were intermediate non-manual workers and employed/self-employed professionals/higher civil servants/executives.

Table 2. Baseline characteristics of the study population in relation to work ability (n=16,460)

Characteristic	Good work ability n: 14,471 (88%)		Poor[1] work ability n: 1,989 (12%)	
	n	%	n	%
Female	8,279	57	1,252	63
Age Mean (SD)	43.2	10.0	42.9	10.5
Age Median (min-max)	44	18–60	44	18–60
Socioeconomic Status				
Unskilled/semiskilled workers	1,498	11	406	22
Skilled workers	1,401	10	248	13
Assistant non-manual workers	1,932	14	244	13
Intermediate non-manual workers	4,164	30	468	25
Employed/self-employed professionals,	3,501	25	333	18
Self-employed other than professionals	1,283	9	169	9
Household composition				
Living together with adult (with or without children)	11,628	81	1,464	74
Living with children	805	5	147	7
Living alone	1,990	14	369	19
Body Mass Index, kg/m^2				
< 18,5	187	1	39	2
18.5–24.9	7,978	56	1,022	53
25.0–29.9	4,628	33	600	31

≥ 30.0	1,446	10	281	15
Daily Smoking	1,424	10	320	16
Physical Activity[2]				
None or low (less than 1 hr/w)	1,989	14	445	23
Intermediate	8,730	60	1,149	58
High	3,288	23	336	17
Very High (more than 5 hrs /w)	424	3	47	2
Sedentary leisure time (TV, reading etc.)				
< 2 hrs/day	9,111	63	1,038	53
2–3 hrs/day	3,740	26	578	29
More than 3 hrs/day	1,558	11	360	18
Sleep disturbances				
No	10,478	73	914	47
Yes, mild	355	25	866	44
Yes, severe	237	2	169	9
Psychological Distress (GHQ12 [3])				
No (0-2)	12,250	85	1,005	51
Mild (3-6)	1,590	11	485	25
Severe (7-12)	602	4	493	25
Long-standing illness	8,200	22	3,837	54

[1] WAI (Work Ability Index) items[11], self-perceived physical and/or mental work ability in relation to job demands and defined as moderate, rather poor, poor. [2] Defined as a combination of cycling/walking and other physical activity expressed as hours per week

[3] GHQ12 General Health Questionnaire – 12 items[27].Total numbers across rows differ due to internal missing values

In 2014, 1,056 (9%) of the 11,229 responders had developed LNBP. Those successfully followed-up were compared with those who dropped out/had missing information on the outcome (n=5,231), with respect to the main exposure work ability. Fifteen percent of the drop-outs had poor work ability compared to 11% among those successfully followed-up.

The results of the Poisson log linear regression analyses are presented in tables 3 and 4. Of those with poor work ability, 214 (18%) participants developed LNBP. The confounders in this association were socioeconomic status (SES) and long-standing illness and were therefore adjusted for, yielding an RR of 1.8 (95% CI;1.6–2.2). Adding sleep disturbances to the model yields an RR of 1.7 (95% CI; 1.4–2.0) (table 3 a).

Of those with sleep disturbances, 411 (13%) developed LNBP. Socioeconomic status (SES) and long-standing illness were confounders also in the association between sleep disturbances and the outcome (adjusted RR 1.5 (95%CI; 1.3–1.7)). Adding poor work ability to the model yields an RR of 1.4 (95%CI:1.2–1.6) (table 3b).

Table 3. Association between poor work ability[1] (a) and sleep disturbances[2] (b) and long-duration troublesome neck -and/or back pain. Risk Ratio (RR) and 95% Confidence Interval (95%CI)

(a)	Cases/ All	Crude RR	95 % CI	Model 1[3] Adjusted RR	95% CI	Model 2 [4]Adjusted RR	95% CI
Good work ability	842/10,011	ref		ref		ref	
Poor work ability[1]	214/1,218	2.1	(1.8-2.4)	1.8	(1.6-2.1)	1.7	(1.4-2.0)
(b)	Cases/ All	Crude RR	95 % CI	Model 1[3] Adjusted RR	95% CI	Model 2 [5]Adjusted RR	95% CI
Good sleep	625/7,833	ref		ref		ref	
Sleep disturbances [2]	411 /3,257	1.6	(1.4-1.8)	1.5	(1.3-1.7)	1.4	(1.2-1.5)

[1] WAI (Work Ability Index) items, self-perceived physical and/or mental work ability in relation to job demands and defined as moderate, rather poor, poor. [2] Sleep disturbances = current mild or severe sleep disturbances. [3] Adjusted for socioeconomic status, chronic comorbidity and subsample (year 2002, 2006, 2010). [4] Adjusted for socioeconomic status, chronic comorbidity, sleep disturbances and subsample (year 2002, 2006, 2010). [5]Adjusted for socioeconomic status, chronic comorbidity, work ability and subsample (year 2002, 2006, 2010)

The analysis including the interaction variable, poor work ability and sleep disturbances, showed after adjusting for SES and chronic comorbidity that those solely with poor WAI had a doubly increased risk of developing LNBP (RR 2.1 (95% CI; 1.7–2.6) compared to those with none of the risk factors. Having sleep disturbances solely yields an RR 1.5 (95% CI; 1.3–1.7), and having both conditions was similar to having poor WAI only (RR 2.1 (95%CI;1.7–2.6) (table 4).

Table 4. Association between different combinations of poor work ability[1] and sleep disturbances[2,] and long-duration troublesome neck -and/or back pain.

Risk Ratio (RR) and 95% Confidence Interval (95%CI)

	Cases/ All	Crude RR	95 % CI	Adjusted[3] RR	95% CI
Good work ability/ No sleep disturbances	534/7,281	ref		ref	
Poor work ability / No sleep disturbances	91/552	2.4	(2.0-3.0)	2.1	(1.7-2.6)
Good work ability /Sleep disturbances	294/2,610	1.5	(1.3-1.8)	1.5	(1.3-1.7)
Poor work ability /Sleep disturbances	117/647	2.4	(1.9-2.9)	2.1	(1.6-2.6)

[1] Assessed with WAI (Work Ability Index) items, self-perceived physical and/or mental work ability in relation to job demands and defined as moderate, rather poor, poor. [2] Sleep disturbances = current mild or severe sleep disturbances. [3] Adjusted for socioeconomic status, long-standing illness and subsample (year 2002, 2006, 2010)

DISCUSSION

The results of this study suggest that persons with occasional NBP who assess their work ability (mental and/or physical) as poor, in relation to the work demands have a higher risk of developing LNBP. Also those who reported sleep disturbances had a higher risk of such an outcome. The risk in persons with both poor work ability and sleep disturbances was not more than additive.

When it comes to research about work ability and NBP, we only found one earlier study, namely on primary care patients with various durations of low back pain. In that prognostic study, they used another item from the WAI when predicting decrease in disability[14], thus it is not comparable to our risk study.

The majority of published studies using items from the WAI, when measuring work ability and its impact on health, have sickness absence as the outcome[7, 8, 30, 31]. In the present study, 33% of the cases reported all-cause sickness absence longer than 7 days during the 12 months preceding the follow-up (8–30 days: 18%, and longer than 30 days: 15%). Among the non-cases the corresponding figures were 14% (11% and 4% respectively). In all, we note that only 1/3 of the cases had a history of sickness absence in the year prior to the follow up, thus our study adds new knowledge to this topic, since the outcome in our study is not equal or similar to sickness absenteeism or disability pension investigated in previous studies.

Perceived physical and/or mental work ability in relation to work demands are theoretically modifiable factors, although they are not always easy to change without changing job or employer. Poor work ability has been shown to be associated with high work turnover[10], thus job change may be an option in order to prevent long-duration activity limiting pain conditions. Another option might be that the employee in dialogue with their employer investigates the possibilities of changes within the current job, or that the individual takes

their own responsibility for physical and mental health maintenances through self-care such as leisure time physical activity or similar actions.

Several studies have shown that sleep disturbance or daytime sleepiness are risk factors for the onset of NBP as well as a factor that impedes recovery[32-34], and are also a risk factor for the onset of musculoskeletal pain in general[35, 36]. One likely mechanism behind the association between sleep disturbances and pain is elevated levels of inflammatory markers triggering the onset of, and continuation of pain[37]. We have, however not found any previous studies based on a population with occasional NBP. Sleep disturbance is a modifiable factor, and cognitive behaviour therapy is a recommended treatment for insomnia, the most common sleep disturbance[38]. There is also some evidence that cognitive therapy for insomnia may improve other health problems such as depression and anxiety; thus, treating sleep problems may also improve comorbid conditions that in turn are often related to pain [39]. It is, therefore, possible that treating sleep problems in persons with occasional NBP may reduce the risk of activity limiting pain, but this needs to be evaluated in future studies.

Strengths

This is a population-based longitudinal study covering residents in the largest county in Sweden with a large sample size allowing interaction analysis. Another strength is the thorough control for possible confounding factors in the analyses. Furthermore,

although almost 1/3 of the study participants had dropped out at the follow up in 2014, the prevalence of the main exposure was 11% and 15% of these successfully followed versus the drop-outs. We believe that selection bias has a minor impact on the results, although this cannot be fully ruled out. If the exposed participants who dropped out were less likely to have the outcome compared to the exposed participants who were successfully followed, we may

have overestimated the true effect. We excluded those who in 2010 reported that they had a sickness absence of more than 90 days during the 12 months preceding entry to the study. The reason for this was to avoid the issue of major morbidity influencing the participants' judgment of their work ability for illness not related to NBP, and thus also reducing the risk of null-findings when there would be a true risk.

Limitations

The main limitations are possible misclassification due to imprecise or time-varying exposure, resulting in a non-differential exposure misclassification which, if any, will have led to a dilution of the effect estimate. In particular, we believe that the way sleep disturbances were measured may be prone to misclassification. One single question with three response alternatives may not fully capture the concept of sleep disturbances.

