BMJ Open

The influence of work ability and smoking on the prognosis of long-duration activity-limiting neck/back pain – a cohort study of a Swedish working population

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-054512
Article Type:	Original research
Date Submitted by the Author:	14-Jun-2021
Complete List of Authors:	Bohman, Tony; Karolinska Institutet, Institute of Environmental Medicine; Dalarna University School of Education Health and Social Studies Holm, Lena; Karolinska Institutet, Institute of Environmental Medicine Lekander, Mats; Stockholm University, Stress Research Institute; Karolinska Institutet, Department of Clinical Neuroscience Hallqvist, Johan; Uppsala University, Department of Public Health and Caring Sciences Skillgate, Eva; Karolinska Institutet, Institute of Environmental Medicine; Sophiahemmet University, Department of health promotion science
Keywords:	Musculoskeletal disorders < ORTHOPAEDIC & TRAUMA SURGERY, PUBLIC HEALTH, EPIDEMIOLOGY, Back pain < ORTHOPAEDIC & TRAUMA SURGERY

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

The influence of work ability and smoking on the prognosis of long-duration activity-limiting neck/back pain – a cohort study of a Swedish working population

Tony Bohman[1,2]*, Lena W Holm[1], Mats Lekander[3,4], Johan Hallqvist[5], Eva Skillgate[1,6]

[1]Institute of Environmental Medicine, Unit of Intervention and Implementation Research for Worker Health, Karolinska Institutet, Stockholm, Sweden

[2]School of Education, Health and Social Studies, Dalarna University, Sweden

[3]Stress Research Institute, Stockholm University, Sweden

[4]Department of Clinical Neuroscience, Karolinska Institutet, Stockholm, Sweden

[5]Department of Public Health and Caring Sciences, Family Medicine and Preventive Medicine, Uppsala University, Uppsala, Sweden

[6]Department of health promotion science, Musculoskeletal & Sports Injury Epidemiology Center, Sophiahemmet University, Stockholm, Sweden

*Corresponding author:

Tony Bohman

Institute of Environmental Medicine, Unit of Intervention and Implementation Research for Worker Health, Karolinska Institutet, Box 210, SE-171 77 Stockholm, Sweden

E-mail: tony.bohman@ki.se

Cell phone: +46 70 299 62 63

Abstract

Objectives

Long-duration activity-limiting neck/back pain is common, but the knowledge of what work and lifestyle factors that influence the prognosis is sparse. The objective was therefore to here evaluate if two factors, good self-perceived work ability and no daily smoking, are associated with a favourable prognosis of long-duration activity-limiting neck/back pain in a working population, and if these exposures have a synergistic prognostic effect.

Design

A prospective cohort study based on three subsamples from the Stockholm Public Health Cohort.

Settings

A working population in Stockholm County.

Participants

Individuals, 18-61 years old, reporting long-duration activity-limiting neck/back pain the previous six months at baseline in 2010 (n=5,177).

Measures

The exposures were: self-perceived work ability (categorised into good, moderate, and poor), and daily smoking (no/yes). The outcome in 2014 was "absence of long-duration activity-limiting neck/back pain" the previous six months representing a favourable prognosis of reported problems at baseline in 2010. Risk ratios (RRs) and risk differences (RDs) with 95% CI was estimated by general linear regressions, and the synergistic effect by the synergy index (SI) with 95% CI.

Results

Participants with moderate or good work ability, respectively, had an adjusted RR for a favourable prognosis of 1.37 (95% CI: 1.11-1.69), and 1.80 (1.49-2.17) in comparison to participants with poor work ability. The corresponding adjusted RD were 0.07 (02-0.11) and 0.17 (0.12-0.22). Participants not smoking on daily basis had an adjusted RR of 1.21 (1.02-1.42), and an adjusted RD of 0.05 (0.01-0.10) for a favourable outcome compared to daily smokers. The adjusted SI was 0.92 (0.60-1.43).

Conclusion

For participants with long-duration activity-limiting neck/back pain, moderate or good self-perceived work ability and not being a daily smoker were associated with a favourable prognosis but having both exposures seemed to have no synergistic prognostic effect.

Keywords: disability evaluation, musculoskeletal pain, public health, tobacco use

Strengths and limitations of this study

- The longitudinal design ensures temporality and the comprehensive confounder control increase the possibility of a causal association between the exposers and the outcome.
- The large sample size and robust analyses strengthens the internal validity.
- The main limitations of this study are possible misclassification of the exposures and the outcome, a relatively large loss to follow-up and a possible change of exposure category during the follow-up period of four years, although these limitations most probably lead to an underestimation of the associations studied.

- There is a possible risk that reversed causation have influenced the analyses with perceived work ability as exposure, but the additional analyses indicates that this risk is small.

Introduction

According to the Global Burden of Disease study, neck pain and back pain are among the top causes for "years lived with disability", with a high and rising prevalence globally (1). Most neck and back problems resolve, but many individuals experience pain for a long time following onset (2, 3). Between 17% to 70% of individuals with neck pain report activity-limiting pain (3). Long-duration activity-limiting neck/back pain (LANBP) is most prevalent in working age, and often decrease work performance (2, 4). From a public health perspective, LANBP adds to the societal and individual burden as it is a common cause for absenteeism and early retirement (5). Still, and in accordance with current recommendations, many individuals with musculoskeletal pain go to work (4).

One way to address this burden of LANBP is to increase the understanding of modifiable lifestyle and work-related factors associated to a favourable prognosis and their potential interactions. Research about prognosis of LANBP have so far focused on factors of potential importance for the transition from acute/sub-acute neck and back pain to LANBP, and several biopsychosocial factors are suggested to be associated to such an unfavourable prognosis. Examples of such factors are smoking, low physical activity, depression, anxiety and low work satisfaction (2, 6). On the other hand, only greater optimism, good social support, positive coping and exercise/sport activities are proposed as factors associated to a favourable prognosis for long-duration and activity-limiting neck pain, and none for back pain (6). Thus, knowledge of if work-related factors and lifestyle factors, other than physical activities, associate to a favourable prognosis of LANBP is lacking.

The multidimensional work ability model was introduced in Finland in the 1980s in order to study self-perceived work ability in relation to work-disability and health (7, 8). According to the model, self-perceived work ability is based on health and functional capacity and built on a balance between a person´s resources such as competence, values, attitudes, motivation, and

work demands. Self-perceived work ability is commonly assessed by the Work Ability Index (WAI) or by single items of the instrument (9). As, such work ability is associated with health and health related outcomes, eg depression, osteoarthritis, neck and back pain, sickness absence and general health (7, 10). Furthermore, the total WAI or single WAI items seems to be valuable for predicting sickness absence in healthy as well in unhealthy populations, with good work ability being a protective factor in all diseases studied (10-15). However, work ability in relation to the prognosis of neck/back pain is rarely studied. Nordstoga et al., studying back pain patients referred to physiotherapy, found no association between baseline work ability and disability or pain three months later (16). Ahlström et al., followed Swedish female workers on long-term sick leave for 12 months, the majority with neck pain, and found work ability to predict the future degree of neck pain (10). In a recent study from our group, we found that poor work ability, assessed with the second WAI item (perceived mental and/or physical work ability), increased the risk of LANBP in workers with occasional neck- and/or back pain (17).

Poor work ability is also associated to individual lifestyle factors such as low physical capacity, smoking and obesity (18). So far, we know that smoking is associated with the onset of neck and back pain, and with the transition from acute/subacute to long-duration back pain, but we do not know if being a non-smoker is associated with a favourable prognosis of LANBP (2, 6). If so, and considering the association between smoking and work ability, examine their potential interaction on the prognosis of LANBP would enhance our understanding and meet the demand for studies examining such interactions from reviews on the prognosis of neck and back pain (19, 20).

Therefore, the objective of this study was to evaluate if good self-perceived work ability and no daily smoking are associated with a favourable prognosis of LANBP in a working population, and if these exposures have a synergistic prognostic effect.

Methods

Design and study population

In this prospective cohort study, we used merged data from three subcohorts of the Stockholm Public Health Cohort (SPHC) (21). The SPHC consists of several public health surveys of individuals randomly selected from the adult population of Stockholm County. The first subcohort included individuals selected in 2002 and followed up in 2007, 2010 and 2014. The second cohort included individuals selected in 2006 and followed up in 2010 and 2014, and the third subcohort individuals selected in 2010 and followed up in 2014. Approximately 74,000 individuals from the subcohorts responded to the questionnaire in 2010, which was used as baseline in the present study. Of these approximately 50,000 individuals (68%) responded to the questionnaire in 2014, used as the follow-up survey in the present study. Of the responders in 2010, 39,704 were 18-61 years of age and were working since at least 12 months, representing our "working population". We chose the age limit of 61 in 2010 to ensure that most of our population would still be working in 2014 as 65 was the norm for retirement age in Sweden at the time of the study. Figure 1 describes the inclusion of participants into the study population and the analyses sample.

Neck and back pain at baseline in 2010 were assessed with 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?". Both questions were followed by the question; "If yes: Do these problems limit your ability to work or carry out other daily activities?". Individuals answering, "Yes, on average, a few days per week or more" to at least one of the first two questions and then "Yes, to a high degree *or* to some degree" to the following question were considered as having LANBP. The questions defining LANBP incorporates

duration, frequency and the impact on daily activity and work which is recommended when classifying neck and back pain (19, 22).

Ethical approval was received from the regional ethical board in Stockholm (Dnr; 2007/545-31, 2013/497-32 and 2015/1204-32).

Exposures

The exposure "self-perceived work ability" (PWA) was categorised based on the second item of the WAI (7, 9, 23). The item consists of two question, one regarding physical demands and one regarding mental demands at work, respectively: "How do you rate your current work ability with respect to the *physical demands/mental demands* of your work". The response alternatives were "Very good", "Rather good", "Moderate", "Rather poor" and "Very poor". The answers were dichotomized into good (very good or rather good) and poor (moderate, rather poor or very poor) physical and mental work ability, respectively. Finally, PWA was operationalised into three categories: good PWA (good physical *and* good mental work ability), moderate PWA (good physical *or* good mental work ability, but not both) and poor PWA (poor physical *and* poor mental work ability).

The WAI is considered a reliable and valid instrument used in cross-national research (9, 24-26). Most often, the full WAI is used in research, but also single items have been utilised as measures (10-12). Lundin et al. found the second WAI item defining PWA in the present study to have acceptable ability to predict sickness absence within one year in a Swedish general population (27).

The exposure "daily smoking" (DS) was dichotomized by the answer yes or no to the question: "Do you currently smoke daily or almost daily?".

Outcome

The outcome "absence of long-duration activity-limiting neck/back pain" in 2014 represents a favourable prognosis of reported problems at baseline in 2010. The definition was based on the same questions used defining the study population. Participants defined as having a favourable prognosis (cases) were those reporting no neck/back pain *or* neck/back pain not limiting their activity in daily life or at work the preceding six months. Consequently, non-cases have had pain of any duration and frequency in the neck and/or back that limited activity in daily life or at work to some or to a high degree during the preceding six months.

Potential confounders

Potential confounders for the association between the exposure and the outcome were chosen based on literature, theoretical and clinical considerations, and availability in the questionnaire (2, 3, 6, 28). Potential confounders are presented in the Appendix. Most of the items used to measure the potential confounders have regularly been used in Swedish public health surveys since 1975, and since 2002 in the SPHC (21).

Statistics

Stata version 14.2 (StataCorp College Station, TX, USA) were used for statistical analyses. The association between the exposures and the outcome were estimated using general linear models with a binomial distribution and a log-link and reported as risk ratio (RR) and risk difference (RD) with corresponding 95% confidence intervals (CI). The exposures, PWA and DS were assessed separately. Potential confounders were identified by reviewing the literature of prognostic factors, clinical considerations, and availability. After careful discussion about if they instead possibly could be intermediators or colliders, they were introduced into the crude models one by one. Potential confounders changing the estimated RR by 5% or more were considered confounders and were included in the final adjusted models (29, 30). DS was

tested as a confounder in the analyses with PWA as exposure and PWA was tested as a confounder in the analyses with DS as exposure. A variable indicating subsample participation was included in all models to adjust for potential systematic difference between the subcohorts. All analyses were performed using complete cases, that is, cases with no missing data. The Chi-square test was used to test a potential dose-response effect (31).

To calculate the potential synergistic effect of PWA and DS on the outcome, we used the EpiNET´s epidemiological tool (32). We dichotomised PWA into good PWA and moderate/poor PWA and then combined the dichotomized PWA and DS in a dummy variable, where the reference group was set to those having moderate/poor PWA and being daily smokers. The dummy variable was then used as the independent factor in a crude and an adjusted logistic regression. The results were presented as RR with corresponding 95% CI together with the synergy index (SI) with corresponding 95% CI. A SI >1 indicates a joint effect between two factors greater than the sum of their individual effects.

Additional analyses

We had no information on the intensity of LANBP at baseline, which may be an important confounder in the analyses. As poor self-related health may be a consequence of severe pain intensity, we performed the adjusted analyses with PWA as exposure stratified by good (very good/good) and poor (fair/poor/very poor) self-rated health (SRH), as a proxy for the intensity of neck/back pain at baseline (33).

The potential influence of attrition was assessed by comparing the prevalence of the two exposures among non-responders (n=1,865) to the prevalence among responders (n=3,312) using Chi-square tests.

Patient and Public Involvement

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

Results

Baseline characteristics of the study population are presented in Table 1. The mean age was 46 years (SD 10) and 66% were women. Eighty percent reported good or moderate self-perceived work ability and 84% were not smoking daily. Most participants were non-manual workers or self-employed (65%), and the majority lived together with another adult person, with or without children (77%). At follow-up in 2014, 36% of the participants showed a favourable prognosis of LANBP.

The crude and adjusted associations between self-perceived work ability, daily smoking and a favourable prognosis of LANBP are presented in Table 2. Socioeconomic status, headache/migraine and sleep disturbances were identified as confounders in the analyses with self-perceived work ability as exposure, while socioeconomic status, sleep disturbances and self-perceived work ability confounded the association between daily smoking and the outcome.

In comparison to participants with poor work ability participants with moderate or good work ability, had an adjusted RR for a favourable prognosis of 1.37 (95% CI: 1.11-1.69), and 1.80 (1.49-2.17), respectively. The corresponding adjusted RD were 0.07 (02-0.11) and 0.17 (0.12-0.22). Participants not smoking on daily basis had an adjusted RR of 1.21 (1.02-1.42), and an adjusted RD of 0.05 (0.01-0.10) for a favourable outcome compared to daily smokers.

The analyses with self-perceived work ability as exposure showed a significant dose-response towards a more favourable prognosis with higher work ability ($p < 0.001$).

Table 3 shows the result of the evaluation of the synergistic associations between the exposures and the outcome, resulting in an adjusted SI of 0.92 (95% CI: 0.60-1.43).

Additional results

Stratifying the analyses of the exposure self-perceived work ability by good and poor self-rated health, as a proxy for the intensity of neck/back pain at baseline, resulted in similar adjusted RR for the two strata. The RR for a favourable prognosis of LANBP when reporting moderate work ability showed a similar increase for participants with poor self-rated health and participants with good self-rated health, 1.42 (95% CI; 0.93-2.15) and 1.27 (95% CI; 0.98-1.63), compared with participants with poor work ability. The RR were also similar for those reporting good work ability in both strata, 1.72 (95% CI; 1.17-2.53) and 1.56 (95% CI; 1.23-1.96), respectively.

At baseline in 2010, non-responders had a significantly higher prevalence ($p < 0.001$) of individuals with poor self-perceived work ability and daily smokers (23% and 19%) in comparison with responders (18% and 14%).

Discussion

In this study we found an association between self-perceived work ability and a favourable prognosis of long-duration activity-limiting neck/back pain four years later. The results revealed that individuals in a working population with either good physical or good mental work ability had a 37% increased chance of a favourable prognosis of long-duration activity-limiting neck/back pain, compared to individuals with poor physical and poor mental work ability. The chance of a favourable prognosis was even higher (80%) for individuals reporting both good physical and good mental work ability. In addition, the results showed that individuals that did not smoke daily had a 21% higher chance of a favourable prognosis than did daily smokers.

A possible synergetic effect on a favourable prognosis for participants reporting good work ability and not smoke on daily basis could not be confirmed.