Also, work ability may be prone to non-differential misclassification, since we did not have access to the full WAI. However, these single questions on perceived work ability in relation to job demands have previously been validated, both against the full WAI[13] and when used as predictors for sickness absences with acceptable results[12]. Nevertheless, if anything, such misclassification bias would lead to diluted associations. Furthermore, the exposure work ability may change over the follow-up period, most likely due to a job change. Exactly the same proportion among cases and non-cases had changed job/new employer in 2014 compared to 2010, (28%), which to some extent reduces the likelihood of differential misclassification of work ability.

We claim that the results of our study is generalizable to other settings on persons active in working life. Even though the study showed that the absolute risk of LNBP is modest, with less than 10% of those with occasional NBP developing the more severe condition according

to our definition, it is a major and expensive public health problem that accumulates over time.

This study adds knowledge to the area of why persons with occasional NBP develop long-duration and activity limiting NBP. Paying attention to persons with occasional NBP who have poor perceived work ability and/or sleep disturbances, and taking action accordingly, may reduce this burden of ill-health. We welcome future research on the effect of occupational preventive measures for workers with poor work ability.

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AUTHOR CONTRIBUTIONS

LWH, TB, ML and ES contributed to the conceptualisation and methodology of the study which was approved by CM. CM provided the data resources. LWH made the statistical analyses based on a protocol approved by the co-authors. LWH wrote a draft of the manuscript. All authors contributed to the interpretation of the results and critically revised the manuscript and finally approved the last version.

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COMPETING INTERESTS

Dr:s Eva Skillgate and Lena Holm are scientific consultants at the Scandinavian College of Naprapathic Manual Medicine and members of their Scientific Board.

ETHICS APPROVAL

Ethical approval was obtained from the regional ethical review board in Stockholm (Dnr; 2007/545-31, 2013/497-32 and 2015/1204-32). The questionnaires included information about handling of personal data, and the participants accepted the use of their data by answering to the questionnaires (written informed consent).

DATA SHARING STATEMENT

Due to ethical restrictions and laws (GDPR) of disclosing personal data, authors have to seek permission to allow us to make the data used in this study available. Data will be available upon request after permission is granted from the Karolinska Institutet's Ethics Review Board in Stockholm. Inquiries for data access should first be sent to eva.skillgate@ki.se, who will then contact the ethics board for permission to openly share the data.

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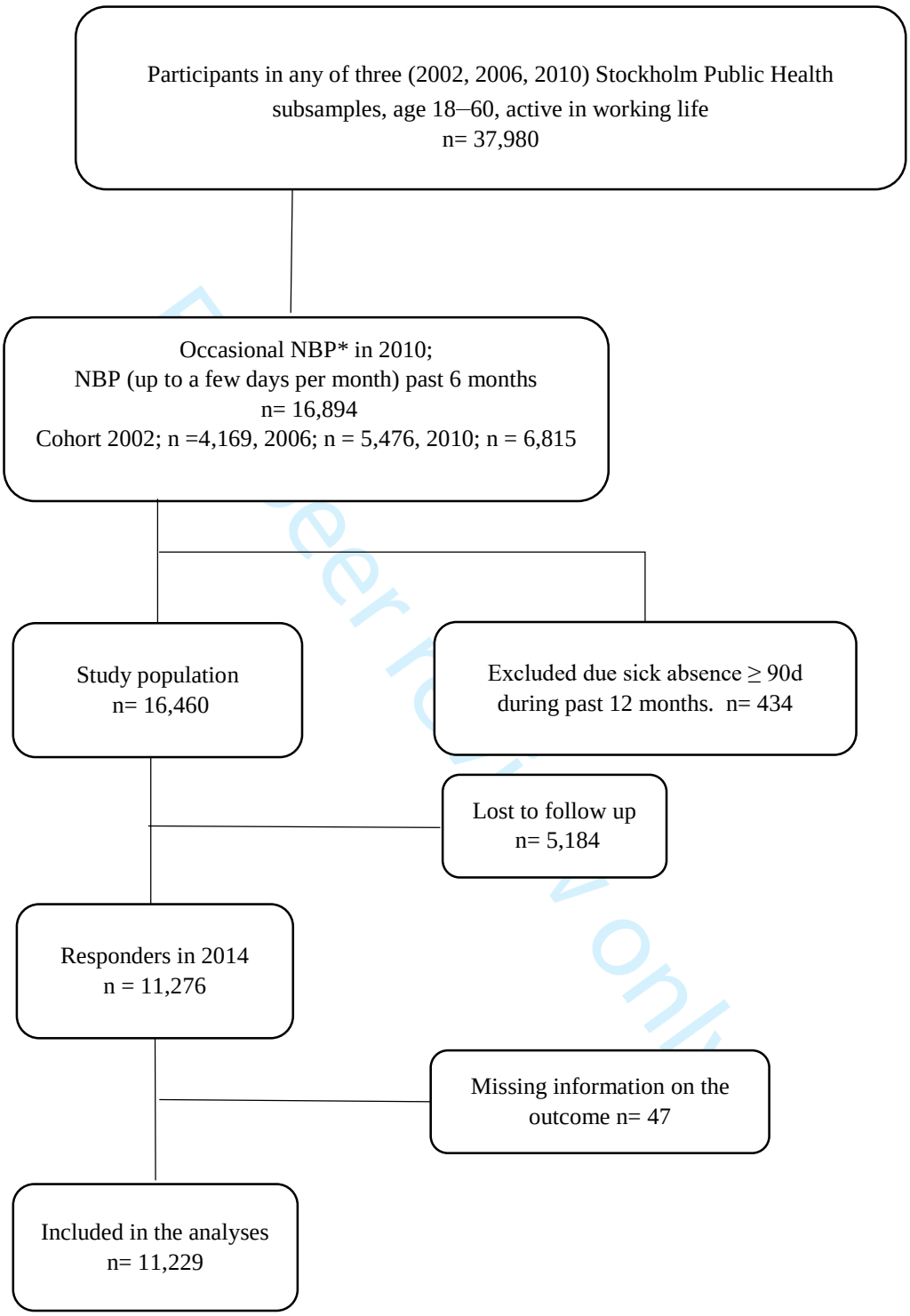
Figure 1. Flowchart of the inclusion of the study population and follow up.

* NBP; neck and/or back pain.



STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Considered
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	yes
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	yes
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	yes
Objectives	3	State specific objectives, including any prespecified hypotheses	yes
Methods			
Study design	4	Present key elements of study design early in the paper	yes
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	yes
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	yes
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	yes
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	yes
Bias	9	Describe any efforts to address potential sources of bias	yes
Study size	10	Explain how the study size was arrived at	yes
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	yes
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	yes
		(*b*) Describe any methods used to examine subgroups and interactions	yes
		(*c*) Explain how missing data were addressed	yes
		(*d*) If applicable, explain how loss to follow-up was addressed	yes
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(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	yes
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	yes
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	yes
		(b) Indicate number of participants with missing data for each variable of interest	yes

		(c) Summarise follow-up time (eg, average and total amount)	yes
Outcome data	15*	Report numbers of outcome events or summary measures over time	yes
Main results	16	(*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	yes
		(*b*) Report category boundaries when continuous variables were categorized	yes
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	yes
Discussion			
Key results	18	Summarise key results with reference to study objectives	yes
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	yes
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	yes
Generalisability	21	Discuss the generalisability (external validity) of the study results	yes
Other information			
Funding	22	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	yes

*Give information separately for exposed and unexposed groups.

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 http://www.strobe-statement.org.

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Risk of transition from occasional neck/back pain to long-duration activity limiting neck/back pain: the influence of poor work ability and sleep disturbances in the working population in Stockholm County

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Risk of transition from occasional neck/back pain to long-duration activity limiting neck/back pain: the influence of poor work ability and sleep disturbances in the working population in Stockholm County

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ABSTRACT

Objectives: The prevalence of neck/back pain (NBP) is high worldwide. Limited number of studies have investigated workers with occasional NBP regarding the risk of developing long-duration activity limiting NBP (LNBP). The objectives were to assess (1) the effect of poor work ability and sleep disturbances in persons with occasional NBP on the risk of LNBP, (2) the interaction effect of these exposures.

Design: Cohort study based on three subsamples from the Stockholm Public Health Cohort.

Settings*:* The working population in Stockholm County.

Participants*:* Persons aged 18–60, reporting occasional NBP the past 6 months at baseline year 2010 (n=16,460).

Measures*:* Work ability was assessed with items from the Work Ability Index, perceived mental and/or physical work ability. Sleep disturbances were self-reported current mild/severe disturbances. The outcome in year 2014; reporting NBP the previous 6 months, occurring ≥ couple of days per week and resulting in decreased work ability/restricted other daily activities. The additive effect of having both poor work ability and sleep disturbances was modelled with a dummy variable, including both exposures. Poisson log linear regression was used to calculate risk ratios (RR) and 95% confidence intervals (95% CI).

Results: At follow up, 9% had developed LNBP. Poor work ability and sleep disturbances were independent risk factors for LNBP; adjusted RR 1.7;(95%CI:1.4-2.0) and 1.4;(95%CI:1.2-1.5) respectively. No additive interaction was observed.

Conclusion: Workers with occasional NBP who have poor work ability and/or sleep disturbances are at risk of developing long-duration activity limiting NBP. Having both conditions does not exceed additive risk.

ARTICLE SUMMARY

Strengths and limitations of this study

- A longitudinal design and the exposures were measured at baseline and the outcome at follow-up four years later, thus the temporality has been taken care of.
- Large study population securing statistical power.
- A comprehensive control of confounding factors increases the possibility of causality.
- The main possible limitation is the misclassification of the exposures and the outcome and would, if any, result in an underestimation of the results.