Previously, Nordstoga et al. found no association between baseline work ability and improvement of back pain or disability in physiotherapy patients with back pain of any duration, which contrasts with our results (16). Their study included patients with back pain of any duration, had a follow-up time of only three months, and they used the question "describe your current work ability compared with the lifetime best (0-10)'' as a measure of self-perceived work ability. More in line with our result, Ahlström et al. found higher baseline work ability, defined by the same question as Nordstoga et al. and by the full WAI, to predict lower degree of neck pain at six and 12 months among women on long-term sick-leave (10). We have not found any previous study of association between smoking and a favourable prognosis, either for neck or for back pain, or on the synergetic effect of work ability and smoking.

The mechanism for smoking to affect spinal pain is not yet well understood, but impaired blood supply, increased levels of pro-inflammatory cytokines and higher prevalence of osteoporosis due to smoking has been suggested (34). As the concept of self-perceived work ability incorporate individual factors, work-related factors and environmental factors, a specific mechanism for good self-perceived work ability to associate with a favourable prognosis of LANBP may be difficult to delineate (7).

The present study has some possible limitations. Clustering individuals with neck and back pain when studying prognostic factors may be questioned, since prognostic factors for neck- and back pain may differ. But, as a priory analysis evaluating participants with long-duration activity-limiting neck and back pain separately, resulted in almost identical crude estimates, we decided to merge the data to increase the statistical power.

Even though a comprehensive confounder control was performed, residual and unmeasured confounding could not be ruled out. We had no baseline information on pain intensity prior to

inclusion into the cohort, therefore we could not consider pain intensity as a potential confounder. If pain intensity at baseline is associated with the reported levels of PWA at baseline, bias due to reversed causation may be present (30). Then our results may have been overestimated.

However, we believe that the risk of reversed causation due to baseline pain intensity is limited as individual self-perceived work ability is most likely a combination of many factors other than pain, for example content, demands and organisation of work, personal attitudes, motivation, knowledge and skills, and functional capacity (8). Furthermore, given that pain is related to health, the additional analyses stratified by good and poor self-rated health indicating that good PWA is beneficial no matter the intensity of pain also supports a low risk of bias due to reversed causation.

Misclassification of the outcome needs consideration. Problems to recall and to appraise whether the pain during the preceding six months was activity-limiting or not may have resulted in non-cases being classified as cases and vice versa. This possible misclassification of the outcome is most probably non-differential potentially leading to a dilution of our results (30). As the follow-up period was four years work ability and smoking status may have varied across this period, and participants may have changed jobs or work assignments. If so, this would probably dilute the estimation of the association.

With a response rate of 64% between baseline and follow-up there is a risk of selection bias. Non-responders had a significantly higher proportion of smokers and individuals with poor self-perceived work ability than did responders. If most of these individuals would experience a favourable prognosis of their long-duration activity-limiting neck/back pain, a scenario we find unlikely, or results may be overestimated.

Strengths of this study are the longitudinal design, and a relatively large sample size, allowing evaluation of the outcome along categories of the exposure. However, despite a large sample,

the evaluation of synergetic effects may have been hampered by few cases in the reference categories. The dose-response results found supports a causal association between self-perceived work ability and long-duration activity-limiting neck/back pain, and the extensive confounder control supports internal validity. We also regard the incorporation of activity limitations in the definition of the baseline pain and in the outcome as a strength. Activity limitations is recommended to be included in measures for chronic pain, recognised to be of clinical importance, and to have negative consequences for the affected individual and for the society (1, 5, 19, 22, 35).

To our knowledge this is the first study assessing self-perceived work ability and smoking focusing on a favourable prognosis of long-duration activity-limiting neck/back pain. Even though more research is needed to confirm our findings, they imply that good work ability and not smoking daily appears to predict a favourable prognosis of long-duration activity-limiting neck/back pain. Thus, interventions to improve physical and mental work ability and reduce smoking may enhance the chance for a favourable prognosis in workers with long-duration activity-limiting neck/back pain. Therefore, further research focusing on such interventions is motivated. Such interventions could be directed towards both the workplace organisation and the individual, possibly resulting in reduced human suffering and societal costs.

Conclusion

Having a good physical and/or mental self-perceived work ability as well as not smoking on daily basis is associated to a favourable prognosis in a working population with long-duration activity-limiting neck/back pain. However, fulfilling both criteria seem to have no synergistic prognostic effect.

Acknowledgement

Thanks to Peeter Fredlund, Research Statistician at Karolinska Institutet and SLL Centre for Epidemiology and Community Medicine, Stockholm, for providing us with the data.

Contributors

TB, LWH, ML and ES contributed to the conceptualisation and methodology of the study. JH approved the conceptualisation and method and provided the data resources. Based on a protocol approved by all authors TB made the statistical analyses and wrote the first draft of the manuscript. All authors contributed to the interpretation of the results and critically revised the manuscript and approved the last manuscript version.

Funding

This study was supported by AFA Insurance, grant number 170095. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests

Non to declare.

Data availability statement

Data are available upon reasonable request. 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.

References

1. Vos T, Abajobir AA, Abate KH, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet. 2017;390(10100):1211-59.

2. Hartvigsen J, Hancock MJ, Kongsted A, et al. What low back pain is and why we need to pay attention. The Lancet. 2018;391(10137):2356-67.

3. Hoy DG, Protani M, De R, Buchbinder R. The epidemiology of neck pain. Best Pract Res Clin Rheumatol. 2010;24(6):783-92.

4. Cochrane A, Higgins NM, Rothwell C, et al. Work Outcomes in Patients Who Stay at Work Despite Musculoskeletal Pain. J Occup Rehabil. 2018;28(3):559-67.

5. Schofield DJ, Shrestha RN, Percival R, Callander EJ, Kelly SJ, Passey ME. Early retirement and the financial assets of individuals with back problems. Eur Spine J. 2011;20(5):731-6.

6. Green BN, Johnson CD, Haldeman S, et al. A scoping review of biopsychosocial risk factors and co-morbidities for common spinal disorders. PLoS One. 2018;13(6):e0197987.

7. Gould R, Ilmarinen J, Järvisalo J, Koskinen S. Dimensions of Work Ability. Results of the 2000 Health Survey. Vaasa: Waasa Graphics Oy; 2008.

8. Ilmarinen J. Work ability, a comprehensive concept for occupational health research and prevention. Scand J Work Environ Health. 2009;35(1):1-5.

9. Ilmarinen J. The Work Ability Index (WAI). Occupational Medicine. 2006;57(2):160.

10. Ahlstrom L, Grimby-Ekman A, Hagberg M, Dellve L. The work ability index and single-item question: associations with sick leave, symptoms, and health – a prospective study of women on long-term sick leave. Scand J Work Environ Health. 2010;36(5):404-12.

11. Kinnunen U, Natti J. Work ability score and future work ability as predictors of register-based disability pension and long-term sickness absence: A three-year follow-up study. Scand J Public Health. 2018;46(3):321-30.

12. Lundin A, Kjellberg K, Leijon O, Punnett L, Hemmingsson T. The Association Between Self-Assessed Future Work Ability and Long-Term Sickness Absence, Disability Pension and Unemployment in a General Working Population: A 7-Year Follow-Up Study. J Occup Rehabil. 2016;26(2):195-203.

13. Reeuwijk KG, Robroek SJ, Niessen MA, Kraaijenhagen RA, Vergouwe Y, Burdorf A. The Prognostic Value of the Work Ability Index for Sickness Absence among Office Workers. PLoS One. 2015;10(5):e0126969.

14. Sundstrup E, Jakobsen MD, Mortensen OS, Andersen LL. Joint association of multimorbidity and work ability with risk of long-term sickness absence: a prospective cohort study with register follow-up. Scand J Work Environ Health. 2017;43(2):146-54.

15. Vingard E, Lindberg P, Josephson M, et al. Long-term sick-listing among women in the public sector and its associations with age, social situation, lifestyle, and work factors: a three-year follow-up study. Scand J Public Health. 2005;33(5):370-5.

16. Nordstoga AL, Vasseljen O, Meisingset I, Nilsen TIL, Unsgaard-Tondel M. Improvement in Work Ability, Psychological Distress and Pain Sites in Relation to Low Back Pain Prognosis: A Longitudinal Observational Study in Primary Care. Spine (Phila Pa 1976). 2019;44(7):E423-e9.

17. Holm LW, Bohman T, Lekander M, Magnusson C, Skillgate E. 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. BMJ Open. 2020;10(6):e033946.

18. van den Berg TI, Elders LA, de Zwart BC, Burdorf A. The effects of work-related and individual factors on the Work Ability Index: a systematic review. Occup Environ Med. 2009;66(4):211-20.

19. Supplement article: Carroll LJ, Hurwitz EL, Cote P, et al. Research priorities and methodological implications: the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. Spine. 2008;33(4 Suppl):S214-20.

20. Hayden JA, Dunn KM, van der Windt DA, Shaw WS. What is the prognosis of back pain? Best Pract Res Clin Rheumatol. 2010;24(2):167-79.

21. Svensson AC, Fredlund P, Laflamme L, et al. Cohort profile: The Stockholm Public Health Cohort. Int J Epidemiol. 2013;42(5):1263-72.

22. Dionne CE, Dunn KM, Croft PR, et al. A consensus approach toward the standardization of back pain definitions for use in prevalence studies. Spine (Phila Pa 1976). 2008;33(1):95-103.

23. Tuomi K, Ilmarinen J, Jahkola A, Katajarinne L, Tulkki A. Work ability index. 2 ed. Helsinki: Finnish Institute of Occupational Health; 1998.

24. Alavinia SM, de Boer AG, van Duivenbooden JC, Frings-Dresen MH, Burdorf A. Determinants of work ability and its predictive value for disability. Occup Med (Lond). 2009;59(1):32-7.

25. de Zwart BCH, Frings-Dresen MHW, van Duivenbooden JC. Test–retest reliability of the Work Ability Index questionnaire. Occupational Medicine. 2002;52(4):177-81.

26. Radkiewicz P, Widerszal-Bazyl M. Psychometric properties of Work Ability Index in the light of comparative survey study. International Congress Series. 2005;1280:304-9.

27. Lundin A, Leijon O, Vaez M, Hallgren M, Torgén M. Predictive validity of the Work Ability Index and its individual items in the general population. Scand J Public Health. 2017;45(4):350-6.

28. Verkerk K, Luijsterburg PA, Miedema HS, Pool-Goudzwaard A, Koes BW. Prognostic factors for recovery in chronic nonspecific low back pain: a systematic review. Phys Ther. 2012;92(9):1093-108.

29. Mickey RM, Greenland S. The impact of confounder selection criteria on effect estimation. Am J Epidemiol. 1989;129(1):125-37.

30. Rothman KJ, Greenland S, Lash TL. Modern epidemiology. 3rd ed. Philadelphia: Wolters Kluwer Health/Lippincott Williams & Wilkins; 2008. x, 758 p.

31. Vittinghoff E, Glidden DV, Shiboski SC, McCulloch CE. Regression Methods in Biostatistics, Linear, Logistic, Survival, and Repeated Measures Models. 2nd ed. New York, USA: Springer New York; 2012.

32. Andersson T, Alfredsson L, Kallberg H, Zdravkovic S, Ahlbom A. Calculating measures of biological interaction. Eur J Epidemiol. 2005;20(7):575-9.

33. Perruccio AV, Power JD, Badley EM. Arthritis onset and worsening self-rated health: a longitudinal evaluation of the role of pain and activity limitations. Arthritis Rheum. 2005;53(4):571-7

34. Shiri R, Karppinen J, Leino-Arjas P, Solovieva S, Viikari-Juntura E. The association between smoking and low back pain: a meta-analysis. Am J Med. 2010;123(1):87 e7-35.

35. Dworkin RH, Turk DC, Farrar JT, et al. Core outcome measures for chronic pain clinical trials: IMMPACT recommendations. Pain. 2005;113(1-2):9-19.

Table 1 Baseline characteristics by the exposures perceived work ability (PWA) and daily smoking (DS). Total study population, n = 5,177.

Baseline characteristics		**Perceived work ability**			**Daily smoking**	
	All	**Good**	**Moderate**	**Poor**	**No**	**Yes**
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
	5,177	3,076 (59)	1,080 (21)	1,021 (20)	4,320 (84)	818 (16)
Sex						
Women	3,396 (66)	1,974 (64)	734 (68)	688 (67)	2,840 (66)	534 (65)
Average age, years (SD)	46 (10)	45 (10)	46 (10)	47 (10)	45 (10)	47 (10)
Perceived work ability						
Good					2,679 (62)	377 (46)
Moderate					888 (21)	186 (23)
Poor					753 (17)	255 (31)
Daily smoking - Yes	818 (16)	377 (12)	186 (17)	255 (25)		
BMI						
Under weight	60 (1)	43 (1)	8 (1)	9 (1)	50 (1)	9 (1)

Normal weight	2,428 (48)	1,507 (50)	522 (50)	399 (40)	2,043 (48)	374 (47)
Overweight	1,814 (36)	1,074 (36)	360 (34)	380 (38)	1,502 (36)	291 (37)
Obese	747 (15)	383 (13)	162 (15)	202 (21)	620 (15)	122 (15)
Socioeconomic status						
Unskilled/semiskilled worker	955 (20)	435 (15)	219 (22)	301 (32)	712 (17)	236 (30)
Skilled worker	749 (15)	393 (13)	173 (17)	183 (20)	566 (14)	174 (22)
Low level non-manual employees	722 (15)	465 (16)	137 (13)	120 (13)	603 (15)	115 (15)
Middle level non-manual employees	1,241 (25)	806 (27)	255 (25)	180 (19)	1,111 (27)	124 (16)
High level non-manual employees/self-employed	755 (15)	543 (19)	133 (13)	79 (8)	692 (17)	58 (8)
Self-employed (other than high level)	488 (10)	306 (10)	105 (10)	77 (8)	411 (10)	73 (9)
Household						
Living with adult, with/without children	3,939 (77)	2,463 (81)	791 (74)	685 (68)	3,361 (78)	555 (68)
Living alone	817 (16)	410 (13)	197 (18)	210 (21)	629 (15)	178 (22)
Living with children only	381 (7)	191 (6)	80 (8)	110 (11)	299 (7)	80 (10)
Headache/migraine - Yes	2,517 (50)	1,330 (44)	556 (53)	631 (66)	2,084 (50)	416 (53)
Psychological distress						

No	3,381 (66)	2,403 (78)	596 (56)	382 (38)	2,876 (67)	479 (59)
Mild	978 (19)	456 (15)	259 (24)	263 (26)	801 (19)	169 (21)
Severe	793 (15)	207 (7)	217 (20)	369 (36)	622 (14)	167 (20)
Personal support - No	885 (17)	359 (12)	219 (20)	307 (30)	698 (16)	182 (22)
Sleep disturbances - Yes	2,621 (51)	1,254 (42)	623 (59)	744 (76)	2,120 (50)	480 (61)
Sedentary leisure time						
<2 hours/day	2,844 (55)	1,082 (59)	540 (50)	502 (50)	2,441 (57)	385 (48)
2-3 hours/day	1,458 (29)	854 (28)	340 (32)	264 (26)	1,200 (28)	248 (31)
>3 hours/day	840 (16)	399 (13)	196 (18)	245 (20)	654 (15)	177 (22)
Leisure physical activity, moderate intensity						
<20 minutes/day	1,802 (35)	977 (32)	389 (36)	436 (43)	1,435 (34)	352 (44)
20-40 minutes/day	1,944 (38)	1,208 (40)	399 (37)	337 (34)	1,682 (39)	248 (31)
>40 minutes/day	1,379 (27)	865 (28)	284 (27)	230 (23)	1,169 (27)	203 (25)
Leisure physical activity, high intensity						
<1 hour/week	2,395 (47)	1,301 (43)	532 (50)	562 (56)	1,883 (44)	495 (61)
1-2 hours/week	1,371 (27)	842 (27)	294 (27)	235 (23)	1,200 (28)	158 (20)

>2 hours/week	1,366 (26)	911 (30)	246 (23)	209 (21)	1,204 (28)	155 (19)
Physical workload						
Sedentary at least 50%	2,789 (55)	1,801 (60)	537 (51)	448 (46)	2,410 (57)	361 (46)
Standing/walking/some lifting	1,377 (26)	727 (24)	291 (27)	319 (33)	1,094 (26)	230 (29)
Walking/lifting/heavy work	937 (19)	496 (16)	232 (22)	209 (21)	738 (17)	191 (25)
Subsample participation						
2002/2007/2010/2014	1,283 (25)	781 (25)	269 (25)	233 (23)	1,106 (26)	170 (21)
2006/2010/2014	1,706 (33)	1,011 (33)	352 (33)	346 (34)	1,432 (33)	268 (33)
2010/2014	2,185 (42)	1,284 (42)	459 (42)	442 (43)	1,782 (41)	380 (46)
Self-rated health						
Very good	328 (6)	293 (9)	23 (2)	12 (1)	302 (7)	26 (3)
Good	2,282 (44)	1,801 (59)	336 (32)	145 (14)	1,982 (46)	286 (35)
Fair	1,980 (39)	877 (29)	567 (53)	536 (53)	1,585 (37)	376 (46)
Poor or very poor	538 (11)	82 (3)	137 (13)	319 (32)	408 (10)	125 (16)

Note: Numbers may differ due to internal missing. For a description of the variables and their categorisation see the Appendix.