INTRODUCTION

Despite decades of research aiming to understand how to prevent and treat long-duration activity limiting neck and/or back pain (LNBP), these health conditions seem to increase over time and are the leading causes of disability globally[1, 2]. Preventive measures are necessary in order to reduce the burden of disease in society and require a knowledge of modifiable risk factors. A recent systemic review of risk factors for the onset of "first episode" neck pain concludes that personal as well as work-related factors play a role in the development of neck pain, some of which are modifiable while others are not [3]. Another systematic review concludes that physical activity may reduce the risk of long-duration low back pain, [4] while the evidence of risk factors for recurrence of low back pain,[5] and neck pain,[6] is sparse. Most people experience recurrent occasional short duration NBP, and it is necessary to identify the factors involved in the transition to long-duration and activity limiting pain conditions in order to address these in prevention measures.

Self-perceived work ability is a concept which has been widely studied in occupational settings, often as a predictor of future sickness absence,[7, 8], but it has also been shown to be associated with outcomes such as health-related production loss,[9] and work turnover [10]. A frequently used measurement is the Work Ability Index (WAI) and its subscales. WAI consists of seven items including two about perceived work ability in relation to physical and mental work demands[11]. Ahlstrom et al.,[12] used both the full WAI and the single item WAI-S; "current work ability compared with the lifetime best", and found that both were associated with sickness absenteeism over a 12-month period . Lundin et al. found that this single WAI item had an excellent ability to predict long-term sickness absence, and also that the two items covering perceived mental and physical work ability had acceptable predictive validity [13].

Little is known about the impact of perceived work ability on the development of NBP. A recent clinical study of primary care patients with low back pain found an association between higher work ability measured with the WAI item "current work ability compared with the lifetime best" and improvement in work ability, pain and quality of life at follow up[14], but other than this, the topic appears to have escaped scientific investigation despite the construct's connection to future ill-health.

It is well-established that impaired sleep increases the risk of several health problems of varying severity, for instance all-cause cardiopulmonary mortality, respiratory tract infections, hypertension as well as depression[15-17]. Current evidence suggests that sleep disturbances are a risk factor for the onset of NBP [18], as well as a prognostic factor in subacute or long-lasting pain conditions,[19, 20], and for sickness absence[21]. Hypothesizing that poor work ability and sleep disturbances are independent risk factors for the development of LNBP, it is possible that having both factors results in a synergistic effect.

Few studies have focused on workers with occasional NBP and their risk of LNBP. We have previously studied job strain and sleep disturbances,[22, 23] regarding the risk of LNBP and have found that high job strain (high job demands/low job control) and active jobs (high job demands/high job control) as well as sleep disturbances were independent risk factors, but the estimates were modest for both conditions. The results also indicated that sleep disturbances may modify the association between high job strain and long-duration activity limiting neck pain, [22], but this was not the case for back pain[23]. In another study, also based on workers with occasional neck pain, work-related and leisure time physical activity were assessed for the risk of long-duration activity limiting neck pain, but no associations were found[24].

In summary, there is some evidence that poor perceived work ability and sleep disturbances contribute both to the onset of and the recovery from pain conditions, however little is known about the transitions from occasional pain to long-duration pain that affects daily activities, including the spectra from minor restrictions to full work disability. The primary aim of this study was to assess the effect of poor mental and/or poor physical work ability and sleep disturbances, respectively, in persons with occasional NBP, for the risk of developing LNBP. A secondary aim was to assess the additive interaction effect between these two exposures.

MATERIAL AND METHODS

Design, source and study population

A prospective cohort was formed based on three subsamples of the Stockholm Public Health Cohort; one recruited in year 2002 and followed up in year 2006, 2010 and 2014, one formed in 2006 and followed up in 2010 and 2014, and a third formed in 2010 and followed up in 2014. We used the 2010 and 2014 waves as baseline and follow-up, respectively, in all subsamples. The data used (i.e. the questions) were defined in the same way in these subsamples in 2010 and 2014.

Men and women, aged 18–60 who were participating in any of the three subsamples in 2010 were included if they reported NBP during the past six months up to a couple of days per month but not more often, and were responding to any of two items from the WAI); physical and mental capacity in relation to work demands (indicating that the persons were active in working life) at baseline. NBP was defined based on the questions: "Have you had any pain in your upper back or neck in the preceding 6 months?", and "Have you had any pain in your lower back in the preceding 6 months?". Persons who responded "Yes, a couple of days per month or less frequent" to one or both of these questions fulfilled the criteria for NBP.

Persons with sickness absence of more than 90 days during the past 12 months were excluded.

Exposures

The exposure self-perceived physical work ability and mental work ability in relation to work demands was measured with two questions from the WAI. The psychometric properties of this instrument have been tested,[25, 26], and it is considered stable at a group level, predictive and internally coherent. Physical work ability was measured with the question: "How do you rate your current work ability with respect to the physical demands of your

work?" The answering alternatives were: "Very good", "Good", "Moderate"," Rather poor", and "Poor". The variable was dichotomised into poor work ability ("Moderate", "Rather poor" or "Poor"), and good work ability ("Very good" or "Rather good"). Mental work ability was measured with the question: "How do you rate your current work ability with respect to the psychological and mental demands of your work?" The alternative response for mental work ability were the same as for physical work ability and the variable was dichotomised in the same way. The two items were then merged into "poor work ability" ("Moderate", "Rather poor", "Poor" in one or both of the items), whereas those scoring "Good" or "Very good" on both items, were categorised as having "Good work ability" (non-exposed).

The exposure sleep disturbances were defined as having responded "Yes mild" or "Yes severe" to the question "Do you have sleep disturbances?". Those responding "No" were classified as unexposed.

Outcome

The outcome LNBP was operationalised by the response from the 2014 questionnaire and was defined as having reported NBP during the past 6 months, occurring a couple of days per week or more often, and resulting in a decreased work ability/restricted other daily activity.

Confounding control

We investigated several potential confounders, based on relevance and on the literature on risk factors for long lasting NBP (table 1). For the work ability exposure, one model was run, adding sleep disturbances as a confounder, and similarly for the model sleep disturbances, one model was run adding work ability as a confounder.

1 Table 1. Description of the variables, tested as potential confounders

Variables	Operationalisation [1]
Age	Continuous and categorised in 5-year intervals
Sex	Man/Woman
Socioeconomic Status	Based on occupational class, classified according to the Swedish socioeconomic classification, developed by Statistics Sweden and retrieved from National Register in Sweden: A combination of current occupation and highest educational level (6 categories)
Body Mass Index	Continuous and categorised into Underweight <18.5, Normal weight 18.5–24.9, Overweight 25–29.9, Obese ≥ 30
Daily Smoking	Question: "Are you currently smoking daily or almost daily" Response alternatives: "Yes," "No"
Sedentary Leisure Time Activity	"State your average physical activity during the past 12 months"; Leisure time sitting; watching, TV, reading. The response alternatives were added up and categorised into <2 hrs/day, 2-3 hrs/day, and more than 3 hrs/day
Physical Activity	"State your physical activity (PA) during the past 12 months" categorised into Walking/cycling less than 20 min/day AND other leisure time PA less than 1 hr/week vs PA (walking/biking, other PA) exceeding these time durations

Household Composition	Three categories; adult living alone, adult living with other adult(s) with/without children, adult living with children
Psychological Distress	Derived from the General Health Questionnaire (GHQ12) [27, 28] and categorized into < 3, 3–7 and > 7.
Long-standing illness	The question "Do you have any long-duration sickness, health problems as a result of an accident, handicap or other long-duration health problem?" Response alternatives: "Yes ","No"

[1] All variables were retrieved from the baseline questionnaire except Socioeconomic Status, which is retrieved from National Swedish Registers

Statistical Methods

Generalized Linear models with Poisson log linear regression was used to estimate the association between the exposures and the outcome. The results are presented as a risk ratio (RR) with 95% confidence intervals (CI). We ran four adjusted models. For work ability, the first model excluding and the second including sleep disturbances, and for sleep disturbances, one model excluding and the second including work ability. This was done since it might be argued that these factors act as mediators rather than confounders.

To assess whether the interaction between the two risk factors poor work ability and sleep disturbances deviated from additivity regarding the risk of developing LNBP, we created a dummy variable: having poor work ability/no sleep disturbances, no poor work ability/sleep disturbances, both poor work ability and sleep disturbances[29]. Having none of the conditions served as a reference, and this model was run in a Poisson log linear regression.

Factors potentially confounding the effect between the exposures and the outcome were added one at the time to each univariate model. If the crude estimate changed by 5% or more, the factor was considered a confounder and was included in the adjusted model. We also added a variable including the origin of the three subsamples, since, for two of the merged subsamples, the first and second follow-up wave respectively were used as baseline in our study.

To assess the potential selection bias, attrition analysis was conducted by comparing the prevalence of the main exposure, work ability, among those lost to follow-up and those with missing data on any of the outcome variables, with the prevalence of this exposure among those successfully followed.

IBM® SPSS Statistics version 25 was used.

Patient and Public Involvement

Patients or the public were not involved in the design or planning of the study.

RESULTS

The total study population was 16,460. Of those, 11,276 were successfully followed up and 11,229 responded to the back/neck pain questions, which gives a follow-up rate of 68%, (figure 1).

Of the 16,460 participants, 1,989 (12%) reported poor work ability and 1,392 (8%) reported mild or severe sleep disturbances at baseline. A detailed description of the study population is displayed in table 2 and stratified into those with poor versus good work ability. Age and sex were relatively evenly distributed across the two groups. The most common occupations represented were intermediate non-manual workers and employed/self-employed professionals/higher civil servants/executives.

Table 2. Baseline characteristics of the study population in relation to work ability (n=16,460)

Characteristic	Good work ability n: 14,471 (88%)		Poor[1] work ability n: 1,989 (12%)	
	n	%	n	%
Female	8,279	57	1,252	63
Age Mean (SD)	43.2	10.0	42.9	10.5
Age Median (min-max)	44	18–60	44	18–60
Socioeconomic Status				
Unskilled/semiskilled workers	1,498	11	406	22
Skilled workers	1,401	10	248	13
Assistant non-manual workers	1,932	14	244	13
Intermediate non-manual workers	4,164	30	468	25
Employed/self-employed professionals,	3,501	25	333	18
Self-employed other than professionals	1,283	9	169	9
Household composition				
Living together with adult (with or without children)	11,628	81	1,464	74
Living with children	805	5	147	7
Living alone	1,990	14	369	19
Body Mass Index, kg/m^2				
< 18,5	187	1	39	2
18.5–24.9	7,978	56	1,022	53
25.0–29.9	4,628	33	600	31

≥ 30.0	1,446	10	281	15
Daily Smoking	1,424	10	320	16
Physical Activity[2]				
None or low (less than 1 hr/w)	1,989	14	445	23
Intermediate	8,730	60	1,149	58
High	3,288	23	336	17
Very High (more than 5 hrs /w)	424	3	47	2
Sedentary leisure time (TV, reading etc.)				
< 2 hrs/day	9,111	63	1,038	53
2–3 hrs/day	3,740	26	578	29
More than 3 hrs/day	1,558	11	360	18
Sleep disturbances				
No	10,478	73	914	47
Yes, mild	355	25	866	44
Yes, severe	237	2	169	9
Psychological Distress (GHQ12 [3])				
No (0-2)	12,250	85	1,005	51
Mild (3-6)	1,590	11	485	25
Severe (7-12)	602	4	493	25
Long-standing illness	8,200	22	3,837	54

[1] WAI (Work Ability Index) items[11], self-perceived physical and/or mental work ability in relation to job demands and defined as moderate, rather poor, poor. [2] Defined as a combination of cycling/walking and other physical activity expressed as hours per week

[3] GHQ12 General Health Questionnaire – 12 items[27].Total numbers across rows differ due to internal missing values

In 2014, 1,056 (9%) of the 11,229 responders had developed LNBP. Those successfully followed-up were compared with those who dropped out/had missing information on the outcome (n=5,231), with respect to the main exposure work ability. Fifteen percent of the dropouts had poor work ability compared to 11% among those successfully followed-up.

The results of the Poisson log linear regression analyses are presented in tables 3 and 4. Of those with poor work ability, 214 (18%) participants developed LNBP. The confounders in this association were socioeconomic status (SES) and long-standing illness and were therefore adjusted for, yielding an RR of 1.8 (95% CI;1.6–2.2). Adding sleep disturbances to the model yields an RR of 1.7 (95% CI; 1.4–2.0) (table 3 a).

Of those with sleep disturbances, 411 (13%) developed LNBP. Socioeconomic status (SES) and long-standing illness were confounders also in the association between sleep disturbances and the outcome (adjusted RR 1.5 (95%CI; 1.3–1.7)). Adding poor work ability to the model yields an RR of 1.4 (95%CI:1.2–1.6) (table 3b).

Table 3. Association between poor work ability[1] (a) and sleep disturbances[2] (b) and long-duration activity limiting neck -and/or back pain. Risk Ratio (RR) and 95% Confidence Interval (95%CI)

(a)	Cases/ All	Crude RR	95 % CI	Model 1[3] Adjusted RR	95% CI	Model 2 [4]Adjusted RR	95% CI
Good work ability	842/10,011	ref		ref		ref	
Poor work ability[1]	214/1,218	2.1	(1.8-2.4)	1.8	(1.6-2.1)	1.7	(1.4-2.0)
(b)	Cases/ All	Crude RR	95 % CI	Model 1[3] Adjusted RR	95% CI	Model 2 [5]Adjusted RR	95% CI
Good sleep	625/7,833	ref		ref		ref	
Sleep disturbances [2]	411 /3,257	1.6	(1.4-1.8)	1.5	(1.3-1.7)	1.4	(1.2-1.5)

[1] WAI (Work Ability Index) items, self-perceived physical and/or mental work ability in relation to job demands and defined as moderate, rather poor, poor. [2] Sleep disturbances = current mild or severe sleep disturbances. [3] Adjusted for socioeconomic status, chronic comorbidity and subsample (year 2002, 2006, 2010). [4] Adjusted for socioeconomic status, chronic comorbidity, sleep disturbances and subsample (year 2002, 2006, 2010). [5]Adjusted for socioeconomic status, chronic comorbidity, work ability and subsample (year 2002, 2006, 2010)

The analysis including the interaction variable, poor work ability and sleep disturbances, showed after adjusting for SES and chronic comorbidity that those solely with poor WAI had a doubly increased risk of developing LNBP (RR 2.1 (95% CI; 1.7–2.6) compared to those with none of the risk factors. Having sleep disturbances solely yields an RR 1.5 (95% CI; 1.3–1.7) and having both conditions was similar to having poor WAI only (RR 2.1 (95%CI;1.7–2.6) (table 4).

Table 4. Association between different combinations of poor work ability[1] and sleep disturbances[2,] and long-duration activity limiting neck - and/or back pain.

Risk Ratio (RR) and 95% Confidence Interval (95%CI)

	Cases/ All	Crude RR	95 % CI	Adjusted[3] RR	95% CI
Good work ability/ No sleep disturbances	534/7,281	ref		ref	
Poor work ability / No sleep disturbances	91/552	2.4	(2.0-3.0)	2.1	(1.7-2.6)
Good work ability /Sleep disturbances	294/2,610	1.5	(1.3-1.8)	1.5	(1.3-1.7)
Poor work ability /Sleep disturbances	117/647	2.4	(1.9-2.9)	2.1	(1.6-2.6)

[1] Assessed with WAI (Work Ability Index) items, self-perceived physical and/or mental work ability in relation to job demands and defined as moderate, rather poor, poor. [2] Sleep disturbances = current mild or severe sleep disturbances. [3] Adjusted for socioeconomic status, long-standing illness and subsample (year 2002, 2006, 2010)

DISCUSSION

The results of this study suggest that persons with occasional NBP who assess their work ability (mental and/or physical) as poor, in relation to the work demands, have a higher risk of developing LNBP. Also, those who reported sleep disturbances have a higher risk of such an outcome. The risk in persons with both poor work ability and sleep disturbances was not more than additive.

When it comes to research about work ability and NBP, we only found one earlier study, namely on primary care patients with various durations of low back pain. In that prognostic study, they used another item from the WAI when predicting decrease in disability[14], thus it is not comparable to our risk study.

The majority of published studies using items from the WAI, when measuring work ability and its impact on health, have sickness absence as the outcome[7, 8, 30, 31]. In the present study,we note that only 1/3 of the cases had a history of sickness absence in the year prior to the follow up, thus our study adds new knowledge to this topic, since the outcome in our study is not equal or similar to sickness absenteeism or disability pension investigated in previous studies.

Perceived physical and/or mental work ability in relation to work demands are theoretically modifiable factors, although they are not always easy to change without changing job or employer. Poor work ability has been shown to be associated with high work turnover[10], thus job change may be an option in order to prevent long-duration activity limiting pain conditions. Another option might be that the employee in dialogue with their employer investigates the possibilities of changes within the current job, or that the individual takes their own responsibility for physical and mental health maintenances through self-care such as leisure time physical activity or similar actions.

Several studies have shown that sleep disturbance or daytime sleepiness are risk factors for the onset of NBP as well as a factor that impedes recovery[32-34], and are also a risk factor for the onset of musculoskeletal pain in general[35, 36]. One likely mechanism behind the association between sleep disturbances and pain is elevated levels of inflammatory markers triggering the onset of, and continuation of pain[37]. We have, however, not found any previous studies based on a population with occasional NBP. Sleep disturbance is a modifiable factor, and cognitive behaviour therapy is a recommended treatment for insomnia, the most common sleep disturbance[38]. There is also some evidence that cognitive therapy for insomnia may improve other health problems such as depression and anxiety; thus, treating sleep problems may also improve comorbid conditions that in turn are often related to pain [39]. It is, therefore, possible that treating sleep problems in persons with occasional NBP may reduce the risk of activity limiting pain, but this needs to be evaluated in future studies.

Strengths

This is a population-based longitudinal study covering residents in the largest county in Sweden with a large sample size allowing interaction analysis. Another strength is the thorough control for possible confounding factors in the analyses. Furthermore, although almost 1/3 of the study participants had dropped out at the follow up in 2014, the prevalence of the main exposure was 11% and 15% of these successfully followed versus the dropouts. We believe that selection bias has a minor impact on the results, although this cannot be fully ruled out. If the exposed participants who dropped out were less likely to have the outcome compared to the exposed participants who were successfully followed, we may have overestimated the true effect. We excluded those who in 2010 reported that they had a sickness absence of more than 90 days during the 12 months preceding entry to the study.

The reason for this was to avoid the issue of major morbidity influencing the participants' judgment of their work ability for illness not related to NBP, and thus also reducing the risk of null findings when there would be a true risk.

Limitations

The main limitations are possible misclassification due to imprecise or time-varying exposure, resulting in a non-differential exposure misclassification which, if any, will have led to a dilution of the effect estimate. In particular, we believe that the way sleep disturbances were measured may be prone to misclassification. One single question with three response alternatives may not fully capture the concept of sleep disturbances.

Also, work ability may be prone to non-differential misclassification, since we did not have access to the full WAI. However, these single questions on perceived work ability in relation to job demands have previously been validated, both against the full WAI[13] and when used as predictors for sickness absences with acceptable results[12]. Nevertheless, if anything, such misclassification bias would lead to diluted associations. Furthermore, the exposure work ability may change over the follow-up period, most likely due to a job change. Exactly the same proportion among cases and non-cases had changed job/new employer in 2014 compared to 2010, (28%), which to some extent reduces the likelihood of differential misclassification of work ability.

There is also a risk of residual confounding due to unprecise measure of confounding factors, such as physical activity, sedentary leisure time activities and smoking, as well as unmeasured confounding. Such bias may have led to under or overestimation of the results. During a four-year follow-up, time varying prognostic factors, among others treatment for NBP, may have had an impact on the risk of developing LNBP. Since these are present

among exposed as well as un-exposed, the most likely effect of such factors would be a dilution of the associations reported.