Table 2 Associations* between the exposures perceived work ability (PWA) and daily smoking (DS) in 2010, and a favourable prognosis of long-duration activity-limiting neck and/or back pain in 2014.

Exposure	Cases/total	Crude		Adjusted		Adjusted	
		RR	95% CI	RR	95% CI	RD	95% CI
Perceived work ability							
(n = 3,312)							
Poor	115/596	1		1		0	
Moderate	203/688	1.53	1.25-1.87	1.37[a]	1.11-1.69	0.07[a]	0.02-0.11
Good	873/2,028	2.23	1.88-2.65	1.80[a]	1.49-2.17	0.17[a]	0.12-0.22
Daily smoking							
(n = 3,292)							
Yes	115/459	1		1		0	
No	1,070/2,833	1.51	1.28-1.78	1.21[b]	1.02-1.42	0.05[b]	0.01-0.10

Note: *General linear models with a binomial distribution and a log-link, estimating the risk ratio (RR), or an identity-link, estimating the risk difference (RD), with corresponding 95% confidence intervals (CI).

[a]Adjusted for socioeconomic status, headache/migraine, sleep disturbances and subsample participation; [b]Adjusted for socioeconomic status, sleep disturbances, perceived work ability and subsample participation.

Table 3 Analyses* of the potential synergistic effects of the two exposures perceived work ability (PWA) and daily smoking (DS), on a favourable prognosis of long-duration activity-limiting neck and/or back pain.

Exposure	Cases/total	Crude		Adjusted[a]	
		RR	95% CI	RR	95% CI
Moderate/poor perceived work ability and daily smoking	39/253	1		1	
Moderate/poor perceived work ability and no daily smoking	276/1,022	1.88	1.32-2.66	1.61	1.11-2.34
Good perceived work ability and daily smoking	76/206	2.96	1.93-4.54	2.33	1.49-3.66
Good perceived work ability and no daily smoking	794/1,811	3.96	2.84-5.52	2.80	1.95-4.02
Synergy index				0.92	0.60-1.43

*Using EpiNET´s epidemiological tool “Epinetcaculation.xlsx” based on the results from logistic regressions.

[a]Adjusted for socioeconomic status, headache/migraine, sleep disturbances and subsample participation.

Abbreviations: RR; risk ratio, CI; confidence interval.

Figure legends

Figure 1 Flow chart describing the inclusion of participants into the study population and the analyses sample. NP; neck pain, BP; low back pain, PWA; perceived work ability.

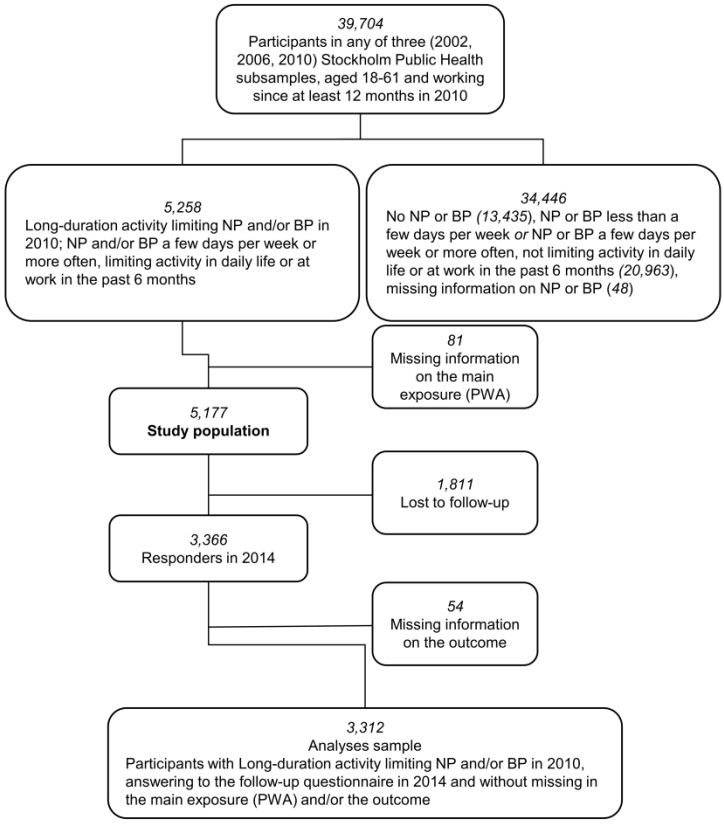

Figure 1. Flow chart describing the inclusion of participants into the study population and the analyses sample. NP; neck pain, BP; low back pain, PWA; perceived work ability.

383x511mm (300 x 300 DPI)

Appendix Potential confounding factors.

Potential confounder	Measurement	Categorisation in the analyses
Daily smoking[a]	"Do you currently smoke daily or almost daily?"	No, yes
Self-perceived work ability[b]	"How do you rate your current work ability with respect to the physical demands/mental demands of your work"	Good, moderate and poor
Sex	Sex at baseline 2010	Men, women (no other alternatives available)
Age	Age at baseline 2010	Continuous and in quartiles (18-38), (39-46), (47-54), (55-61)
Body mass index (BMI)	Weight/height^2 (kg/m^2)	Categorical; underweight (<18.5), normal weight (18.5-24.9), overweight (25-29.9), obese (≥30)
Socioeconomic status (SES)	According to the classification from Statistics Sweden. Based on current occupation and education for the economically active population.	Unskilled/semiskilled worker, skilled worker, low level non-manual employees, middle level non-manual employees, high level non-manual employees/self-employed, self-employed (other than high level)
Household	"Do you live together with someone?"	Categorical; living together with adult/s and child/ren, living alone, living with child/children only
Headache/migraine	"Do you have headache or migraine?"	No, yes; somewhat or severe
Psychological distress[1, 2]	Based on the 12-item General Health Questionnaire (GHQ-12), using the scoring system 0-0-1-1.	No (0-2), mild (3-6), severe (7-12)
Personal support[2, 3]	"Do you know persons who can provide you with personal support for personal problems or crises in your life?"	No-usually not or never, yes-always or for the most part
Sleep disturbances	"Do you have sleep disturbances"	No, yes; somewhat or severe

Sedentary leisure time	"Refer to your leisure physical activity during the past 12 months? If the activities vary during the year and during a week, refer to an average." Sitting/watching TV/reading during leisure time.	Categorical: less than 2 hours/day, 2-3 hours/day, more than 3 hours/day
Leisure physical activity - moderate intensity	"Refer to your leisure physical activity during the past 12 months? If the activities vary during the year and during a week, refer to an average." Walking/biking during leisure time.	Categorical: less than 20 minutes/day, 20-40 minutes/day, more than 40 minutes/day
Leisure physical activity - high intensity	Refer to your leisure physical activity during the past 12 months? If the activities vary during the year and during a week, refer to an average." Exercise, other than walking/biking, during leisure time.	Categorical: less than 1 hour/week, 1-2 hours/week, more than 2 hours/week
Physical workload[4]	"Refer to your physical activity during your daily activity and/or work during the past 12 months? If the activity vary during the year and during a week, refer to an average.	Categorical; sedentary at least to 50 %, standing/walking/some lifting, walking/lifting/heavy work
Subsample participation[c]	Refers to the subsample of the Stockholm Public Health Cohort the participants belonged to.	Categorical: 2002/2007/2010/2014, 2006/2010/2014, 2010/2014

[a] Daily smoking was assessed as a potential confounder in the analyses with self-perceived work ability as exposure. [b] Self-perceived work ability was assessed as a potential confounder in the analyses with daily smoking as exposure.[c] Subsample participation was included in all adjusted models order to adjust for potential systematic difference between the subsamples. [#] Bibliographical references to definition and psychometric properties of the factors.

1. Goldberg DP, Gater R, Sartorius N, Ustun TB, Piccinelli M, Gureje O, et al. The validity of two versions of the GHQ in the WHO study of mental illness in general health care. Psychol Med. 1997;27(1):191-7.
2. McDowell I. Measuring health a guide to rating scales and questionnaires. 3rd ed. New York ; Oxford: Oxford University Press; 2006. xvi, 748 p. p.
3. Unden AL, Orth-Gomer K. Development of a social support instrument for use in population surveys. Soc Sci Med. 1989;29(12):1387-92.

4. Leijon O, Wiktorin C, Harenstam A, Karlqvist L. Validity of a self-administered questionnaire for assessing physical work loads in a general population. J Occup Environ Med. 2002;44(8):724-35.

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

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract **Page 1, line 3**
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found **Page 2 -4**
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported **Page 5 and 6**
Objectives	3	State specific objectives, including any prespecified hypotheses **Page 6, line 115-117**
Methods		
Study design	4	Present key elements of study design early in the paper **Page 7, line 119-125**
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection **Page 7, line 120-128, and Figure 1**
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up **Page 7, line 120-133, and Figure 1**
		(*b*) For matched studies, give matching criteria and number of exposed and unexposed **N/A**
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable **Page 7-9, line 134-176, and Appendix**
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 **Page 7-9, line 134-176, and Page 10, line 201-208, plus Appendix**
Bias	9	Describe any efforts to address potential sources of bias **Page 9, line 182-190 (confounding), Page 10, line 200-208 (Additional analyses)**
Study size	10	Explain how the study size was arrived at **Page 7, line 125-129. Figure 1. Page 10 line 190-191.**
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why **Page 8-9, line 145-176. Page 10, line 200-208. Appendix.**
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding **Page 9 and 10, line 177-208**
		(*b*) Describe any methods used to examine subgroups and interactions **Page 10, line 192-208**
		(*c*) Explain how missing data were addressed **Page 10, line 190-191**
		(*d*) If applicable, explain how loss to follow-up was addressed **Page 10, line 206-208**
		(*e*) Describe any sensitivity analyses **Page 10, line 200-208**
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 **Figure 1**

		(b) Give reasons for non-participation at each stage **Figure 1**
		(c) Consider use of a flow diagram **Figure 1**
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders **Table 1**
		(b) Indicate number of participants with missing data for each variable of interest **Table 1 and Figure 1**
		(c) Summarise follow-up time (eg, average and total amount) **N/A**
Outcome data	15*	Report numbers of outcome events or summary measures over time **Page 11, line 216-217. Table 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 **Page 11, line 218-232. Table 2 and Table 3**
		(*b*) Report category boundaries when continuous variables were categorized **Appendix**
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **Page 11 line 224-228, Table 2**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **Page 11, line 231-232. Page 12, line 233-244. Table 3.**
Discussion		
Key results	18	Summarise key results with reference to study objectives **Page 12, line 246-256**
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 **Page 13-14, line 274-303**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **Page 15, line 314-323**
Generalisability	21	Discuss the generalisability (external validity) of the study results **Page 15, line 314-323 and Conclusion**
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 **Page 16, line 338-341**

*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

The influence of work ability and smoking on the prognosis of long-duration activity-limiting neck/back pain – a cohort study of a Swedish working population

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-054512.R1
Article Type:	Original research
Date Submitted by the Author:	13-Jan-2022
Complete List of Authors:	Bohman, Tony; Karolinska Institutet, Institute of Environmental Medicine; Dalarna University School of Education Health and Social Studies Holm, Lena; Karolinska Institutet, Institute of Environmental Medicine Lekander, Mats; Stockholm University, Stress Research Institute; Karolinska Institutet, Department of Clinical Neuroscience Hallqvist, Johan; Uppsala University, Department of Public Health and Caring Sciences Skillgate, Eva; Karolinska Institutet, Institute of Environmental Medicine; Sophiahemmet University, Department of health promotion science
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health
Keywords:	Musculoskeletal disorders < ORTHOPAEDIC & TRAUMA SURGERY, PUBLIC HEALTH, EPIDEMIOLOGY, Back pain < ORTHOPAEDIC & TRAUMA SURGERY, Spine < ORTHOPAEDIC & TRAUMA SURGERY

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

The influence of work ability and smoking on the prognosis of long-duration activity-limiting neck/back pain – a cohort study of a Swedish working population

Tony Bohman[1,2]*, Lena W Holm[1], Mats Lekander[3,4], Johan Hallqvist[5], Eva Skillgate[1,6]

[1]Institute of Environmental Medicine, Unit of Intervention and Implementation Research for Worker Health, Karolinska Institutet, Stockholm, Sweden

[2]School of Education, Health and Social Studies, Dalarna University, Sweden

[3]Stress Research Institute, Stockholm University, Sweden

[4]Department of Clinical Neuroscience, Karolinska Institutet, Stockholm, Sweden

[5]Department of Public Health and Caring Sciences, Family Medicine and Preventive Medicine, Uppsala University, Uppsala, Sweden

[6]Department of Health Promotion Science, Musculoskeletal & Sports Injury Epidemiology Center, Sophiahemmet University, Stockholm, Sweden

*Corresponding author:

Tony Bohman

Institute of Environmental Medicine, Unit of Intervention and Implementation Research for Worker Health, Karolinska Institutet, Box 210, SE-171 77 Stockholm, Sweden

E-mail: tony.bohman@ki.se

Cell phone: +46 70 299 62 63

Abstract

Objectives

Long-duration activity-limiting neck/back pain is common, but the knowledge of what work and lifestyle factors that influence the prognosis is sparse. The objective was therefore to here evaluate if two factors, good self-perceived work ability and no daily smoking, are associated with a favourable prognosis of long-duration activity-limiting neck/back pain in a working population, and if these exposures have a synergistic prognostic effect.

Design

A prospective cohort study based on three subsamples from the Stockholm Public Health Cohort.

Settings

A working population in Stockholm County, Sweden.

Participants

Individuals, 18-61 years old, reporting long-duration activity-limiting neck/back pain the previous six months at baseline in 2010 (n=5,177).

Measures

The exposures were: self-perceived work ability (categorised into good, moderate, and poor), and daily smoking (no/yes). The outcome in 2014 was "absence of long-duration activity-limiting neck/back pain" the previous six months representing a favourable prognosis of reported problems at baseline in 2010. Risk ratios (RRs) and risk differences (RDs) with 95% CI was estimated by general linear regressions, and the synergistic effect by the synergy index (SI) with 95% CI.

Results

Participants with moderate or good work ability, respectively, had an adjusted RR for a favourable prognosis of 1.37 (95% CI: 1.11-1.69), and 1.80 (1.49-2.17) in comparison to participants with poor work ability. The corresponding adjusted RD were 0.07 (0.02-0.11) and 0.17 (0.12-0.22). Participants not smoking on daily basis had an adjusted RR of 1.21 (1.02-1.42), and an adjusted RD of 0.05 (0.01-0.10) for a favourable outcome compared to daily smokers. The adjusted SI was 0.92 (0.60-1.43).

Conclusion

For participants with long-duration activity-limiting neck/back pain, moderate or good self-perceived work ability and not being a daily smoker were associated with a favourable prognosis but having both exposures seemed to have no synergistic prognostic effect.

Keywords: disability evaluation, musculoskeletal pain, public health, tobacco use

Strengths and limitations of this study

- The longitudinal design ensures temporality and the large number of potential confounders considered increase the possibility of a causal association between the exposers and the outcome.
- The large sample size and robust analyses strengthens the internal validity.
- The main limitations of this study are possible misclassification of the exposures and the outcome, a relatively large loss to follow-up and a possible change of exposure category during the follow-up period of four years, although these limitations most probably lead to an underestimation of the associations studied.

- There is a possible risk that reversed causation have influenced the analyses with perceived work ability as exposure, but the additional analyses indicates that this risk is small.