We claim that the results of our study are generalizable to other settings on persons active in working life. Even though the study showed that the absolute risk of LNBP is modest, with less than 10% of those with occasional NBP developing the more severe condition according to our definition, it is a major and expensive public health problem that accumulates over time.

This study adds knowledge to the area of why persons with occasional NBP develop long-duration and activity limiting NBP. Paying attention to persons with occasional NBP who have poor perceived work ability and/or sleep disturbances, and taking action accordingly, may reduce this burden of ill-health. We welcome future research on the effect of occupational preventive measures for workers with poor work ability.

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AUTHOR CONTRIBUTIONS

LWH, TB, ML and ES contributed to the conceptualisation and methodology of the study which was approved by CM. CM provided the data resources. LWH made the statistical analyses based on a protocol approved by the co-authors. LWH wrote a draft of the manuscript. All authors contributed to the interpretation of the results and critically revised the manuscript and finally approved the last version.

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COMPETING INTERESTS

Dr:s Eva Skillgate and Lena Holm are scientific consultants at the Scandinavian College of Naprapathic Manual Medicine and members of their Scientific Board.

ETHICS APPROVAL

Ethical approval was obtained from the regional ethical review board in Stockholm (Dnr; 2007/545-31, 2013/497-32 and 2015/1204-32). The questionnaires included information about handling of personal data, and the participants accepted the use of their data by answering to the questionnaires (written informed consent).

DATA SHARING STATEMENT

Due to ethical restrictions and laws (GDPR) of disclosing personal data, authors have to seek permission to allow us to make the data used in this study available. Data will be available upon request after permission is granted from the Karolinska Institutet's Ethics Review Board in Stockholm. Inquiries for data access should first be sent to eva.skillgate@ki.se, who will then contact the ethics board for permission to openly share the data.

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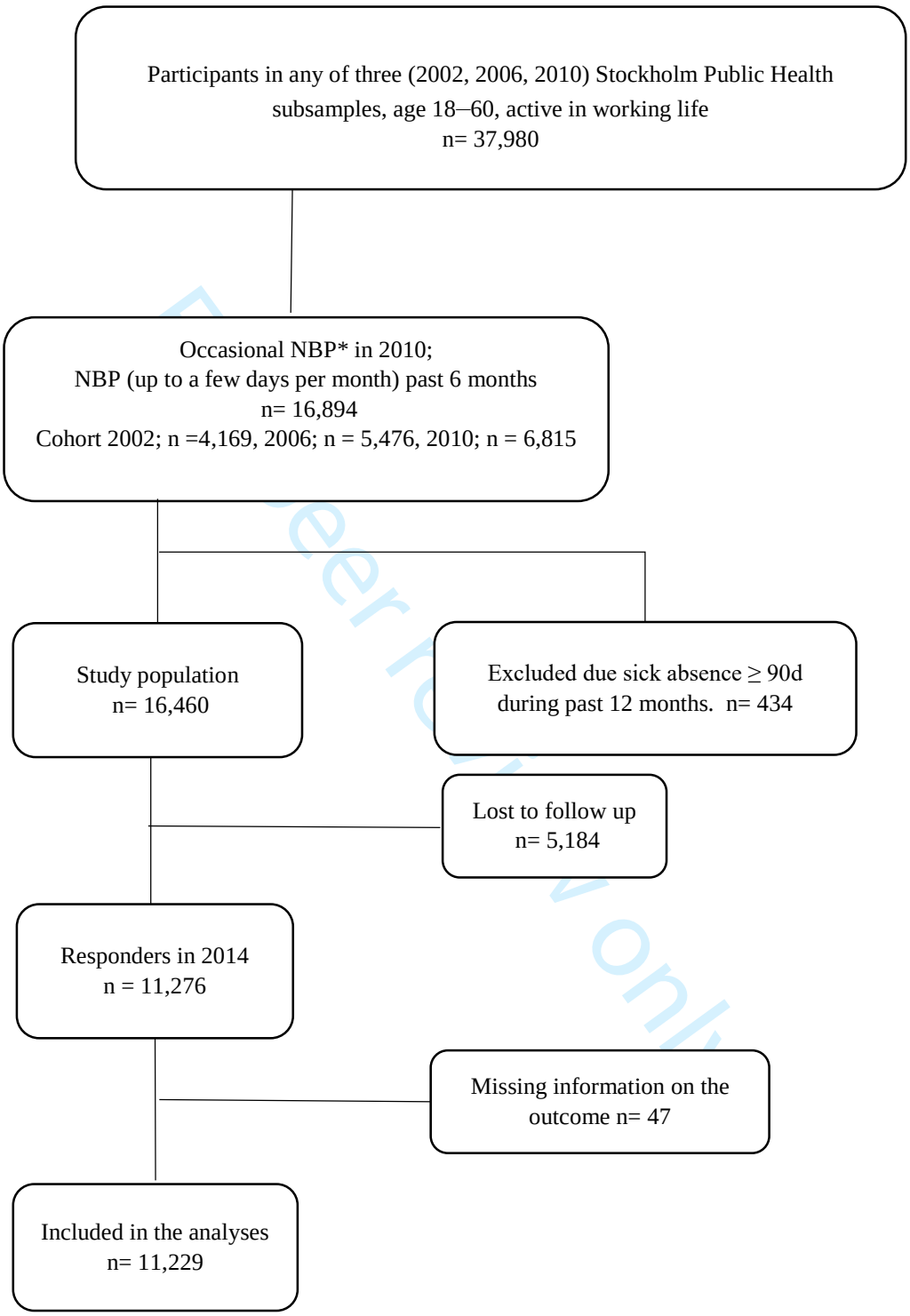
Figure 1. Flowchart of the inclusion of the study population and follow up.

* NBP; neck and/or back pain.


Participants in any of three (2002, 2006, 2010) Stockholm Public Health subsamples, age 18–60, active in working life
n= 37,980
Occasional NBP* in 2010;
NBP (up to a few days per month) past 6 months
n= 16,894
Cohort 2002; n =4,169, 2006; n = 5,476, 2010; n = 6,815
Study population
n= 16,460
Excluded due sick absence ≥ 90d during past 12 months. n= 434
Lost to follow up
n= 5,184
Responders in 2014
n = 11,276
Missing information on the outcome n= 47
Included in the analyses
n= 11,229

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Considered
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	yes
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	yes
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Yes pp 5; lines 3 – 8, 14-18 Pp 7 lines 3-6
Objectives	3	State specific objectives, including any prespecified hypotheses	Yes pp 7 lines 6-9
Methods			
Study design	4	Present key elements of study design early in the paper	Yes pp 8 Lines 3-4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Yes Pp 8 , lines 3-24, pp9 lines 1-13
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Yes pp 8, lines 9-18 Pp 9 lines 15-17
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Yes Pp 8 lines 19-24 pp -9, lines 1-22
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Yes Table 1 + pp 8-9
Bias	9	Describe any efforts to address potential sources of bias	Yes Pp 25 Lines 7-23
Study size	10	Explain how the study size was arrived at	Yes Figure 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Yes Table 1 Pp 8 Lines 20-24, pp 9, lines 1-13, pp 12- Lines 9-12
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Yes pp 9, lines 18-22, pp 11, lines 3-24
		(*b*) Describe any methods used to examine subgroups and interactions	Yes pp 12 lines 9- 13
		(*c*) Explain how missing data were addressed	Yes table 2

		(*d*) If applicable, explain how loss to follow-up was addressed	Yes pp 12 . lines 20-23
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(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	Yes Figure 1
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	Yes Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Yes Table 2 Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Yes Table 2
		(c) Summarise follow-up time (eg, average and total amount)	Yes 4 years pp 8 lines 6-7
Outcome data	15*	Report numbers of outcome events or summary measures over time	Yes Pp 15 line 2
Main results	16	(*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	Yes Pp 15 lines 6-14 -Tables 3 a and 3 b
		(*b*) Report category boundaries when continuous variables were categorized	Yes Table 1 and 2
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Yes tabl4 4 and pp 21 lines 2-7
Discussion			
Key results	18	Summarise key results with reference to study objectives	Yes pp 23. Lines 3-7
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Yes Pp 25 lines 7-23
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Yes pp 26 lines 6-10
Generalisability	21	Discuss the generalisability (external validity) of the study results	yes Yes pp 26 lines 1-5
Other information			
Funding	22	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	Yes pp 25, lines 22-23

*Give information separately for exposed and unexposed groups.

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 http://www.strobe-statement.org.

BMJ Open

Risk of transition from occasional neck/back pain to long-duration activity limiting neck/back pain: A cohort study on the influence of poor work ability and sleep disturbances in the working population in Stockholm County

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Risk of transition from occasional neck/back pain to long-duration activity limiting neck/back pain: A cohort study on the influence of poor work ability and sleep disturbances in the working population in Stockholm County

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ABSTRACT

Objectives: The prevalence of neck/back pain (NBP) is high worldwide. Limited number of studies have investigated workers with occasional NBP regarding the risk of developing long-duration activity limiting NBP (LNBP). The objectives were to assess (1) the effect of poor work ability and sleep disturbances in persons with occasional NBP on the risk of LNBP, (2) the interaction effect of these exposures.

Design: Cohort study based on three subsamples from the Stockholm Public Health Cohort.

Settings*:* The working population in Stockholm County.

Participants*:* Persons aged 18–60, reporting occasional NBP the past 6 months at baseline year 2010 (n=16,460).

Measures*:* Work ability was assessed with items from the Work Ability Index, perceived mental and/or physical work ability. Sleep disturbances were self-reported current mild/severe disturbances. The outcome in year 2014; reporting NBP the previous 6 months, occurring ≥ couple of days per week and resulting in decreased work ability/restricted other daily activities. The additive effect of having both poor work ability and sleep disturbances was modelled with a dummy variable, including both exposures. Poisson log linear regression was used to calculate risk ratios (RR) and 95% confidence intervals (95% CI).