Introduction

According to the Global Burden of Disease study, neck pain and back pain are among the top causes for "years lived with disability", with a high and rising prevalence globally (1). Most neck and back problems resolve, but many individuals experience pain for a long time following onset (2, 3). Between 17% to 70% of individuals with neck pain report activity-limiting pain (3). Long-duration activity-limiting neck/back pain (LANBP) is most prevalent in working age, and often decrease work performance (2, 4). From a public health perspective, LANBP adds to the societal and individual burden as it is a common cause for absenteeism and early retirement (5). Still, and in accordance with current recommendations, many individuals with musculoskeletal pain go to work (4).

One way to address this burden of LANBP is to increase the understanding of modifiable lifestyle and work-related factors associated to a favourable prognosis and their potential interactions. Research about prognosis of LANBP have so far focused on factors of potential importance for the transition from acute/sub-acute neck and back pain to LANBP, and several biopsychosocial factors are suggested to be associated to such an unfavourable prognosis. Examples of such factors are smoking, low physical activity, depression, anxiety, and low work satisfaction (2, 6). On the other hand, only greater optimism, good social support, positive coping and exercise/sport activities are proposed as factors associated to a favourable prognosis for long-duration and activity-limiting neck pain, and none for back pain (6). Thus, knowledge of if work-related factors and lifestyle factors, other than physical activities, associate to a favourable prognosis of LANBP is lacking.

The multidimensional work ability model was introduced in Finland in the 1980s in order to study self-perceived work ability in relation to work-disability and health (7, 8). According to the model, self-perceived work ability is based on health and functional capacity and built on a balance between a person´s resources such as competence, values, attitudes, motivation, and

work demands. Self-perceived work ability is commonly assessed by the Work Ability Index (WAI) or by single items of the instrument (9). Work ability is associated with health and health related outcomes, eg depression, osteoarthritis, neck and back pain, sickness absence and general health (7, 10). Furthermore, the total WAI or single WAI items seems to be valuable for predicting sickness absence in healthy as well in unhealthy populations, with good work ability being a protective factor in all diseases studied (10-14). However, work ability in relation to the prognosis of neck/back pain is rarely studied. Nordstoga et al., studying back pain patients referred to physiotherapy, found no association between baseline work ability and disability or pain three months later (15). Ahlström et al., followed Swedish female workers on long-term sick leave for 12 months, the majority with neck pain, and found work ability to predict the future degree of neck pain (10). In a recent study from our group, we found that poor work ability, assessed with the second WAI item (perceived mental and/or physical work ability), increased the risk of LANBP in workers with occasional neck- and/or back pain (16).

So far, we know that smoking is associated with the onset of neck and back pain, and with the transition from acute/subacute to long-duration back pain, but we do not know if being a non-smoker is associated with a favourable prognosis of LANBP (2, 6). If so, and considering a known association between smoking and poor work ability, examine their potential interaction on the prognosis of LANBP would enhance our understanding and meet the demand for studies examining such interactions from reviews on the prognosis of neck and back pain (17, 18, 19).

Therefore, the objective of this study was to evaluate if good self-perceived work ability and no daily smoking are associated with a favourable prognosis of LANBP in a working population, and if these exposures have a synergistic prognostic effect.

Methods

Design and study population

In this prospective cohort study, we used merged data from three subcohorts of the Stockholm Public Health Cohort (SPHC) (20). The SPHC consists of several public health surveys of individuals randomly selected from the adult population of Stockholm County. The first subcohort included individuals selected in 2002 and followed up in 2007, 2010 and 2014. The second cohort included individuals selected in 2006 and followed up in 2010 and 2014, and the third subcohort individuals selected in 2010 and followed up in 2014. Approximately 74,000 individuals from the subcohorts responded to the questionnaire in 2010, which was used as baseline in the present study. Of these, approximately 50,000 individuals (68%) responded to the questionnaire in 2014, used as the follow-up survey in the present study. Of the responders in 2010, 39,704 were 18-61 years of age and were working since at least 12 months, representing our "working population". We chose the age limit of 61 in 2010 to ensure that most of our population would still be working in 2014 as 65 was the norm for retirement age in Sweden at the time of the data collection. Figure 1 describes the inclusion of participants into the study population and the analyses sample.

Neck and back pain at baseline in 2010 were assessed with 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?". Both questions were followed by the question; "If yes: Do these problems limit your ability to work or carry out other daily activities?". Individuals answering, "Yes, on average, a few days per week or more" to at least one of the first two questions and then "Yes, to a high degree *or* to some degree" to the following question were considered as having LANBP. The questions defining LANBP incorporates

duration, frequency and the impact on daily activity and work which is recommended when classifying neck and back pain (18, 21).

Ethical approval was received from the regional ethical board in Stockholm (Dnr; 2007/545-31, 2013/497-32 and 2015/1204-32).

Exposures

The exposure "self-perceived work ability" (PWA) was categorised based on the second item of the WAI (7, 9, 22). The item consists of two questions, one regarding physical demands and one regarding mental demands at work, respectively: "How do you rate your current work ability with respect to the *physical demands/mental demands* of your work". The response alternatives were "Very good", "Rather good", "Moderate", "Rather poor" and "Very poor". The answers were dichotomized into good (very good or rather good) and poor (moderate, rather poor or very poor) physical and mental work ability, respectively. Finally, PWA was operationalised into three categories: good PWA (good physical *and* good mental work ability), moderate PWA (good physical *or* good mental work ability, but not both) and poor PWA (poor physical *and* poor mental work ability).

The WAI is considered an internally coherent, reliable, and valid instrument appropriate for use in cross-national research (9, 23, 24). Most often, the full WAI is used in research, but also single items have been utilised as measures, for example the second WAI item used to operationalise the exposure in the present study (10-12, 25).

The exposure "daily smoking" (DS) was dichotomized by the answer yes or no to the question: "Do you currently smoke daily or almost daily?".

Outcome

The outcome "absence of long-duration activity-limiting neck/back pain" in 2014 represents a favourable prognosis of reported problems at baseline in 2010. The definition was based on

the same questions used defining the study population. Participants defined as having a favourable prognosis (cases) were those reporting no neck/back pain *or* neck/back pain not limiting their activity in daily life or at work the preceding six months. Consequently, non-cases have had pain of any duration and frequency in the neck and/or back that limited activity in daily life or at work to some or to a high degree during the preceding six months.

Potential confounders

Potential confounders for the association between the exposure and the outcome were chosen based on literature, theoretical and clinical considerations, and availability in the questionnaire (2, 3, 6, 26). Potential confounders are presented in the Appendix. Most of the items used to measure the potential confounders have regularly been used in Swedish public health surveys since 1975, and since 2002 in the SPHC (20).

Statistics

Stata version 14.2 (StataCorp College Station, TX, USA) were used for statistical analyses. The association between the exposures and the outcome were estimated using general linear models with a binomial distribution and a log-link and reported as risk ratio (RR) and risk difference (RD) with corresponding 95% confidence intervals (CI). The exposures, PWA and DS were assessed in separate general linear models. Potential confounders were identified by reviewing the literature of prognostic factors, clinical considerations, and availability. After careful discussion about if they instead possibly could be intermediators or colliders, the potential confounders were introduced into the crude models one by one. Potential confounders changing the estimated RR by 5% or more were considered confounders and were included in the final adjusted models (27). DS was tested as a confounder in the analyses with PWA as exposure and PWA was tested as a confounder in the analyses with DS as exposure. A variable indicating subsample participation was included in all models to adjust

for potential systematic difference between the subcohorts. The general linear models were performed using complete-subject analyses. The Chi-square test was used to test a potential dose-response effect (28).

To calculate the potential synergistic effect of PWA and DS on the outcome, we used the EpiNET´s epidemiological tool (29). We dichotomised PWA into good PWA and moderate/poor PWA and then combined the dichotomized PWA and DS in a dummy variable, where the reference group was set to those having moderate/poor PWA and being daily smokers. The dummy variable was then used as the independent factor in a crude and an adjusted logistic regression. The results were presented as RR with corresponding 95% CI together with the synergy index (SI) with corresponding 95% CI. A SI >1 indicates a joint effect between two factors greater than the sum of their individual effects.

Additional analyses

We had no information on the intensity of LANBP at baseline, which may be an important confounder in the analyses. As poor self-related health may be a consequence of severe pain intensity, we performed the adjusted analyses with PWA as exposure stratified by good (very good/good) and poor (fair/poor/very poor) self-rated health (SRH), as a proxy for the intensity of neck/back pain at baseline (30).

The potential influence of attrition was assessed by comparing the prevalence of the two exposures among non-responders (n=1,865) to the prevalence among responders (n=3,312) using Chi-square tests.

Patient and Public Involvement

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

Results

Baseline characteristics of the study population are presented in Table 1. The mean age was 46 years (SD 10) and 66% were women. Eighty percent reported good or moderate self-perceived work ability and 84% were not smoking daily. Most participants were non-manual workers or self-employed (65%), and the majority lived together with another adult person, with or without children (77%). At follow-up in 2014, 36% of the participants showed a favourable prognosis of LANBP.

Table 1 Baseline characteristics by the exposures perceived work ability (PWA) and daily smoking (DS). Study population, n=5,177.

Baseline characteristics, n (%)	**Perceived work ability** (n=5,177)			**Daily smoking** (n=5,138)		**Int. Missing** PWA/DS
	Good	**Moderate**	**Poor**	**No**	**Yes**	n/n
	3,076 (59)	1,080 (21)	1,021 (20)	4,320 (84)	818 (16)	
Sex: Women	1,974 (64)	734 (68)	688 (67)	2,840 (66)	534 (65)	0/0
Average age, years (SD)	45 (10)	46 (10)	47 (10)	45 (10)	47 (10)	0/0
Perceived work ability: Good				2,679 (62)	377 (46)	-/0
Moderate				888 (21)	186 (23)	
Poor				753 (17)	255 (31)	
Daily smoking: Yes	377 (12)	186 (17)	255 (25)			39/-
BMI: Underweight/Normal weight	1,550 (51)	530 (51)	408 (41)	2,093 (49)	383 (48)	128/127
Overweight/Obese	1,457 (49)	522 (49)	582 (59)	2,122 (51)	413 (52)	
SES: Unskilled/semiskilled worker	435 (15)	219 (22)	301 (32)	712 (17)	236 (30)	267/263
Skilled worker	393 (13)	173 (17)	183 (20)	566 (14)	174 (22)	
Low level non-manual employees	465 (16)	137 (13)	120 (13)	603 (15)	115 (15)	
Middle level non-manual employees	806 (27)	255 (25)	180 (19)	1,111 (27)	124 (16)	
High level non-manual employees/self-employed	849 (29)	238 (23)	156 (16)	1,103 (27)	131 (17)	
Household: Living with adult, with/without children	2,463 (81)	791 (74)	685 (68)	3,361 (78)	555 (68)	40/36
Living alone/Living with children only	601 (19)	277 (26)	320 (42)	928 (22)	258 (32)	
Headache/migraine: Yes	1,330 (44)	556 (53)	631 (66)	2,084 (50)	416 (53)	160/152

Psychological distress: No	2,403 (78)	596 (56)	382 (38)	2,876 (67)	479 (59)	25/24
Mild/Severe	456 (15)	259 (24)	263 (26)	801 (19)	169 (21)	
Severe	207 (7)	217 (20)	369 (36)	622 (14)	167 (20)	
Personal support: No	359 (12)	219 (20)	307 (30)	698 (16)	182 (22)	32/28
Sleep disturbances: Yes	1,254 (42)	623 (59)	744 (76)	2,120 (50)	480 (61)	150/144
Sedentary leisure time: <2 hours/day	1,802 (59)	540 (50)	502 (50)	2,441 (57)	385 (48)	35/33
>2 hours/day	1,253 (41)	536 (50)	509 (50)	1,854 (43)	425 (52)	
Leisure physical activity, mod intensity: <20 min/day	977 (32)	389 (36)	436 (43)	1,435 (34)	352 (44)	52/49
>20 min/day	2,073 (68)	683 (64)	567 (57)	2,851 (66)	456 (56)	
Leisure physical activity, high intensity: <1 hour/week	1,301 (43)	532 (50)	562 (56)	1,883 (44)	495 (61)	45/43
>1 hour/week	1,753 (57)	540 (50)	444 (44)	2,404 (56)	313 (39)	
Physical workload: Sedentary at least 50%	1,801 (60)	537 (51)	448 (46)	2,410 (57)	361 (46)	117/114
Standing/walking/some lifting	727 (24)	291 (27)	319 (33)	1,094 (26)	230 (29)	
Walking/lifting/heavy work	496 (16)	232 (22)	209 (21)	738 (17)	191 (25)	
Subsample participation: 2002/2007/2010/2014	781 (25)	269 (25)	233 (23)	1,106 (26)	170 (21)	0/0
2006/2010/2014	1,011 (33)	352 (33)	346 (34)	1,432 (33)	268 (33)	
2010/2014	1,284 (42)	459 (42)	442 (43)	1,782 (41)	380 (46)	
Self-rated health: Very good	293 (9)	23 (2)	12 (1)	302 (7)	26 (3)	49/48
Good	1,801 (59)	336 (32)	145 (14)	1,982 (46)	286 (35)	
Fair	877 (29)	567 (53)	536 (53)	1,585 (37)	376 (46)	
Poor or very poor	82 (3)	137 (13)	319 (32)	408 (10)	125 (16)	

Note: For a description of the variables and their categorisation see the Appendix. **Abbreviation**: SES; Socioeconomic status.

The crude and adjusted associations between self-perceived work ability, daily smoking and a favourable prognosis of LANBP are presented in Table 2. Socioeconomic status, headache/migraine and sleep disturbances were identified as confounders in the analyses with self-perceived work ability as exposure, while socioeconomic status, sleep disturbances and self-perceived work ability confounded the association between daily smoking and the outcome.

Table 2 Associations* between the exposures perceived work ability (PWA) and daily smoking (DS) in 2010, and a favourable prognosis of long-duration activity-limiting neck and/or back pain in 2014.

Exposure	**Cases/total**	**Crude** (n=3,312)		**Adjusted**[a] (n=3,049)		**Adjusted**[a]	
		RR	**95% CI**	**RR**	**95% CI**	**RD**	**95% CI**
Perceived work ability							
Poor	115/596	1		1		0	
Moderate	203/688	1.53	1.25-1.87	1.37	1.11-1.69	0.07	0.02-0.11
Good	873/2,028	2.23	1.88-2.65	1.80	1.49-2.17	0.17	0.12-0.22
Exposure	**Cases/total**	**Crude** (n=3,292)		**Adjusted**[b] (n=3,088)		**Adjusted**[b]	
		RR	**95% CI**	**RR**	**95% CI**	**RD**	**95% CI**
Daily smoking							
Yes	115/459	1		1		0	
No	1,070/2,833	1.51	1.28-1.78	1.21	1.02-1.42	0.05	0.01-0.10

*General linear models with a binomial distribution and a log-link, estimating the risk ratio (RR), or an identity-link, estimating the risk difference (RD), with corresponding 95% confidence intervals (CI). [a]Adjusted for socioeconomic status, headache/migraine, sleep disturbances and subsample participation; [b]Adjusted for socioeconomic status, sleep disturbances, perceived work ability and subsample participation.

In comparison to participants with poor work ability participants with moderate or good work ability, had an adjusted RR for a favourable prognosis of 1.37 (95% CI: 1.11-1.69), and 1.80 (1.49-2.17), respectively. The corresponding adjusted RD were 0.07 (0.02-0.11) and 0.17 (0.12-0.22). Participants not smoking on daily basis had an adjusted RR of 1.21 (1.02-1.42), and an adjusted RD of 0.05 (0.01-0.10) for a favourable outcome compared to daily smokers. The analyses with self-perceived work ability as exposure showed a significant dose-response towards a more favourable prognosis with higher work ability ($p < 0.001$).

Table 3 shows the result of the evaluation of the synergistic associations between the exposures and the outcome, resulting in an adjusted SI of 0.92 (95% CI: 0.60-1.43).

Table 3 Analyses* of the potential synergistic effects of the two exposures perceived work ability (PWA) and daily smoking (DS), on a favourable prognosis of long-duration activity-limiting neck and/or back pain.

Exposure	**Cases/total**	**Crude** (n=3,312)		**Adjusted**[a] (n=3,049)	
		RR	**95% CI**	**RR**	**95% CI**
Moderate/poor perceived work ability and daily smoking	39/253	1		1	
Moderate/poor perceived work ability and no daily smoking	276/1,022	1.88	1.32-2.66	1.61	1.11-2.34
Good perceived work ability and daily smoking	76/206	2.96	1.93-4.54	2.33	1.49-3.66
Good perceived work ability and no daily smoking	794/1,811	3.96	2.84-5.52	2.80	1.95-4.02
Synergy index				0.92	0.60-1.43

*Using EpiNET´s epidemiological tool "Epinetcaculation.xlsx" based on the results from logistic regressions. [a]Adjusted for socioeconomic status, headache/migraine, sleep disturbances and subsample participation. **Abbreviations:** RR; risk ratio, CI; confidence interval.

Additional results

Stratifying the analyses of the exposure self-perceived work ability by good and poor self-rated health, as a proxy for the intensity of neck/back pain at baseline, resulted in similar adjusted RR for the two strata. The RR for a favourable prognosis of LANBP when reporting moderate work ability showed a similar increase for participants with poor self-rated health and participants with good self-rated health, 1.42 (95% CI; 0.93-2.15) and 1.27 (95% CI; 0.98-1.63), compared with participants with poor work ability. The RR were also similar for those reporting good work ability in both strata, 1.72 (95% CI; 1.17-2.53) and 1.56 (95% CI; 1.23-1.96), respectively.

At baseline in 2010, non-responders had a significantly higher prevalence ($p < 0.001$) of individuals with poor self-perceived work ability and daily smokers (23% and 19%) in comparison with responders (18% and 14%).

Discussion

In this study we found an association between self-perceived work ability and a favourable prognosis of long-duration activity-limiting neck/back pain four years later. The results revealed that individuals in a working population with moderate self-perceived work ability (either good physical or good mental work ability) had a 37% increased chance of a favourable prognosis of long-duration activity-limiting neck/back pain, compared to individuals with poor self-perceived work ability (poor physical and poor mental work ability). The chance of a favourable prognosis was even higher (80%) for individuals reporting good self-perceived work ability (both good physical and good mental work ability). In addition, the results showed that individuals that did not smoke daily had a 21% higher chance of a favourable prognosis than did daily smokers.

A possible synergetic effect on a favourable prognosis for participants reporting good work ability and not smoke on daily basis could not be confirmed.

Previously, Nordstoga et al. found no association between baseline work ability and improvement of back pain or disability in physiotherapy patients with back pain of any duration, which contrasts with our results (15). Their study included patients with back pain of any duration, had a follow-up time of only three months, and they used the question "describe your current work ability compared with the lifetime best (0-10)'' as a measure of self-perceived work ability. More in line with our result, Ahlström et al. found higher baseline work ability, defined by the same question as Nordstoga et al. and by the full WAI, to predict lower degree of neck pain at six and 12 months among women on long-term sick-leave (10). We have not found any previous study of association between smoking and a favourable prognosis, either for neck or for back pain, or on the synergetic effect of work ability and smoking.

The mechanism for smoking to affect spinal pain is not yet well understood, but increased levels of pro-inflammatory cytokines, changed pain perception, impaired blood supply, and impaired oxygen delivery to tissues caused by increased sympathetic outflow has been suggested (31, 32). The latter could be one possible underlying mechanism to the higher prevalence of osteoporosis and lumbar disc disease found in smokers compared to non-smokers (31, 32). As the concept of self-perceived work ability incorporate individual factors, work-related factors and environmental factors, a specific mechanism for good self-perceived work ability to associate with a favourable prognosis of LANBP may be difficult to delineate (7).

The present study has some possible limitations. Clustering individuals with neck and back pain when studying prognostic factors may be questioned, since prognostic factors for neck- and back pain may differ. But, as a priory analysis evaluating participants with long-duration

activity-limiting neck and back pain separately, resulted in almost identical crude estimates, we decided to merge the data to increase the statistical power.

Even though a large number of potential confounders was considered unmeasured confounding could not be ruled out. There is also a risk of residual confounding due to unprecise measure of confounding factors, i.e. socioeconomic status. Such bias may have led to underestimation or overestimation of the results. We had no baseline information on pain intensity prior to inclusion into the cohort, therefore we could not consider pain intensity as a potential confounder. If pain intensity at baseline is associated with the reported levels of PWA at baseline, bias due to reversed causation may be present (27). Then our results may have been overestimated.

However, we believe that the risk of reversed causation due to baseline pain intensity is limited as individual self-perceived work ability is most likely a combination of many factors other than pain, for example content, demands and organisation of work, personal attitudes, motivation, knowledge and skills, and functional capacity (8). Furthermore, given that pain is related to health, the additional analyses stratified by good and poor self-rated health indicating that good PWA is beneficial no matter the degree of self-rated health also supports a low risk of bias due to reversed causation.

Misclassification of the exposures and outcome needs consideration. Problems to recall and to appraise whether the pain during the preceding six months was activity-limiting or not may have resulted in non-cases being classified as cases and vice versa. This possible misclassification of the outcome is most probably non-differential potentially leading to a dilution of our associations (27). The exposure PWA was assessed with only one subscale of the WAI. Nonetheless, this subscale from the WAI is found to be internally coherent to the full WAI (25). Furthermore, the operationalisation of the exposure PWA by dichotomising a five category scales of mental and physical work ability and then combining them may have

led to bias due to misclassification. Smoking was measured with a yes/no question about daily smoking, which is a rough measure of such exposure. By categorising former smokers as non-smokers and smokers who only smoke a few cigarettes a day as smokers, we might have introduced a misclassification of this exposure. These potential misclassifications of the exposures most likely is non-differential, thus potentially diluting the associations.

As the follow-up period was four years work ability and smoking status may have varied across this period, and participants may have changed jobs or work assignments. If so, this would probably dilute the estimation of the association.

With a response rate of 64% between baseline and follow-up there is a risk of selection bias. Non-responders had a significantly higher proportion of smokers and individuals with poor self-perceived work ability than did responders. If most of these individuals would experience a favourable prognosis of their long-duration activity-limiting neck/back pain, a scenario we find unlikely, our results may be overestimated.

Strengths of this study are the longitudinal design, and a relatively large sample size, allowing evaluation of the outcome along categories of the exposure. However, despite a large sample, the evaluation of synergetic effects may have been hampered by few cases in the reference categories. The dose-response results found supports a causal association between self-perceived work ability and long-duration activity-limiting neck/back pain, and the extensive confounder control supports internal validity. We also regard the incorporation of activity limitations in the definition of the baseline pain and in the outcome as a strength. Activity limitations is recommended to be included in measures for neck and back pain, recognised to be of clinical importance, and to have negative consequences for the affected individual and for the society (1, 5, 18, 21).

To our knowledge this is the first study assessing self-perceived work ability and smoking focusing on a favourable prognosis of long-duration activity-limiting neck/back pain. Even

though more research is needed to confirm our findings, they imply that good work ability and not smoking daily appears to predict a favourable prognosis of long-duration activity-limiting neck/back pain. Thus, interventions to improve physical and mental work ability and reduce smoking may enhance the chance for a favourable prognosis in workers with long-duration activity-limiting neck/back pain. Therefore, further research focusing on such interventions is motivated. Such interventions could be directed towards both the workplace organisation and the individual, possibly resulting in reduced human suffering and societal costs.

Conclusion

Having a good physical and/or mental self-perceived work ability as well as not smoking on daily basis is associated to a favourable prognosis in a working population with long-duration activity-limiting neck/back pain. However, fulfilling both criteria seem to have no synergistic prognostic effect.

Acknowledgement

Thanks to Peeter Fredlund, Research Statistician at Karolinska Institutet and SLL Centre for Epidemiology and Community Medicine, Stockholm, for providing us with the data.

Contributors

TB, LWH, ML and ES contributed to the conceptualisation and methodology of the study. JH approved the conceptualisation and method and provided the data resources. Based on a protocol approved by all authors TB made the statistical analyses and wrote the first draft of the manuscript. All authors contributed to the interpretation of the results and critically revised the manuscript and approved the last manuscript version.

Funding

This study was supported by AFA Insurance, grant number 170095. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests

Non to declare.

Data availability statement

Data are available upon reasonable request. 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.

References

1. Vos T, Abajobir AA, Abate KH, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet. 2017;390(10100):1211-59.

2. Hartvigsen J, Hancock MJ, Kongsted A, et al. What low back pain is and why we need to pay attention. The Lancet. 2018;391(10137):2356-67.

3. Hoy DG, Protani M, De R, Buchbinder R. The epidemiology of neck pain. Best Pract Res Clin Rheumatol. 2010;24(6):783-92.

4. Cochrane A, Higgins NM, Rothwell C, et al. Work Outcomes in Patients Who Stay at Work Despite Musculoskeletal Pain. J Occup Rehabil. 2018;28(3):559-67.

5. Schofield DJ, Shrestha RN, Percival R, Callander EJ, Kelly SJ, Passey ME. Early retirement and the financial assets of individuals with back problems. Eur Spine J. 2011;20(5):731-6.

6. Green BN, Johnson CD, Haldeman S, et al. A scoping review of biopsychosocial risk factors and co-morbidities for common spinal disorders. PLoS One. 2018;13(6):e0197987.

7. Gould R, Ilmarinen J, Järvisalo J, Koskinen S. Dimensions of Work Ability. Results of the 2000 Health Survey. Vaasa: Waasa Graphics Oy; 2008.

8. Ilmarinen J. Work ability, a comprehensive concept for occupational health research and prevention. Scand J Work Environ Health. 2009;35(1):1-5.

9. Ilmarinen J. The Work Ability Index (WAI). Occupational Medicine. 2006;57(2):160.

10. Ahlstrom L, Grimby-Ekman A, Hagberg M, Dellve L. The work ability index and single-item question: associations with sick leave, symptoms, and health – a prospective study of women on long-term sick leave. Scand J Work Environ Health. 2010;36(5):404-12.

11. Kinnunen U, Natti J. Work ability score and future work ability as predictors of register-based disability pension and long-term sickness absence: A three-year follow-up study. Scand J Public Health. 2018;46(3):321-30.

12. Lundin A, Kjellberg K, Leijon O, Punnett L, Hemmingsson T. The Association Between Self-Assessed Future Work Ability and Long-Term Sickness Absence, Disability Pension and Unemployment in a General Working Population: A 7-Year Follow-Up Study. J Occup Rehabil. 2016;26(2):195-203.

13. Reeuwijk KG, Robroek SJ, Niessen MA, Kraaijenhagen RA, Vergouwe Y, Burdorf A. The Prognostic Value of the Work Ability Index for Sickness Absence among Office Workers. PLoS One. 2015;10(5):e0126969.

14. Sundstrup E, Jakobsen MD, Mortensen OS, Andersen LL. Joint association of multimorbidity and work ability with risk of long-term sickness absence: a prospective cohort study with register follow-up. Scand J Work Environ Health. 2017;43(2):146-54.

15. Nordstoga AL, Vasseljen O, Meisingset I, Nilsen TIL, Unsgaard-Tondel M. Improvement in Work Ability, Psychological Distress and Pain Sites in Relation to Low Back Pain Prognosis: A Longitudinal Observational Study in Primary Care. Spine (Phila Pa 1976). 2019;44(7):E423-e9.

16. Holm LW, Bohman T, Lekander M, Magnusson C, Skillgate E. 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. BMJ Open. 2020;10(6):e033946.

17. van den Berg TI, Elders LA, de Zwart BC, Burdorf A. The effects of work-related and individual factors on the Work Ability Index: a systematic review. Occup Environ Med. 2009;66(4):211-20.

18. Supplement article: Carroll LJ, Hurwitz EL, Cote P, et al. Research priorities and methodological implications: the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. Spine. 2008;33(4 Suppl):S214-20.

19. Hayden JA, Dunn KM, van der Windt DA, Shaw WS. What is the prognosis of back pain? Best Pract Res Clin Rheumatol. 2010;24(2):167-79.

20. Svensson AC, Fredlund P, Laflamme L, et al. Cohort profile: The Stockholm Public Health Cohort. Int J Epidemiol. 2013;42(5):1263-72.

21. Dionne CE, Dunn KM, Croft PR, et al. A consensus approach toward the standardization of back pain definitions for use in prevalence studies. Spine (Phila Pa 1976). 2008;33(1):95-103.

22. Tuomi K, Ilmarinen J, Jahkola A, Katajarinne L, Tulkki A. Work ability index. 2 ed. Helsinki: Finnish Institute of Occupational Health; 1998.

23. de Zwart BCH, Frings-Dresen MHW, van Duivenbooden JC. Test–retest reliability of the Work Ability Index questionnaire. Occupational Medicine. 2002;52(4):177-81.

24. Radkiewicz P, Widerszal-Bazyl M. Psychometric properties of Work Ability Index in the light of comparative survey study. International Congress Series. 2005;1280:304-9.

25. Lundin A, Leijon O, Vaez M, Hallgren M, Torgén M. Predictive validity of the Work Ability Index and its individual items in the general population. Scand J Public Health. 2017;45(4):350-6.

26. Verkerk K, Luijsterburg PA, Miedema HS, Pool-Goudzwaard A, Koes BW. Prognostic factors for recovery in chronic nonspecific low back pain: a systematic review. Phys Ther. 2012;92(9):1093-108.

27. Lash TL, VanderWeele TJ, Haneuse S, Rothman KJ. Modern epidemiology. Philadelphia, PA: Wolters Kluwer; 2021.

28. Vittinghoff E, Glidden DV, Shiboski SC, McCulloch CE. Regression Methods in Biostatistics, Linear, Logistic, Survival, and Repeated Measures Models. 2nd ed. New York, USA: Springer New York; 2012.

29. Andersson T, Alfredsson L, Kallberg H, Zdravkovic S, Ahlbom A. Calculating measures of biological interaction. Eur J Epidemiol. 2005;20(7):575-9.

30. Perruccio AV, Power JD, Badley EM. Arthritis onset and worsening self-rated health: a longitudinal evaluation of the role of pain and activity limitations. Arthritis Rheum. 2005;53(4):571-7

31. Shiri R, Karppinen J, Leino-Arjas P, Solovieva S, Viikari-Juntura E. The association between smoking and low back pain: a meta-analysis. Am J Med. 2010;123(1):87 e7-35.

32. Shi Y, Weingarten TN, Mantilla CB, Hooten WM, Warner DO. Smoking and Pain: Pathophysiology and Clinical Implications. Anesthesiology. 2010;113(4):977-92.

Figure legends

Figure 1 Flow chart describing the inclusion of participants into the study population and the analyses sample. NP; neck pain, BP; low back pain, PWA; perceived work ability.

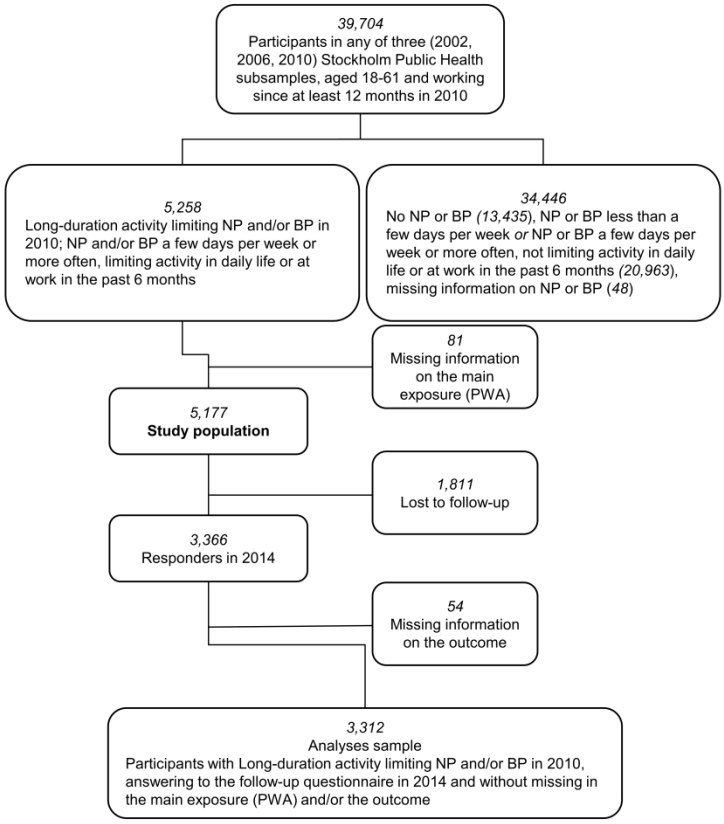

Figure 1. Flow chart describing the inclusion of participants into the study population and the analyses sample. NP; neck pain, BP; low back pain, PWA; perceived work ability.

383x511mm (300 x 300 DPI)

Appendix Potential confounding factors.