Results: At follow up, 9% had developed LNBP. Poor work ability and sleep disturbances were independent risk factors for LNBP; adjusted RR 1.7;(95%CI:1.4-2.0) and 1.4;(95%CI:1.2-1.5) respectively. No additive interaction was observed.

Conclusion: Workers with occasional NBP who have poor work ability and/or sleep disturbances are at risk of developing long-duration activity limiting NBP. Having both conditions does not exceed additive risk.

ARTICLE SUMMARY

Strengths and limitations of this study

- A longitudinal design and the exposures were measured at baseline and the outcome at follow-up four years later, thus the temporality has been taken care of.
- Large study population securing statistical power.
- A comprehensive control of confounding factors increases the possibility of causality.
- The main possible limitation is the misclassification of the exposures and the outcome and would, if any, result in an underestimation of the results.

INTRODUCTION

Despite decades of research aiming to understand how to prevent and treat long-duration activity limiting neck and/or back pain (LNBP), these health conditions seem to increase over time and are the leading causes of disability globally[1, 2]. Preventive measures are necessary in order to reduce the burden of disease in society and require a knowledge of modifiable risk factors. A recent systemic review of risk factors for the onset of "first episode" neck pain concludes that personal as well as work-related factors play a role in the development of neck pain, some of which are modifiable while others are not [3]. Another systematic review concludes that physical activity may reduce the risk of long-duration low back pain, [4] while the evidence of risk factors for recurrence of low back pain,[5] and neck pain,[6] is sparse. Most people experience recurrent occasional short duration NBP, and it is necessary to identify the factors involved in the transition to long-duration and activity limiting pain conditions in order to address these in prevention measures.

Self-perceived work ability is a concept which has been widely studied in occupational settings, often as a predictor of future sickness absence,[7, 8], but it has also been shown to be associated with outcomes such as health-related production loss,[9] and work turnover [10]. A frequently used measurement is the Work Ability Index (WAI) and its subscales. WAI consists of seven items including two about perceived work ability in relation to physical and mental work demands[11]. Ahlstrom et al.,[12] used both the full WAI and the single item WAI-S; "current work ability compared with the lifetime best", and found that both were associated with sickness absenteeism over a 12-month period . Lundin et al. found that this single WAI item had an excellent ability to predict long-term sickness absence, and also that the two items covering perceived mental and physical work ability had acceptable predictive validity [13].

Little is known about the impact of perceived work ability on the development of NBP. A recent clinical study of primary care patients with low back pain found an association between higher work ability measured with the WAI item "current work ability compared with the lifetime best" and improvement in work ability, pain and quality of life at follow up[14], but other than this, the topic appears to have escaped scientific investigation despite the construct's connection to future ill-health.

It is well-established that impaired sleep increases the risk of several health problems of varying severity, for instance all-cause cardiopulmonary mortality, respiratory tract infections, hypertension as well as depression[15-17]. Current evidence suggests that sleep disturbances are a risk factor for the onset of NBP [18], as well as a prognostic factor in subacute or long-lasting pain conditions,[19, 20], and for sickness absence[21]. Hypothesizing that poor work ability and sleep disturbances are independent risk factors for the development of LNBP, it is possible that having both factors results in a synergistic effect.

Few studies have focused on workers with occasional NBP and their risk of LNBP. We have previously studied job strain and sleep disturbances,[22, 23] regarding the risk of LNBP and have found that high job strain (high job demands/low job control) and active jobs (high job demands/high job control) as well as sleep disturbances were independent risk factors, but the estimates were modest for both conditions. The results also indicated that sleep disturbances may modify the association between high job strain and long-duration activity limiting neck pain, [22], but this was not the case for back pain[23]. In another study, also based on workers with occasional neck pain, work-related and leisure time physical activity were assessed for the risk of long-duration activity limiting neck pain, but no associations were found[24].

In summary, there is some evidence that poor perceived work ability and sleep disturbances contribute both to the onset of and the recovery from pain conditions, however little is known about the transitions from occasional pain to long-duration pain that affects daily activities, including the spectra from minor restrictions to full work disability. The primary aim of this study was to assess the effect of poor mental and/or poor physical work ability and sleep disturbances, respectively, in persons with occasional NBP, for the risk of developing LNBP. A secondary aim was to assess the additive interaction effect between these two exposures.

MATERIAL AND METHODS

Design, source and study population

A prospective cohort was formed based on three subsamples of the Stockholm Public Health Cohort; one recruited in year 2002 and followed up in year 2006, 2010 and 2014, one formed in 2006 and followed up in 2010 and 2014, and a third formed in 2010 and followed up in 2014. We used the 2010 and 2014 waves as baseline and follow-up, respectively, in all subsamples. The data used (i.e. the questions) were defined in the same way in these subsamples in 2010 and 2014.

Men and women, aged 18–60 who were participating in any of the three subsamples in 2010 were included if they reported NBP during the past six months up to a couple of days per month but not more often, and were responding to any of two items from the WAI); physical and mental capacity in relation to work demands (indicating that the persons were active in working life) at baseline. NBP was defined based on the questions: "Have you had any pain in your upper back or neck in the preceding 6 months?", and "Have you had any pain in your lower back in the preceding 6 months?". Persons who responded "Yes, a couple of days per month or less frequent" to one or both of these questions fulfilled the criteria for NBP.

Persons with sickness absence of more than 90 days during the past 12 months were excluded.

Exposures

The exposure self-perceived physical work ability and mental work ability in relation to work demands was measured with two questions from the WAI. The psychometric properties of this instrument have been tested,[25, 26], and it is considered stable at a group level, predictive and internally coherent. Physical work ability was measured with the question: "How do you rate your current work ability with respect to the physical demands of your

work?" The answering alternatives were: "Very good", "Good", "Moderate"," Rather poor", and "Poor". The variable was dichotomised into poor work ability ("Moderate", "Rather poor" or "Poor"), and good work ability ("Very good" or "Rather good"). Mental work ability was measured with the question: "How do you rate your current work ability with respect to the psychological and mental demands of your work?" The alternative response for mental work ability were the same as for physical work ability and the variable was dichotomised in the same way. The two items were then merged into "poor work ability" ("Moderate", "Rather poor", "Poor" in one or both of the items), whereas those scoring "Good" or "Very good" on both items, were categorised as having "Good work ability" (non-exposed).

The exposure sleep disturbances were defined as having responded "Yes mild" or "Yes severe" to the question "Do you have sleep disturbances?". Those responding "No" were classified as unexposed.

Outcome

The outcome LNBP was operationalised by the response from the 2014 questionnaire and was defined as having reported NBP during the past 6 months, occurring a couple of days per week or more often, and resulting in a decreased work ability/restricted other daily activity.

Confounding control

We investigated several potential confounders, based on relevance and on the literature on risk factors for long lasting NBP (table 1). For the work ability exposure, one model was run, adding sleep disturbances as a confounder, and similarly for the model sleep disturbances, one model was run adding work ability as a confounder.

1 Table 1. Description of the variables, tested as potential confounders

Variables	Operationalisation [1]
Age	Continuous and categorised in 5-year intervals
Sex	Man/Woman
Socioeconomic Status	Based on occupational class, classified according to the Swedish socioeconomic classification, developed by Statistics Sweden and retrieved from National Register in Sweden: A combination of current occupation and highest educational level (6 categories)
Body Mass Index	Continuous and categorised into Underweight <18.5, Normal weight 18.5–24.9, Overweight 25–29.9, Obese ≥ 30
Daily Smoking	Question: "Are you currently smoking daily or almost daily" Response alternatives: "Yes," "No"
Sedentary Leisure Time Activity	"State your average physical activity during the past 12 months"; Leisure time sitting; watching, TV, reading. The response alternatives were added up and categorised into <2 hrs/day, 2-3 hrs/day, and more than 3 hrs/day
Physical Activity	"State your physical activity (PA) during the past 12 months" categorised into Walking/cycling less than 20 min/day AND other leisure time PA less than 1 hr/week vs PA (walking/biking, other PA) exceeding these time durations

Household Composition	Three categories; adult living alone, adult living with other adult(s) with/without children, adult living with children
Psychological Distress	Derived from the General Health Questionnaire (GHQ12) [27, 28] and categorized into < 3, 3–7 and > 7.
Long-standing illness	The question "Do you have any long-duration sickness, health problems as a result of an accident, handicap or other long-duration health problem?" Response alternatives: "Yes ","No"

[1] All variables were retrieved from the baseline questionnaire except Socioeconomic Status, which is retrieved from National Swedish Registers

Statistical Methods

Generalized Linear models with Poisson log linear regression was used to estimate the association between the exposures and the outcome. The results are presented as a risk ratio (RR) with 95% confidence intervals (CI). We ran four adjusted models. For work ability, the first model excluding and the second including sleep disturbances, and for sleep disturbances, one model excluding and the second including work ability. This was done since it might be argued that these factors act as mediators rather than confounders.

To assess whether the interaction between the two risk factors poor work ability and sleep disturbances deviated from additivity regarding the risk of developing LNBP, we created a dummy variable: having poor work ability/no sleep disturbances, no poor work ability/sleep disturbances, both poor work ability and sleep disturbances[29]. Having none of the conditions served as a reference, and this model was run in a Poisson log linear regression.

Factors potentially confounding the effect between the exposures and the outcome were added one at the time to each univariate model. If the crude estimate changed by 5% or more, the factor was considered a confounder and was included in the adjusted model. We also added a variable including the origin of the three subsamples, since, for two of the merged subsamples, the first and second follow-up wave respectively were used as baseline in our study.

To assess the potential selection bias, attrition analysis was conducted by comparing the prevalence of the main exposure, work ability, among those lost to follow-up and those with missing data on any of the outcome variables, with the prevalence of this exposure among those successfully followed.

IBM® SPSS Statistics version 25 was used.

Patient and Public Involvement

Patients or the public were not involved in the design or planning of the study.

RESULTS

The total study population was 16,460. Of those, 11,276 were successfully followed up and 11,229 responded to the back/neck pain questions, which gives a follow-up rate of 68%, (figure 1).

Of the 16,460 participants, 1,989 (12%) reported poor work ability and 1,392 (8%) reported mild or severe sleep disturbances at baseline. A detailed description of the study population is displayed in table 2 and stratified into those with poor versus good work ability. Age and sex were relatively evenly distributed across the two groups. The most common occupations represented were intermediate non-manual workers and employed/self-employed professionals/higher civil servants/executives.

Table 2. Baseline characteristics of the study population in relation to work ability (n=16,460)

Characteristic	Good work ability n: 14,471 (88%)		Poor[1] work ability n: 1,989 (12%)	
	n	%	n	%
Female	8,279	57	1,252	63
Age Mean (SD)	43.2	10.0	42.9	10.5
Age Median (min-max)	44	18–60	44	18–60
Socioeconomic Status				
Unskilled/semiskilled workers	1,498	11	406	22
Skilled workers	1,401	10	248	13
Assistant non-manual workers	1,932	14	244	13
Intermediate non-manual workers	4,164	30	468	25
Employed/self-employed professionals,	3,501	25	333	18
Self-employed other than professionals	1,283	9	169	9
Household composition				
Living together with adult (with or without children)	11,628	81	1,464	74
Living with children	805	5	147	7
Living alone	1,990	14	369	19
Body Mass Index, kg/m^2				
< 18,5	187	1	39	2
18.5–24.9	7,978	56	1,022	53
25.0–29.9	4,628	33	600	31

≥ 30.0	1,446	10	281	15
Daily Smoking	1,424	10	320	16
Physical Activity[2]				
None or low (less than 1 hr/w)	1,989	14	445	23
Intermediate	8,730	60	1,149	58
High	3,288	23	336	17
Very High (more than 5 hrs /w)	424	3	47	2
Sedentary leisure time (TV, reading etc.)				
< 2 hrs/day	9,111	63	1,038	53
2–3 hrs/day	3,740	26	578	29
More than 3 hrs/day	1,558	11	360	18
Sleep disturbances				
No	10,478	73	914	47
Yes, mild	355	25	866	44
Yes, severe	237	2	169	9
Psychological Distress (GHQ12 [3])				
No (0-2)	12,250	85	1,005	51
Mild (3-6)	1,590	11	485	25
Severe (7-12)	602	4	493	25
Long-standing illness	8,200	22	3,837	54

[1] WAI (Work Ability Index) items[11], self-perceived physical and/or mental work ability in relation to job demands and defined as moderate, rather poor, poor. [2] Defined as a combination of cycling/walking and other physical activity expressed as hours per week

[3] GHQ12 General Health Questionnaire – 12 items[27].Total numbers across rows differ due to internal missing values

In 2014, 1,056 (9%) of the 11,229 responders had developed LNBP. Those successfully followed-up were compared with those who dropped out/had missing information on the outcome (n=5,231), with respect to the main exposure work ability. Fifteen percent of the dropouts had poor work ability compared to 11% among those successfully followed-up.

The results of the Poisson log linear regression analyses are presented in tables 3 and 4. Of those with poor work ability, 214 (18%) participants developed LNBP. The confounders in this association were socioeconomic status (SES) and long-standing illness and were therefore adjusted for, yielding an RR of 1.8 (95% CI;1.6–2.2). Adding sleep disturbances to the model yields an RR of 1.7 (95% CI; 1.4–2.0) (table 3 a).

Of those with sleep disturbances, 411 (13%) developed LNBP. Socioeconomic status (SES) and long-standing illness were confounders also in the association between sleep disturbances and the outcome (adjusted RR 1.5 (95%CI; 1.3–1.7)). Adding poor work ability to the model yields an RR of 1.4 (95%CI:1.2–1.6) (table 3b).

Table 3. Association between poor work ability[1] (a) and sleep disturbances[2] (b) and long-duration activity limiting neck -and/or back pain. Risk Ratio (RR) and 95% Confidence Interval (95%CI)

(a)	Cases/ All	Crude RR	95 % CI	Model 1[3] Adjusted RR	95% CI	Model 2 [4]Adjusted RR	95% CI
Good work ability	842/10,011	ref		ref		ref	
Poor work ability[1]	214/1,218	2.1	(1.8-2.4)	1.8	(1.6-2.1)	1.7	(1.4-2.0)
(b)	Cases/ All	Crude RR	95 % CI	Model 1[3] Adjusted RR	95% CI	Model 2 [5]Adjusted RR	95% CI
Good sleep	625/7,833	ref		ref		ref	
Sleep disturbances [2]	411 /3,257	1.6	(1.4-1.8)	1.5	(1.3-1.7)	1.4	(1.2-1.5)

[1] WAI (Work Ability Index) items, self-perceived physical and/or mental work ability in relation to job demands and defined as moderate, rather poor, poor. [2] Sleep disturbances = current mild or severe sleep disturbances. [3] Adjusted for socioeconomic status, chronic comorbidity and subsample (year 2002, 2006, 2010). [4] Adjusted for socioeconomic status, chronic comorbidity, sleep disturbances and subsample (year 2002, 2006, 2010). [5]Adjusted for socioeconomic status, chronic comorbidity, work ability and subsample (year 2002, 2006, 2010)

The analysis including the interaction variable, poor work ability and sleep disturbances, showed after adjusting for SES and chronic comorbidity that those solely with poor WAI had a doubly increased risk of developing LNBP (RR 2.1 (95% CI; 1.7–2.6) compared to those with none of the risk factors. Having sleep disturbances solely yields an RR 1.5 (95% CI; 1.3–1.7) and having both conditions was similar to having poor WAI only (RR 2.1 (95%CI;1.7–2.6) (table 4).

Table 4. Association between different combinations of poor work ability[1] and sleep disturbances[2,] and long-duration activity limiting neck - and/or back pain.

Risk Ratio (RR) and 95% Confidence Interval (95%CI)

	Cases/ All	Crude RR	95 % CI	Adjusted[3] RR	95% CI
Good work ability/ No sleep disturbances	534/7,281	ref		ref	
Poor work ability / No sleep disturbances	91/552	2.4	(2.0-3.0)	2.1	(1.7-2.6)
Good work ability /Sleep disturbances	294/2,610	1.5	(1.3-1.8)	1.5	(1.3-1.7)
Poor work ability /Sleep disturbances	117/647	2.4	(1.9-2.9)	2.1	(1.6-2.6)

[1] Assessed with WAI (Work Ability Index) items, self-perceived physical and/or mental work ability in relation to job demands and defined as moderate, rather poor, poor. [2] Sleep disturbances = current mild or severe sleep disturbances. [3] Adjusted for socioeconomic status, long-standing illness and subsample (year 2002, 2006, 2010)

DISCUSSION

The results of this study suggest that persons with occasional NBP who assess their work ability (mental and/or physical) as poor, in relation to the work demands, have a higher risk of developing LNBP. Also, those who reported sleep disturbances have a higher risk of such an outcome. The risk in persons with both poor work ability and sleep disturbances was not more than additive.

When it comes to research about work ability and NBP, we only found one earlier study, namely on primary care patients with various durations of low back pain. In that prognostic study, they used another item from the WAI when predicting decrease in disability[14], thus it is not comparable to our risk study.

The majority of published studies using items from the WAI, when measuring work ability and its impact on health, have sickness absence as the outcome[7, 8, 30, 31]. In the present study,we note that only 1/3 of the cases had a history of sickness absence in the year prior to the follow up, thus our study adds new knowledge to this topic, since the outcome in our study is not equal or similar to sickness absenteeism or disability pension investigated in previous studies.

Perceived physical and/or mental work ability in relation to work demands are theoretically modifiable factors, although they are not always easy to change without changing job or employer. Poor work ability has been shown to be associated with high work turnover[10], thus job change may be an option in order to prevent long-duration activity limiting pain conditions. Another option might be that the employee in dialogue with their employer investigates the possibilities of changes within the current job, or that the individual takes their own responsibility for physical and mental health maintenances through self-care such as leisure time physical activity or similar actions.

Several studies have shown that sleep disturbance or daytime sleepiness are risk factors for the onset of NBP as well as a factor that impedes recovery[32-34], and are also a risk factor for the onset of musculoskeletal pain in general[35, 36]. One likely mechanism behind the association between sleep disturbances and pain is elevated levels of inflammatory markers triggering the onset of, and continuation of pain[37]. We have, however, not found any previous studies based on a population with occasional NBP. Sleep disturbance is a modifiable factor, and cognitive behaviour therapy is a recommended treatment for insomnia, the most common sleep disturbance[38]. There is also some evidence that cognitive therapy for insomnia may improve other health problems such as depression and anxiety; thus, treating sleep problems may also improve comorbid conditions that in turn are often related to pain [39]. It is, therefore, possible that treating sleep problems in persons with occasional NBP may reduce the risk of activity limiting pain, but this needs to be evaluated in future studies.

Strengths

This is a population-based longitudinal study covering residents in the largest county in Sweden with a large sample size allowing interaction analysis. Another strength is the thorough control for possible confounding factors in the analyses. Furthermore, although almost 1/3 of the study participants had dropped out at the follow up in 2014, the prevalence of the main exposure was 11% and 15% of these successfully followed versus the dropouts. We believe that selection bias has a minor impact on the results, although this cannot be fully ruled out. If the exposed participants who dropped out were less likely to have the outcome compared to the exposed participants who were successfully followed, we may have overestimated the true effect. We excluded those who in 2010 reported that they had a sickness absence of more than 90 days during the 12 months preceding entry to the study.

The reason for this was to avoid the issue of major morbidity influencing the participants' judgment of their work ability for illness not related to NBP, and thus also reducing the risk of null findings when there would be a true risk.