Potential confounder	Measurement	Categorisation in the analyses
Daily smoking[a]	"Do you currently smoke daily or almost daily?"	No, yes
Self-perceived work ability[b]	"How do you rate your current work ability with respect to the physical demands/mental demands of your work"	Good, moderate, and poor
Sex	Sex at baseline 2010	Men, women (no other alternatives available)
Age	Age at baseline 2010	Continuous and in quartiles (18-38), (39-46), (47-54), (55-61)
Body mass index (BMI)	Weight/height^2 (kg/m^2)	Categorical; underweight (<18.5), normal weight (18.5-24.9), overweight (25-29.9), obese (≥30)
Socioeconomic status (SES)	According to the classification from Statistics Sweden. Based on current occupation and education for the economically active population.	Unskilled/semiskilled worker, skilled worker, low level non-manual employees, middle level non-manual employees, high level non-manual employees/self-employed, self-employed (other than high level)
Household	"Do you live together with someone?"	Categorical; living together with adult/s and child/ren, living alone, living with child/children only
Headache/migraine	"Do you have headache or migraine?"	No, yes; somewhat or severe
Psychological distress[1, 2]	Based on the 12-item General Health Questionnaire (GHQ-12), using the scoring system 0-0-1-1.	No (0-2), mild (3-6), severe (7-12)
Personal support[2, 3]	"Do you know persons who can provide you with personal support for personal problems or crises in your life?"	No-usually not or never, yes-always or for the most part
Sleep disturbances	"Do you have sleep disturbances"	No, yes; somewhat or severe
Sedentary leisure time	"Refer to your leisure physical activity during the past 12 months? If the activities vary during the year and during a week, refer to an average." Sitting/watching TV/reading during leisure time.	Categorical: less than 2 hours/day, 2-3 hours/day, more than 3 hours/day
Leisure physical activity - moderate intensity	"Refer to your leisure physical activity during the past 12 months? If the activities vary during the year and during a week, refer to an average." Walking/biking during leisure time.	Categorical: less than 20 minutes/day, 20-40 minutes/day, more than 40 minutes/day
Leisure physical activity - high intensity	Refer to your leisure physical activity during the past 12 months? If the activities vary during the year and during a week, refer to an average." Exercise, other than walking/biking, during leisure time.	Categorical: less than 1 hour/week, 1-2 hours/week, more than 2 hours/week
Physical workload[4]	"Refer to your physical activity during your daily activity and/or work during the past 12 months? If the activity vary during the year and during a week, refer to an average.	Categorical; sedentary at least to 50 %, standing/walking/some lifting, walking/lifting/heavy work
Subsample participation[c]	Refers to the subsample of the Stockholm Public Health Cohort the participants belonged to.	Categorical: 2002/2007/2010/2014, 2006/2010/2014, 2010/2014

[a] Daily smoking was assessed as a potential confounder in the analyses with self-perceived work ability as exposure. [b] Self-perceived work ability was assessed as a potential confounder in the analyses with daily smoking as exposure. [c] Subsample participation was included in all adjusted models order to adjust for potential systematic difference between the subsamples. [#] Bibliographical references to definition and psychometric properties of the factors.

1. Goldberg DP, Gater R, Sartorius N et al. The validity of two versions of the GHQ in the WHO study of mental illness in general health care. Psychol Med. 1997;27(1):191-7.
2. McDowell I. Measuring health a guide to rating scales and questionnaires. 3rd ed. New York ; Oxford: Oxford University Press; 2006. xvi, 748 p
3. Unden AL, Orth-Gomer K. Development of a social support instrument for use in population surveys. Soc Sci Med. 1989;29(12):1387-92.4. Leijon O, Wiktorin C, Harenstam A, Karlqvist L. Validity of a self-administered questionnaire for assessing physical work loads in a general population. J Occup Environ Med. 2002;44(8):724-35.

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

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

		(b) Indicate number of participants with missing data for each variable of interest **Table 1 and Figure 1.**
		(c) Summarise follow-up time (eg, average and total amount) **N/A.**
Outcome data	15*	Report numbers of outcome events or summary measures over time **Page 11, Table 2 and 3.**
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 **Page 14, Table 2 and Table 3.**
		(*b*) Report category boundaries when continuous variables were categorized **Appendix and Table 1.**
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **Page 16 and Table 2.**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **Page 16, last paragraph. Page 18, "Additional results" and Table 3.**
Discussion		
Key results	18	Summarise key results with reference to study objectives **Page 18 and first paragraph at page 19.**
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 **Page 19 last paragraph. Page 20 and page 21 paragraph 1 and 2.**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **Page 21, last paragraph, and page 22 first paragraph.**
Generalisability	21	Discuss the generalisability (external validity) of the study results **Page 21, last paragraph, page 22 first paragraph and in the conclusion.**
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 **Page 23, "Funding".**

*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

The influence of work ability and smoking on the prognosis of long-duration activity-limiting neck/back pain – a cohort study of a Swedish working population

Journal:	*BMJ Open*
Manuscript ID	bmjopen-2021-054512.R2
Article Type:	Original research
Date Submitted by the Author:	18-Mar-2022
Complete List of Authors:	Bohman, Tony; Karolinska Institutet, Institute of Environmental Medicine; Dalarna University School of Education Health and Social Studies Holm, Lena; Karolinska Institutet, Institute of Environmental Medicine Lekander, Mats; Stockholm University, Stress Research Institute; Karolinska Institutet, Department of Clinical Neuroscience Hallqvist, Johan; Uppsala University, Department of Public Health and Caring Sciences Skillgate, Eva; Karolinska Institutet, Institute of Environmental Medicine; Sophiahemmet University, Department of health promotion science
Primary Subject Heading:	Epidemiology
Secondary Subject Heading:	Public health
Keywords:	Musculoskeletal disorders < ORTHOPAEDIC & TRAUMA SURGERY, PUBLIC HEALTH, EPIDEMIOLOGY, Back pain < ORTHOPAEDIC & TRAUMA SURGERY, Spine < ORTHOPAEDIC & TRAUMA SURGERY

I, the Submitting Author has the right to grant and does grant on behalf of all authors of the Work (as defined in the below author licence), an exclusive licence and/or a non-exclusive licence for contributions from authors who are: i) UK Crown employees; ii) where BMJ has agreed a CC-BY licence shall apply, and/or iii) in accordance with the terms applicable for US Federal Government officers or employees acting as part of their official duties; on a worldwide, perpetual, irrevocable, royalty-free basis to BMJ Publishing Group Ltd ("BMJ") its licensees and where the relevant Journal is co-owned by BMJ to the co-owners of the Journal, to publish the Work in this journal and any other BMJ products and to exploit all rights, as set out in our licence.

The Submitting Author accepts and understands that any supply made under these terms is made by BMJ to the Submitting Author unless you are acting as an employee on behalf of your employer or a postgraduate student of an affiliated institution which is paying any applicable article publishing charge ("APC") for Open Access articles. Where the Submitting Author wishes to make the Work available on an Open Access basis (and intends to pay the relevant APC), the terms of reuse of such Open Access shall be governed by a Creative Commons licence – details of these licences and which Creative Commons licence will apply to this Work are set out in our licence referred to above.

Other than as permitted in any relevant BMJ Author's Self Archiving Policies, I confirm this Work has not been accepted for publication elsewhere, is not being considered for publication elsewhere and does not duplicate material already published. I confirm all authors consent to publication of this Work and authorise the granting of this licence.

The influence of work ability and smoking on the prognosis of long-duration activity-limiting neck/back pain – a cohort study of a Swedish working population

Tony Bohman[1,2]*, Lena W Holm[1], Mats Lekander[3,4], Johan Hallqvist[5], Eva Skillgate[1,6]

[1]Institute of Environmental Medicine, Unit of Intervention and Implementation Research for Worker Health, Karolinska Institutet, Stockholm, Sweden

[2]School of Education, Health and Social Studies, Dalarna University, Sweden

[3]Stress Research Institute, Stockholm University, Sweden

[4]Department of Clinical Neuroscience, Karolinska Institutet, Stockholm, Sweden

[5]Department of Public Health and Caring Sciences, Family Medicine and Preventive Medicine, Uppsala University, Uppsala, Sweden

[6]Department of Health Promotion Science, Musculoskeletal & Sports Injury Epidemiology Center, Sophiahemmet University, Stockholm, Sweden

*Corresponding author:

Tony Bohman

Institute of Environmental Medicine, Unit of Intervention and Implementation Research for Worker Health, Karolinska Institutet, Box 210, SE-171 77 Stockholm, Sweden

E-mail: tony.bohman@ki.se

Cell phone: +46 70 299 62 63

Abstract

Objectives

Long-duration activity-limiting neck/back pain is common, but the knowledge of what work and lifestyle factors that influence the prognosis is sparse. The objective was therefore to here evaluate if two factors, good self-perceived work ability and no daily smoking, are associated with a favourable prognosis of long-duration activity-limiting neck/back pain in a working population, and if these exposures have a synergistic prognostic effect.

Design

A prospective cohort study based on three subsamples from the Stockholm Public Health Cohort.

Settings

A working population in Stockholm County, Sweden.

Participants

Individuals, 18-61 years old, reporting long-duration activity-limiting neck/back pain the previous six months at baseline in 2010 (n=5,177).

Measures

The exposures were: self-perceived work ability (categorised into good, moderate, and poor), and daily smoking (no/yes). The outcome in 2014 was "absence of long-duration activity-limiting neck/back pain" the previous six months representing a favourable prognosis of reported problems at baseline in 2010. Risk ratios (RRs) and risk differences (RDs) with 95% CI was estimated by general linear regressions, and the synergistic effect by the synergy index (SI) with 95% CI.

Results

Participants with moderate or good work ability, respectively, had an adjusted RR for a favourable prognosis of 1.37 (95% CI: 1.11-1.69), and 1.80 (1.49-2.17) in comparison to participants with poor work ability. The corresponding adjusted RD were 0.07 (0.02-0.11) and 0.17 (0.12-0.22). Participants not smoking on daily basis had an adjusted RR of 1.21 (1.02-1.42), and an adjusted RD of 0.05 (0.01-0.10) for a favourable outcome compared to daily smokers. The adjusted SI was 0.92 (0.60-1.43).

Conclusion

For participants with long-duration activity-limiting neck/back pain, moderate or good self-perceived work ability and not being a daily smoker were associated with a favourable prognosis but having both exposures seemed to have no synergistic prognostic effect.

Keywords: disability evaluation, musculoskeletal pain, public health, tobacco use

Strengths and limitations of this study

- The longitudinal design ensures temporality and the large number of potential confounders considered supports a possible causal association between the exposers and the outcome.
- The large sample size and robust analyses strengthens the internal validity.
- The main limitations of this study are possible misclassification of the exposures and the outcome, a relatively large loss to follow-up and a possible change of exposure category during the follow-up period of four years, although these limitations most probably lead to an underestimation of the associations studied.

- There is a possible risk that reversed causation have influenced the analyses with perceived work ability as exposure, but the additional analyses indicates that this risk is small.

Introduction

According to the Global Burden of Disease study, neck pain and back pain are among the top causes for "years lived with disability", with a high and rising prevalence globally (1). Most neck and back problems resolve, but many individuals experience pain for a long time following onset (2, 3). Between 17% to 70% of individuals with neck pain report activity-limiting pain (3). Long-duration activity-limiting neck/back pain (LANBP) is most prevalent in working age, and often decrease work performance (2, 4). From a public health perspective, LANBP adds to the societal and individual burden as it is a common cause for absenteeism and early retirement (5). Still, and in accordance with current recommendations, many individuals with musculoskeletal pain go to work (4).

One way to address this burden of LANBP is to increase the understanding of modifiable lifestyle and work-related factors associated to a favourable prognosis and their potential interactions. Research about prognosis of LANBP have so far focused on factors of potential importance for the transition from acute/sub-acute neck and back pain to LANBP, and several biopsychosocial factors are suggested to be associated to such an unfavourable prognosis. Examples of such factors are smoking, low physical activity, depression, anxiety, and low work satisfaction (2, 6). On the other hand, only greater optimism, good social support, positive coping and exercise/sport activities are proposed as factors associated to a favourable prognosis for long-duration and activity-limiting neck pain, and none for back pain (6). Thus, knowledge of if work-related factors and lifestyle factors, other than physical activities, associate to a favourable prognosis of LANBP is lacking.

The multidimensional work ability model was introduced in Finland in the 1980s in order to study self-perceived work ability in relation to work-disability and health (7, 8). According to the model, self-perceived work ability is based on health and functional capacity and built on a balance between a person´s resources such as competence, values, attitudes, motivation, and

work demands. Self-perceived work ability is commonly assessed by the Work Ability Index (WAI) or by single items of the instrument (9). Work ability is associated with health and health related outcomes, eg depression, osteoarthritis, neck and back pain, sickness absence and general health (7, 10). Furthermore, the total WAI or single WAI items seems to be valuable for predicting sickness absence in healthy as well in unhealthy populations, with good work ability being a protective factor in all diseases studied (10-14). However, work ability in relation to the prognosis of neck/back pain is rarely studied. Nordstoga et al., studying back pain patients referred to physiotherapy, found no association between baseline work ability and disability or pain three months later (15). Ahlström et al., followed Swedish female workers on long-term sick leave for 12 months, the majority with neck pain, and found work ability to predict the future degree of neck pain (10). In a recent study from our group, we found that poor work ability, assessed with the second WAI item (perceived mental and/or physical work ability), increased the risk of LANBP in workers with occasional neck- and/or back pain (16).

So far, we know that smoking is associated with the onset of neck and back pain, and with the transition from acute/subacute to long-duration back pain, but we do not know if being a non-smoker is associated with a favourable prognosis of LANBP (2, 6). If so, and considering a known association between smoking and poor work ability, examine their potential interaction on the prognosis of LANBP would enhance our understanding and meet the demand for studies examining such interactions from reviews on the prognosis of neck and back pain (17, 18, 19).

Therefore, the objective of this study was to evaluate if good self-perceived work ability and no daily smoking are associated with a favourable prognosis of LANBP in a working population, and if these exposures have a synergistic prognostic effect.

Methods

Design and study population

In this prospective cohort study, we used merged data from three subcohorts of the Stockholm Public Health Cohort (SPHC) (20). The SPHC consists of several public health surveys of individuals randomly selected from the adult population of Stockholm County. The first subcohort included individuals selected in 2002 and followed up in 2007, 2010 and 2014. The second cohort included individuals selected in 2006 and followed up in 2010 and 2014, and the third subcohort individuals selected in 2010 and followed up in 2014. Approximately 74,000 individuals from the subcohorts responded to the questionnaire in 2010, which was used as baseline in the present study. Of these, approximately 50,000 individuals (68%) responded to the questionnaire in 2014, used as the follow-up survey in the present study. Of the responders in 2010, 39,704 were 18-61 years of age and were working since at least 12 months, representing our "working population". We chose the age limit of 61 in 2010 to ensure that most of our population would still be working in 2014 as 65 was the norm for retirement age in Sweden at the time of the data collection. Figure 1 describes the inclusion of participants into the study population and the analyses sample.

Neck and back pain at baseline in 2010 were assessed with 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?". Both questions were followed by the question; "If yes: Do these problems limit your ability to work or carry out other daily activities?". Individuals answering, "Yes, on average, a few days per week or more" to at least one of the first two questions and then "Yes, to a high degree *or* to some degree" to the following question were considered as having LANBP. The questions defining LANBP incorporates

duration, frequency and the impact on daily activity and work which is recommended when classifying neck and back pain (18, 21).

Ethical approval was received from the regional ethical board in Stockholm (Dnr; 2007/545-31, 2013/497-32 and 2015/1204-32).

Exposures

The exposure "self-perceived work ability" (PWA) was categorised based on the second item of the WAI (7, 9, 22). The item consists of two questions, one regarding physical demands and one regarding mental demands at work, respectively: "How do you rate your current work ability with respect to the *physical demands/mental demands* of your work". The response alternatives were "Very good", "Rather good", "Moderate", "Rather poor" and "Very poor". The answers were dichotomized into good (very good or rather good) and poor (moderate, rather poor or very poor) physical and mental work ability, respectively. Finally, PWA was operationalised into three categories: good PWA (good physical *and* good mental work ability), moderate PWA (good physical *or* good mental work ability, but not both) and poor PWA (poor physical *and* poor mental work ability).

The WAI is considered an internally coherent, reliable, and valid instrument appropriate for use in cross-national research (9, 23, 24). Most often, the full WAI is used in research, but also single items have been utilised as measures, for example the second WAI item used to operationalise the exposure in the present study (10-12, 25).