Limitations

The main limitations are possible misclassification due to imprecise or time-varying exposure, resulting in a non-differential exposure misclassification which, if any, will have led to a dilution of the effect estimate. In particular, we believe that the way sleep disturbances were measured may be prone to misclassification. One single question with three response alternatives may not fully capture the concept of sleep disturbances.

Also, work ability may be prone to non-differential misclassification, since we did not have access to the full WAI. However, these single questions on perceived work ability in relation to job demands have previously been validated, both against the full WAI[13] and when used as predictors for sickness absences with acceptable results[12]. Nevertheless, if anything, such misclassification bias would lead to diluted associations. Furthermore, the exposure work ability may change over the follow-up period, most likely due to a job change. Exactly the same proportion among cases and non-cases had changed job/new employer in 2014 compared to 2010, (28%), which to some extent reduces the likelihood of differential misclassification of work ability.

There is also a risk of residual confounding due to unprecise measure of confounding factors, such as physical activity, sedentary leisure time activities and smoking, as well as unmeasured confounding. Such bias may have led to under or overestimation of the results. During a four-year follow-up, time varying prognostic factors, among others treatment for NBP, may have had an impact on the risk of developing LNBP. Since these are present

among exposed as well as un-exposed, the most likely effect of such factors would be a dilution of the associations reported.

We claim that the results of our study are generalizable to other settings on persons active in working life. Even though the study showed that the absolute risk of LNBP is modest, with less than 10% of those with occasional NBP developing the more severe condition according to our definition, it is a major and expensive public health problem that accumulates over time.

This study adds knowledge to the area of why persons with occasional NBP develop long-duration and activity limiting NBP. Paying attention to persons with occasional NBP who have poor perceived work ability and/or sleep disturbances, and taking action accordingly, may reduce this burden of ill-health. We welcome future research on the effect of occupational preventive measures for workers with poor work ability.

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AUTHOR CONTRIBUTIONS

LWH, TB, ML and ES contributed to the conceptualisation and methodology of the study which was approved by CM. CM provided the data resources. LWH made the statistical analyses based on a protocol approved by the co-authors. LWH wrote a draft of the manuscript. All authors contributed to the interpretation of the results and critically revised the manuscript and finally approved the last version.

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COMPETING INTERESTS

Dr:s Eva Skillgate and Lena Holm are scientific consultants at the Scandinavian College of Naprapathic Manual Medicine and members of their Scientific Board.

ETHICS APPROVAL

Ethical approval was obtained from the regional ethical review board in Stockholm (Dnr; 2007/545-31, 2013/497-32 and 2015/1204-32). The questionnaires included information about handling of personal data, and the participants accepted the use of their data by answering to the questionnaires (written informed consent).

DATA SHARING STATEMENT

Due to ethical restrictions and laws (GDPR) of disclosing personal data, authors have to seek permission to allow us to make the data used in this study available. Data will be available upon request after permission is granted from the Karolinska Institutet's Ethics Review Board in Stockholm. Inquiries for data access should first be sent to eva.skillgate@ki.se, who will then contact the ethics board for permission to openly share the data.

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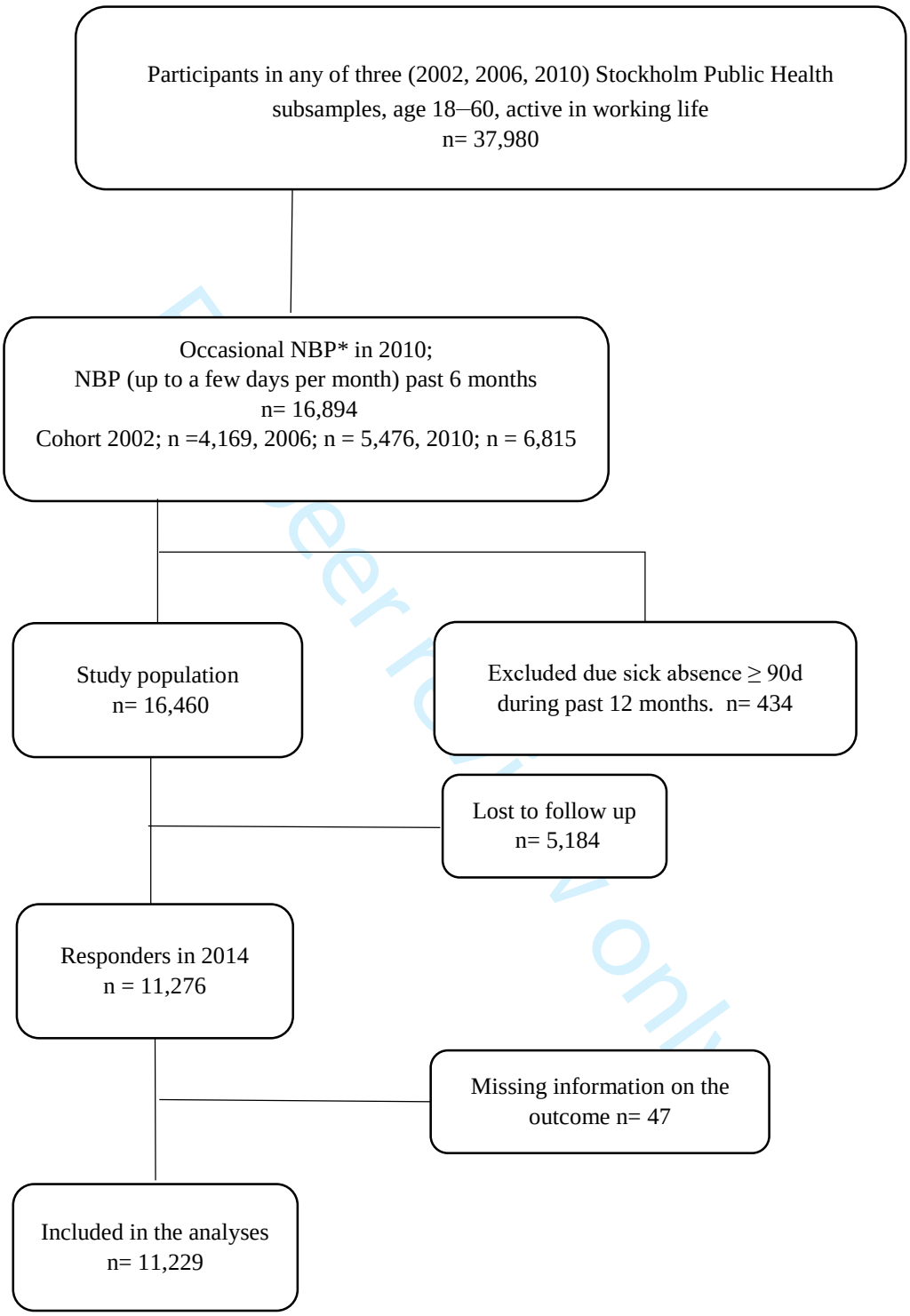
Figure 1. Flowchart of the inclusion of the study population and follow up.

* NBP; neck and/or back pain.


Participants in any of three (2002, 2006, 2010) Stockholm Public Health subsamples, age 18–60, active in working life
n= 37,980
Occasional NBP* in 2010;
NBP (up to a few days per month) past 6 months
n= 16,894
Cohort 2002; n =4,169, 2006; n = 5,476, 2010; n = 6,815
Study population
n= 16,460
Excluded due sick absence ≥ 90d during past 12 months. n= 434
Lost to follow up
n= 5,184
Responders in 2014
n = 11,276
Missing information on the outcome n= 47
Included in the analyses
n= 11,229

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

	Item No	Recommendation	Considered
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	yes
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	yes
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	Yes pp 5; lines 3 – 8, 14-18 Pp 7 lines 3-6
Objectives	3	State specific objectives, including any prespecified hypotheses	Yes pp 7 lines 6-9
Methods			
Study design	4	Present key elements of study design early in the paper	Yes pp 8 Lines 3-4
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	Yes Pp 8 , lines 3-24, pp9 lines 1-13
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up	Yes pp 8, lines 9-18 Pp 9 lines 15-17
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed	NA
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	Yes Pp 8 lines 19-24 pp -9, lines 1-22
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	Yes Table 1 + pp 8-9
Bias	9	Describe any efforts to address potential sources of bias	Yes Pp 25 Lines 7-23
Study size	10	Explain how the study size was arrived at	Yes Figure 1
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	Yes Table 1 Pp 8 Lines 20-24, pp 9, lines 1-13, pp 12- Lines 9-12
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	Yes pp 9, lines 18-22, pp 11, lines 3-24
		(*b*) Describe any methods used to examine subgroups and interactions	Yes pp 12 lines 9- 13
		(*c*) Explain how missing data were addressed	Yes table 2

		(*d*) If applicable, explain how loss to follow-up was addressed	Yes pp 12 . lines 20-23
		(*e*) Describe any sensitivity analyses	NA
Results			
Participants	13*	(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	Yes Figure 1
		(b) Give reasons for non-participation at each stage	NA
		(c) Consider use of a flow diagram	Yes Figure 1
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	Yes Table 2 Table 1
		(b) Indicate number of participants with missing data for each variable of interest	Yes Table 2
		(c) Summarise follow-up time (eg, average and total amount)	Yes 4 years pp 8 lines 6-7
Outcome data	15*	Report numbers of outcome events or summary measures over time	Yes Pp 15 line 2
Main results	16	(*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	Yes Pp 15 lines 6-14 -Tables 3 a and 3 b
		(*b*) Report category boundaries when continuous variables were categorized	Yes Table 1 and 2
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	Yes tabl4 4 and pp 21 lines 2-7
Discussion			
Key results	18	Summarise key results with reference to study objectives	Yes pp 23. Lines 3-7
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	Yes Pp 25 lines 7-23
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	Yes pp 26 lines 6-10
Generalisability	21	Discuss the generalisability (external validity) of the study results	yes Yes pp 26 lines 1-5
Other information			
Funding	22	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	Yes pp 25, lines 22-23

*Give information separately for exposed and unexposed groups.

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 http://www.strobe-statement.org.