The exposure "daily smoking" (DS) was dichotomized by the answer yes or no to the question: "Do you currently smoke daily or almost daily?".

Outcome

The outcome "absence of long-duration activity-limiting neck/back pain" in 2014 represents a favourable prognosis of reported problems at baseline in 2010. The definition was based on

the same questions used defining the study population. Participants defined as having a favourable prognosis (cases) were those reporting no neck/back pain *or* neck/back pain not limiting their activity in daily life or at work the preceding six months. Consequently, non-cases have had pain of any duration and frequency in the neck and/or back that limited activity in daily life or at work to some or to a high degree during the preceding six months.

Potential confounders

Potential confounders for the association between the exposure and the outcome were chosen based on literature, theoretical and clinical considerations, and availability in the questionnaire (2, 3, 6, 26). Potential confounders are presented in the Appendix. Most of the items used to measure the potential confounders have regularly been used in Swedish public health surveys since 1975, and since 2002 in the SPHC (20).

Statistics

Stata version 14.2 (StataCorp College Station, TX, USA) were used for statistical analyses. The association between the exposures and the outcome were estimated using general linear models with a binomial distribution and a log-link and reported as risk ratio (RR) and risk difference (RD) with corresponding 95% confidence intervals (CI). The exposures, PWA and DS were assessed in separate general linear models. Potential confounders were identified by reviewing the literature of prognostic factors, clinical considerations, and availability. After careful discussion about if they instead possibly could be intermediators or colliders, the potential confounders were introduced into the crude models one by one. Potential confounders changing the estimated RR by 5% or more were considered confounders and were included in the final adjusted models (27). DS was tested as a confounder in the analyses with PWA as exposure and PWA was tested as a confounder in the analyses with DS as exposure. A variable indicating subsample participation was included in all models to adjust

for potential systematic difference between the subcohorts. The general linear models were performed using complete-subject analyses. The Chi-square test was used to test a potential dose-response effect (28).

To calculate the potential synergistic effect of PWA and DS on the outcome, we used the EpiNET´s epidemiological tool (29). We dichotomised PWA into good PWA and moderate/poor PWA and then combined the dichotomized PWA and DS in a dummy variable, where the reference group was set to those having moderate/poor PWA and being daily smokers. The dummy variable was then used as the independent factor in a crude and an adjusted logistic regression. The results were presented as RR with corresponding 95% CI together with the synergy index (SI) with corresponding 95% CI. A SI >1 indicates a joint effect between two factors greater than the sum of their individual effects.

Additional analyses

Even though all participants reported LANBP at baseline we had no information on the intensity of LANBP at baseline, which may be an important confounder in the analyses. As poor self-related health may be a consequence of severe pain intensity, we performed the adjusted analyses with PWA as exposure stratified by good (very good/good) and poor (fair/poor/very poor) self-rated health (SRH), as a proxy for the intensity of neck/back pain at baseline (30).

The potential influence of attrition was assessed by comparing the prevalence of the two exposures among non-responders (n=1,865) to the prevalence among responders (n=3,312) using Chi-square tests.

Patient and Public Involvement

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

Results

Baseline characteristics of the study population are presented in Table 1. The mean age was 46 years (SD 10) and 66% were women. Eighty percent reported good or moderate self-perceived work ability and 84% were not smoking daily. Most participants were non-manual workers or self-employed (65%), and the majority lived together with another adult person, with or without children (77%). At follow-up in 2014, 36% of the participants showed a favourable prognosis of LANBP.

Table 1 Baseline characteristics by the exposures perceived work ability (PWA) and daily smoking (DS). Study population, n=5,177.

Baseline characteristics, n (%)	**Perceived work ability** (n=5,177)			**Daily smoking** (n=5,138)		**Int. Missing** PWA/DS
	Good	**Moderate**	**Poor**	**No**	**Yes**	n/n
	3,076 (59)	1,080 (21)	1,021 (20)	4,320 (84)	818 (16)	
Sex: Women	1,974 (64)	734 (68)	688 (67)	2,840 (66)	534 (65)	0/0
Average age, years (SD)	45 (10)	46 (10)	47 (10)	45 (10)	47 (10)	0/0
Perceived work ability: Good				2,679 (62)	377 (46)	-/0
Moderate				888 (21)	186 (23)	
Poor				753 (17)	255 (31)	
Daily smoking: Yes	377 (12)	186 (17)	255 (25)			39/-
BMI: Underweight/Normal weight	1,550 (51)	530 (51)	408 (41)	2,093 (49)	383 (48)	128/127
Overweight/Obese	1,457 (49)	522 (49)	582 (59)	2,122 (51)	413 (52)	
SES: Unskilled/semiskilled worker	435 (15)	219 (22)	301 (32)	712 (17)	236 (30)	267/263
Skilled worker	393 (13)	173 (17)	183 (20)	566 (14)	174 (22)	
Low level non-manual employees	465 (16)	137 (13)	120 (13)	603 (15)	115 (15)	
Middle level non-manual employees	806 (27)	255 (25)	180 (19)	1,111 (27)	124 (16)	
High level non-manual employees/self-employed	849 (29)	238 (23)	156 (16)	1,103 (27)	131 (17)	
Household: Living with adult, with/without children	2,463 (81)	791 (74)	685 (68)	3,361 (78)	555 (68)	40/36
Living alone/Living with children only	601 (19)	277 (26)	320 (42)	928 (22)	258 (32)	
Headache/migraine: Yes	1,330 (44)	556 (53)	631 (66)	2,084 (50)	416 (53)	160/152

Psychological distress: No	2,403 (78)	596 (56)	382 (38)	2,876 (67)	479 (59)	25/24
Mild/Severe	456 (15)	259 (24)	263 (26)	801 (19)	169 (21)	
Severe	207 (7)	217 (20)	369 (36)	622 (14)	167 (20)	
Personal support: No	359 (12)	219 (20)	307 (30)	698 (16)	182 (22)	32/28
Sleep disturbances: Yes	1,254 (42)	623 (59)	744 (76)	2,120 (50)	480 (61)	150/144
Sedentary leisure time: <2 hours/day	1,802 (59)	540 (50)	502 (50)	2,441 (57)	385 (48)	35/33
>2 hours/day	1,253 (41)	536 (50)	509 (50)	1,854 (43)	425 (52)	
Leisure physical activity, mod intensity: <20 min/day	977 (32)	389 (36)	436 (43)	1,435 (34)	352 (44)	52/49
>20 min/day	2,073 (68)	683 (64)	567 (57)	2,851 (66)	456 (56)	
Leisure physical activity, high intensity: <1 hour/week	1,301 (43)	532 (50)	562 (56)	1,883 (44)	495 (61)	45/43
>1 hour/week	1,753 (57)	540 (50)	444 (44)	2,404 (56)	313 (39)	
Physical workload: Sedentary at least 50%	1,801 (60)	537 (51)	448 (46)	2,410 (57)	361 (46)	117/114
Standing/walking/some lifting	727 (24)	291 (27)	319 (33)	1,094 (26)	230 (29)	
Walking/lifting/heavy work	496 (16)	232 (22)	209 (21)	738 (17)	191 (25)	
Subsample participation: 2002/2007/2010/2014	781 (25)	269 (25)	233 (23)	1,106 (26)	170 (21)	0/0
2006/2010/2014	1,011 (33)	352 (33)	346 (34)	1,432 (33)	268 (33)	
2010/2014	1,284 (42)	459 (42)	442 (43)	1,782 (41)	380 (46)	
Self-rated health: Very good	293 (9)	23 (2)	12 (1)	302 (7)	26 (3)	49/48
Good	1,801 (59)	336 (32)	145 (14)	1,982 (46)	286 (35)	
Fair	877 (29)	567 (53)	536 (53)	1,585 (37)	376 (46)	
Poor or very poor	82 (3)	137 (13)	319 (32)	408 (10)	125 (16)	

Note: For a description of the variables and their categorisation see the Appendix. **Abbreviation**: SES; Socioeconomic status.

The crude and adjusted associations between self-perceived work ability, daily smoking and a favourable prognosis of LANBP are presented in Table 2. Socioeconomic status, headache/migraine and sleep disturbances were identified as confounders in the analyses with self-perceived work ability as exposure, while socioeconomic status, sleep disturbances and self-perceived work ability confounded the association between daily smoking and the outcome.

Table 2 Associations* between the exposures perceived work ability (PWA) and daily smoking (DS) in 2010, and a favourable prognosis of long-duration activity-limiting neck and/or back pain in 2014.

Exposure	**Cases/total**	**Crude** (n=3,312)		**Adjusted**[a] (n=3,049)		**Adjusted**[a]	
		RR	**95% CI**	**RR**	**95% CI**	**RD**	**95% CI**
Perceived work ability							
Poor	115/596	1		1		0	
Moderate	203/688	1.53	1.25-1.87	1.37	1.11-1.69	0.07	0.02-0.11
Good	873/2,028	2.23	1.88-2.65	1.80	1.49-2.17	0.17	0.12-0.22
Exposure	**Cases/total**	**Crude** (n=3,292)		**Adjusted**[b] (n=3,088)		**Adjusted**[b]	
		RR	**95% CI**	**RR**	**95% CI**	**RD**	**95% CI**
Daily smoking							
Yes	115/459	1		1		0	
No	1,070/2,833	1.51	1.28-1.78	1.21	1.02-1.42	0.05	0.01-0.10

*General linear models with a binomial distribution and a log-link, estimating the risk ratio (RR), or an identity-link, estimating the risk difference (RD), with corresponding 95% confidence intervals (CI). [a]Adjusted for socioeconomic status, headache/migraine, sleep disturbances and subsample participation; [b]Adjusted for socioeconomic status, sleep disturbances, perceived work ability and subsample participation.

In comparison to participants with poor work ability participants with moderate or good work ability, had an adjusted RR for a favourable prognosis of 1.37 (95% CI: 1.11-1.69), and 1.80 (1.49-2.17), respectively. The corresponding adjusted RD were 0.07 (0.02-0.11) and 0.17 (0.12-0.22). Participants not smoking on daily basis had an adjusted RR of 1.21 (1.02-1.42), and an adjusted RD of 0.05 (0.01-0.10) for a favourable outcome compared to daily smokers. The analyses with self-perceived work ability as exposure showed a significant dose-response towards a more favourable prognosis with higher work ability ($p < 0.001$).

Table 3 shows the result of the evaluation of the synergistic associations between the exposures and the outcome, resulting in an adjusted SI of 0.92 (95% CI: 0.60-1.43).

Table 3 Analyses* of the potential synergistic effects of the two exposures perceived work ability (PWA) and daily smoking (DS), on a favourable prognosis of long-duration activity-limiting neck and/or back pain.

Exposure	**Cases/total**	**Crude** (n=3,312)		**Adjusted**[a] (n=3,049)	
		RR	**95% CI**	**RR**	**95% CI**
Moderate/poor perceived work ability and daily smoking	39/253	1		1	
Moderate/poor perceived work ability and no daily smoking	276/1,022	1.88	1.32-2.66	1.61	1.11-2.34
Good perceived work ability and daily smoking	76/206	2.96	1.93-4.54	2.33	1.49-3.66
Good perceived work ability and no daily smoking	794/1,811	3.96	2.84-5.52	2.80	1.95-4.02
Synergy index				0.92	0.60-1.43

*Using EpiNET´s epidemiological tool "Epinetcaculation.xlsx" based on the results from logistic regressions. [a]Adjusted for socioeconomic status, headache/migraine, sleep disturbances and subsample participation. **Abbreviations:** RR; risk ratio, CI; confidence interval.

Additional results

Stratifying the analyses of the exposure self-perceived work ability by good and poor self-rated health, as a proxy for the intensity of neck/back pain at baseline, resulted in similar adjusted RR for the two strata. The RR for a favourable prognosis of LANBP when reporting moderate work ability showed a similar increase for participants with poor self-rated health and participants with good self-rated health, 1.42 (95% CI; 0.93-2.15) and 1.27 (95% CI; 0.98-1.63), compared with participants with poor work ability. The RR were also similar for those reporting good work ability in both strata, 1.72 (95% CI; 1.17-2.53) and 1.56 (95% CI; 1.23-1.96), respectively.

At baseline in 2010, non-responders had a significantly higher prevalence ($p < 0.001$) of individuals with poor self-perceived work ability and daily smokers (23% and 19%) in comparison with responders (18% and 14%).

Discussion

In this study we found an association between self-perceived work ability and a favourable prognosis of long-duration activity-limiting neck/back pain four years later. The results revealed that individuals in a working population with moderate self-perceived work ability (either good physical or good mental work ability) had a 37% increased chance of a favourable prognosis of long-duration activity-limiting neck/back pain, compared to individuals with poor self-perceived work ability (poor physical and poor mental work ability). The chance of a favourable prognosis was even higher (80%) for individuals reporting good self-perceived work ability (both good physical and good mental work ability). In addition, the results showed that individuals that did not smoke daily had a 21% higher chance of a favourable prognosis than did daily smokers.

A possible synergetic effect on a favourable prognosis for participants reporting good work ability and not smoke on daily basis could not be confirmed.

Previously, Nordstoga et al. found no association between baseline work ability and improvement of back pain or disability in physiotherapy patients with back pain of any duration, which contrasts with our results (15). Their study included patients with back pain of any duration, had a follow-up time of only three months, and they used the question "describe your current work ability compared with the lifetime best (0-10)'' as a measure of self-perceived work ability. More in line with our result, Ahlström et al. found higher baseline work ability, defined by the same question as Nordstoga et al. and by the full WAI, to predict lower degree of neck pain at six and 12 months among women on long-term sick-leave (10). We have not found any previous study of association between smoking and a favourable prognosis, either for neck or for back pain, or on the synergetic effect of work ability and smoking.

The mechanism for smoking to affect spinal pain is not yet well understood, but increased levels of pro-inflammatory cytokines, changed pain perception, impaired blood supply, and impaired oxygen delivery to tissues caused by increased sympathetic outflow has been suggested (31, 32). The latter could be one possible underlying mechanism to the higher prevalence of osteoporosis and lumbar disc disease found in smokers compared to non-smokers (31, 32). As the concept of self-perceived work ability incorporate individual factors, work-related factors and environmental factors, a specific mechanism for good self-perceived work ability to associate with a favourable prognosis of LANBP may be difficult to delineate (7).

The present study has some possible limitations. Clustering individuals with neck and back pain when studying prognostic factors may be questioned, since prognostic factors for neck- and back pain may differ. But, as a priory analysis evaluating participants with long-duration

activity-limiting neck and back pain separately, resulted in almost identical crude estimates, we decided to merge the data to increase the statistical power.

Even though a large number of potential confounders was considered unmeasured confounding could not be ruled out. There is also a risk of residual confounding due to unprecise measure of confounding factors, i.e. socioeconomic status. Such bias may have led to underestimation or overestimation of the results. We had no baseline information on pain intensity prior to inclusion into the cohort, therefore we could not consider pain intensity as a potential confounder. If pain intensity at baseline is associated with the reported levels of PWA at baseline, bias due to reversed causation may be present (27). Then our results may have been overestimated.

However, we believe that the risk of reversed causation due to baseline pain intensity is limited as individual self-perceived work ability is most likely a combination of many factors other than pain, for example content, demands and organisation of work, personal attitudes, motivation, knowledge and skills, and functional capacity (8). Furthermore, given that pain is an important determinator of objective as well as subjective measures of health, the additional analyses stratified by good and poor self-rated health indicating that good PWA is beneficial no matter the degree of self-rated health also supports a low risk of bias due to reversed causation.

Misclassification of the exposures and outcome needs consideration. Problems to recall and to appraise whether the pain during the preceding six months was activity-limiting or not may have resulted in non-cases being classified as cases and vice versa. This possible misclassification of the outcome is most probably non-differential potentially leading to a dilution of our associations (27). The exposure PWA was assessed with only one subscale of the WAI. Nonetheless, this subscale from the WAI is found to be internally coherent to the full WAI (25). Furthermore, the operationalisation of the exposure PWA by dichotomising a

five category scales of mental and physical work ability and then combining them may have led to bias due to misclassification. Smoking was measured with a yes/no question about daily smoking, which is a rough measure of such exposure. By categorising former smokers as non-smokers and smokers who only smoke a few cigarettes a day as smokers, we might have introduced a misclassification of this exposure. These potential misclassifications of the exposures most likely is non-differential, thus potentially diluting the associations.

As the follow-up period was four years work ability and smoking status may have varied across this period, and participants may have changed jobs or work assignments. If so, this would probably dilute the estimation of the association.

With a response rate of 64% between baseline and follow-up there is a risk of selection bias. Non-responders had a significantly higher proportion of smokers and individuals with poor self-perceived work ability than did responders. If most of these individuals would experience a favourable prognosis of their long-duration activity-limiting neck/back pain, a scenario we find unlikely, our results may be overestimated. The study population in the Stockholm County are mainly non-manual employees and self-employees. The generalisability of the results may be limited in general populations with other socioeconomic status.

Strengths of this study are the longitudinal design, and a relatively large sample size, allowing evaluation of the outcome along categories of the exposure. However, despite a large sample, the evaluation of synergetic effects may have been hampered by few cases in the reference categories. The dose-response results found supports a causal association between self-perceived work ability and long-duration activity-limiting neck/back pain, and the extensive confounder control supports internal validity. We also regard the incorporation of activity limitations in the definition of the baseline pain and in the outcome as a strength. Activity limitations is recommended to be included in measures for neck and back pain, recognised to

be of clinical importance, and to have negative consequences for the affected individual and for the society (1, 5, 18, 21).

To our knowledge this is the first study assessing self-perceived work ability and smoking focusing on a favourable prognosis of long-duration activity-limiting neck/back pain. Even though more research is needed to confirm our findings, they imply that good work ability and not smoking daily appears to predict a favourable prognosis of long-duration activity-limiting neck/back pain. Thus, interventions to improve physical and mental work ability and reduce smoking may enhance the chance for a favourable prognosis in workers with long-duration activity-limiting neck/back pain. Therefore, further research focusing on such interventions is motivated. Such interventions could be directed towards both the workplace organisation and the individual, possibly resulting in reduced human suffering and societal costs.

Conclusion

Having a good physical and/or mental self-perceived work ability as well as not smoking on daily basis is associated to a favourable prognosis in a working population with long-duration activity-limiting neck/back pain. However, fulfilling both criteria seem to have no synergistic prognostic effect.

Acknowledgement

Thanks to Peeter Fredlund, Research Statistician at Karolinska Institutet and SLL Centre for Epidemiology and Community Medicine, Stockholm, for providing us with the data.

Contributors

TB, LWH, ML and ES contributed to the conceptualisation and methodology of the study. JH approved the conceptualisation and method and provided the data resources. Based on a protocol approved by all authors TB made the statistical analyses

and wrote the first draft of the manuscript. All authors contributed to the interpretation of the results and critically revised the manuscript and approved the last manuscript version.

Funding

This study was supported by AFA Insurance, grant number 170095. The funders had no role in study design, data collection and analysis, decision to publish, or preparation of the manuscript.

Competing interests

Non to declare.

Data availability statement

Data are available upon reasonable request. 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.

References

1. Vos T, Abajobir AA, Abate KH, et al. Global, regional, and national incidence, prevalence, and years lived with disability for 328 diseases and injuries for 195 countries, 1990–2016: a systematic analysis for the Global Burden of Disease Study 2016. The Lancet. 2017;390(10100):1211-59.

2. Hartvigsen J, Hancock MJ, Kongsted A, et al. What low back pain is and why we need to pay attention. The Lancet. 2018;391(10137):2356-67.

3. Hoy DG, Protani M, De R, Buchbinder R. The epidemiology of neck pain. Best Pract Res Clin Rheumatol. 2010;24(6):783-92.

4. Cochrane A, Higgins NM, Rothwell C, et al. Work Outcomes in Patients Who Stay at Work Despite Musculoskeletal Pain. J Occup Rehabil. 2018;28(3):559-67.

5. Schofield DJ, Shrestha RN, Percival R, Callander EJ, Kelly SJ, Passey ME. Early retirement and the financial assets of individuals with back problems. Eur Spine J. 2011;20(5):731-6.

6. Green BN, Johnson CD, Haldeman S, et al. A scoping review of biopsychosocial risk factors and co-morbidities for common spinal disorders. PLoS One. 2018;13(6):e0197987.

7. Gould R, Ilmarinen J, Järvisalo J, Koskinen S. Dimensions of Work Ability. Results of the 2000 Health Survey. Vaasa: Waasa Graphics Oy; 2008.

8. Ilmarinen J. Work ability, a comprehensive concept for occupational health research and prevention. Scand J Work Environ Health. 2009;35(1):1-5.

9. Ilmarinen J. The Work Ability Index (WAI). Occupational Medicine. 2006;57(2):160.

10. Ahlstrom L, Grimby-Ekman A, Hagberg M, Dellve L. The work ability index and single-item question: associations with sick leave, symptoms, and health – a prospective study of women on long-term sick leave. Scand J Work Environ Health. 2010;36(5):404-12.

11. Kinnunen U, Natti J. Work ability score and future work ability as predictors of register-based disability pension and long-term sickness absence: A three-year follow-up study. Scand J Public Health. 2018;46(3):321-30.

12. Lundin A, Kjellberg K, Leijon O, Punnett L, Hemmingsson T. The Association Between Self-Assessed Future Work Ability and Long-Term Sickness Absence, Disability Pension and Unemployment in a General Working Population: A 7-Year Follow-Up Study. J Occup Rehabil. 2016;26(2):195-203.

13. Reeuwijk KG, Robroek SJ, Niessen MA, Kraaijenhagen RA, Vergouwe Y, Burdorf A. The Prognostic Value of the Work Ability Index for Sickness Absence among Office Workers. PLoS One. 2015;10(5):e0126969.

14. Sundstrup E, Jakobsen MD, Mortensen OS, Andersen LL. Joint association of multimorbidity and work ability with risk of long-term sickness absence: a prospective cohort study with register follow-up. Scand J Work Environ Health. 2017;43(2):146-54.

15. Nordstoga AL, Vasseljen O, Meisingset I, Nilsen TIL, Unsgaard-Tondel M. Improvement in Work Ability, Psychological Distress and Pain Sites in Relation to Low Back Pain Prognosis: A Longitudinal Observational Study in Primary Care. Spine (Phila Pa 1976). 2019;44(7):E423-e9.

16. Holm LW, Bohman T, Lekander M, Magnusson C, Skillgate E. 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. BMJ Open. 2020;10(6):e033946.

17. van den Berg TI, Elders LA, de Zwart BC, Burdorf A. The effects of work-related and individual factors on the Work Ability Index: a systematic review. Occup Environ Med. 2009;66(4):211-20.

18. Supplement article: Carroll LJ, Hurwitz EL, Cote P, et al. Research priorities and methodological implications: the Bone and Joint Decade 2000-2010 Task Force on Neck Pain and Its Associated Disorders. Spine. 2008;33(4 Suppl):S214-20.

19. Hayden JA, Dunn KM, van der Windt DA, Shaw WS. What is the prognosis of back pain? Best Pract Res Clin Rheumatol. 2010;24(2):167-79.

20. Svensson AC, Fredlund P, Laflamme L, et al. Cohort profile: The Stockholm Public Health Cohort. Int J Epidemiol. 2013;42(5):1263-72.

21. Dionne CE, Dunn KM, Croft PR, et al. A consensus approach toward the standardization of back pain definitions for use in prevalence studies. Spine (Phila Pa 1976). 2008;33(1):95-103.

22. Tuomi K, Ilmarinen J, Jahkola A, Katajarinne L, Tulkki A. Work ability index. 2 ed. Helsinki: Finnish Institute of Occupational Health; 1998.

23. de Zwart BCH, Frings-Dresen MHW, van Duivenbooden JC. Test–retest reliability of the Work Ability Index questionnaire. Occupational Medicine. 2002;52(4):177-81.

24. Radkiewicz P, Widerszal-Bazyl M. Psychometric properties of Work Ability Index in the light of comparative survey study. International Congress Series. 2005;1280:304-9.

25. Lundin A, Leijon O, Vaez M, Hallgren M, Torgén M. Predictive validity of the Work Ability Index and its individual items in the general population. Scand J Public Health. 2017;45(4):350-6.

26. Verkerk K, Luijsterburg PA, Miedema HS, Pool-Goudzwaard A, Koes BW. Prognostic factors for recovery in chronic nonspecific low back pain: a systematic review. Phys Ther. 2012;92(9):1093-108.

27. Lash TL, VanderWeele TJ, Haneuse S, Rothman KJ. Modern epidemiology. Philadelphia, PA: Wolters Kluwer; 2021.

28. Vittinghoff E, Glidden DV, Shiboski SC, McCulloch CE. Regression Methods in Biostatistics, Linear, Logistic, Survival, and Repeated Measures Models. 2nd ed. New York, USA: Springer New York; 2012.

29. Andersson T, Alfredsson L, Kallberg H, Zdravkovic S, Ahlbom A. Calculating measures of biological interaction. Eur J Epidemiol. 2005;20(7):575-9.

30. Perruccio AV, Power JD, Badley EM. Arthritis onset and worsening self-rated health: a longitudinal evaluation of the role of pain and activity limitations. Arthritis Rheum. 2005;53(4):571-7

31. Shiri R, Karppinen J, Leino-Arjas P, Solovieva S, Viikari-Juntura E. The association between smoking and low back pain: a meta-analysis. Am J Med. 2010;123(1):87 e7-35.

32. Shi Y, Weingarten TN, Mantilla CB, Hooten WM, Warner DO. Smoking and Pain: Pathophysiology and Clinical Implications. Anesthesiology. 2010;113(4):977-92.

Figure legends

Figure 1 Flow chart describing the inclusion of participants into the study population and the analyses sample. NP; neck pain, BP; low back pain, PWA; perceived work ability.

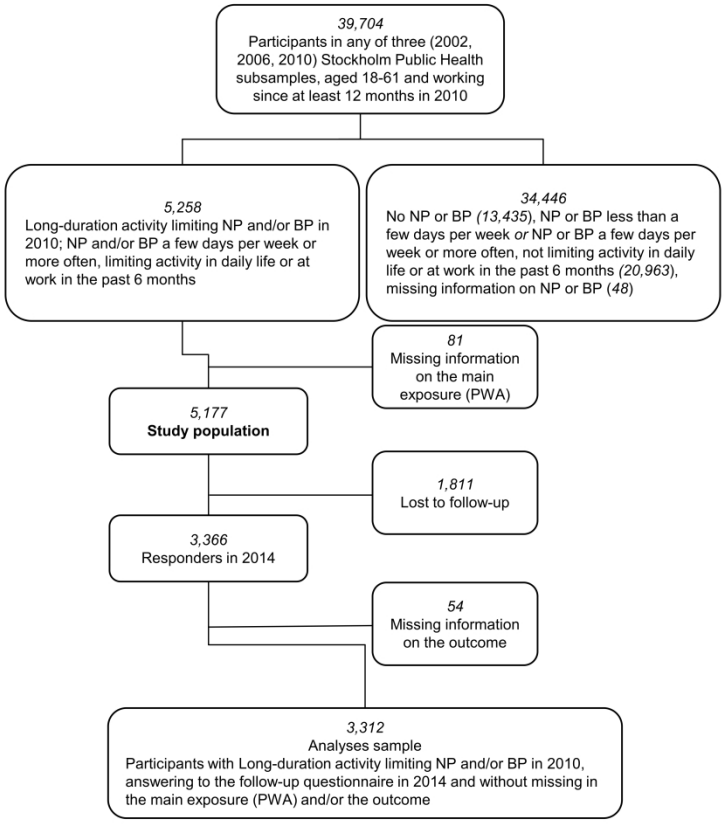

Figure 1. Flow chart describing the inclusion of participants into the study population and the analyses sample. NP; neck pain, BP; low back pain, PWA; perceived work ability.

383x511mm (300 x 300 DPI)

Appendix Potential confounding factors.

Potential confounder	Measurement	Categorisation in the analyses
Daily smoking[a]	"Do you currently smoke daily or almost daily?"	No, yes
Self-perceived work ability[b]	"How do you rate your current work ability with respect to the physical demands/mental demands of your work"	Good, moderate, and poor
Sex	Sex at baseline 2010	Men, women (no other alternatives available)
Age	Age at baseline 2010	Continuous and in quartiles (18-38), (39-46), (47-54), (55-61)
Body mass index (BMI)	Weight/height^2 (kg/m^2)	Categorical; underweight (<18.5), normal weight (18.5-24.9), overweight (25-29.9), obese (≥30)
Socioeconomic status (SES)	According to the classification from Statistics Sweden. Based on current occupation and education for the economically active population.	Unskilled/semiskilled worker, skilled worker, low level non-manual employees, middle level non-manual employees, high level non-manual employees/self-employed, self-employed (other than high level)
Household	"Do you live together with someone?"	Categorical; living together with adult/s and child/ren, living alone, living with child/children only
Headache/migraine	"Do you have headache or migraine?"	No, yes; somewhat or severe
Psychological distress[1, 2]	Based on the 12-item General Health Questionnaire (GHQ-12), using the scoring system 0-0-1-1.	No (0-2), mild (3-6), severe (7-12)
Personal support[2, 3]	"Do you know persons who can provide you with personal support for personal problems or crises in your life?"	No-usually not or never, yes-always or for the most part
Sleep disturbances	"Do you have sleep disturbances"	No, yes; somewhat or severe
Sedentary leisure time	"Refer to your leisure physical activity during the past 12 months? If the activities vary during the year and during a week, refer to an average." Sitting/watching TV/reading during leisure time.	Categorical: less than 2 hours/day, 2-3 hours/day, more than 3 hours/day
Leisure physical activity - moderate intensity	"Refer to your leisure physical activity during the past 12 months? If the activities vary during the year and during a week, refer to an average." Walking/biking during leisure time.	Categorical: less than 20 minutes/day, 20-40 minutes/day, more than 40 minutes/day
Leisure physical activity - high intensity	Refer to your leisure physical activity during the past 12 months? If the activities vary during the year and during a week, refer to an average." Exercise, other than walking/biking, during leisure time.	Categorical: less than 1 hour/week, 1-2 hours/week, more than 2 hours/week
Physical workload[4]	"Refer to your physical activity during your daily activity and/or work during the past 12 months? If the activity vary during the year and during a week, refer to an average.	Categorical; sedentary at least to 50 %, standing/walking/some lifting, walking/lifting/heavy work
Subsample participation[c]	Refers to the subsample of the Stockholm Public Health Cohort the participants belonged to.	Categorical: 2002/2007/2010/2014, 2006/2010/2014, 2010/2014

[a] Daily smoking was assessed as a potential confounder in the analyses with self-perceived work ability as exposure. [b] Self-perceived work ability was assessed as a potential confounder in the analyses with daily smoking as exposure. [c] Subsample participation was included in all adjusted models order to adjust for potential systematic difference between the subsamples. [#] Bibliographical references to definition and psychometric properties of the factors.

1. Goldberg DP, Gater R, Sartorius N et al. The validity of two versions of the GHQ in the WHO study of mental illness in general health care. Psychol Med. 1997;27(1):191-7.
2. McDowell I. Measuring health a guide to rating scales and questionnaires. 3rd ed. New York ; Oxford: Oxford University Press; 2006. xvi, 748 p
3. Unden AL, Orth-Gomer K. Development of a social support instrument for use in population surveys. Soc Sci Med. 1989;29(12):1387-92.4. Leijon O, Wiktorin C, Harenstam A, Karlqvist L. Validity of a self-administered questionnaire for assessing physical work loads in a general population. J Occup Environ Med. 2002;44(8):724-35.

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

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

		(b) Indicate number of participants with missing data for each variable of interest **Table 1 and Figure 1.**
		(c) Summarise follow-up time (eg, average and total amount) **N/A.**
Outcome data	15*	Report numbers of outcome events or summary measures over time **Page 11, Table 2 and 3.**
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 **Page 14, Table 2 and Table 3.**
		(*b*) Report category boundaries when continuous variables were categorized **Appendix and Table 1.**
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period **Page 16 and Table 2.**
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses **Page 16, last paragraph. Page 18, "Additional results" and Table 3.**
Discussion		
Key results	18	Summarise key results with reference to study objectives **Page 18 and first paragraph at page 19.**
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 **Page 19 last paragraph. Page 20 and page 21 paragraph 1 and 2.**
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence **Page 21, two last paragraphs, and page 22 first paragraph.**
Generalisability	21	Discuss the generalisability (external validity) of the study results **Page 21, paragraph three and page 22 second paragraph and in the conclusion.**
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 **Page 23, "Funding".**

*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.