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Risk and Prognostic Factors of Low Back Pain: Repeated Population Based Cohort Study in Sweden

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Abstract

Study Design Prospective longitudinal cohort study.

Objective To determine the associations ofr workload and health-related factors with incident and recurrent low back pain (LBP), and to determine the mediating role of health-related factors in associations between physical workload factors and incident LBP.

Summary of Background Data It is not known whether the risk factors for the development of LBP are also prognostic factors for recurrence of LBP and whether the associations between physical workload and incident LBP are mediated by health-related factors. We used data from the Swedish Longitudinal Occupational Survey of Health (SLOSH) study. Those responding to any two subsequent surveys in 2010-2016 were included for the main analyses (N=17,962). Information on occupational lifting, working in twisted positions, weight/height, smoking, physical activity, depressive symptoms, and sleep problems were self-reported. Incident LBP was defined as pain limiting daily activities in the preceding three months in participants free from LBP at baseline. Recurrent LBP was defined as having LBP both at baseline and follow-up. For the mediation analyses, those responding to three subsequent surveys were included (N=3,516).

Methods Main associations were determined using generalized estimating equation models for repeated measures data. Mediation was examined with counterfactual mediation analysis.

Results All risk factors at baseline but smoking and physical activity were associated with incident LBP after adjustment for confounders. The strongest associations were observed for working in twisted positions (risk ratio (RR)=1.52, 95% CI 1.37, 1.70) and occupational lifting (RR=1.52, 95% CI 1.32, 1.74). These associations were not mediated by health-related factors. The studied factors did not have meaningful effects on recurrent LBP.

Conclusions The findings suggest that workload and health-related factors have stronger effects on the development than on the recurrence or progression of LBP, and that health-related factors do not mediate associations between workload factors and incident LBP.

Key Words: cohort study; depressive symptoms; lifting; low back pain; mediation; occupational; physical activity; physical workload; sleep problems; smoking; twisting

Level of Evidence: 3

Key points

- Physical workload factors, overweight and obesity, depressive symptoms, and poor sleep increased the incidence of low back pain.
- Health-related factors did not mediate the associations between physical workload and incident low back pain.
- Associations of workload and health-related factors with recurrent low back pain were weaker than those for incident low back pain.
- Findings for prognostic factors suggest that employees exposed to occupational lifting or twisting, or employees with obesity and low back pain are likely to be able to continue working without major adverse effects on their recovery.

Introduction (2700/2700)

Low back pain (LBP) is a major cause of disability-adjusted life years worldwide.[1] Non-neutral working postures and physically demanding work increases the incidence of LBP.[2,3] In addition to work-related factors, smoking[4] and overweight or obesity[5] have been associated with an increased incidence of LBP, but the role of leisure-time physical activity in the development of LBP is uncertain.[6] The effect of sleep problems on the incidence of LBP is even less studied.[7] Furthermore, an increased risk of LBP in persons with depressive symptoms has been reported,[8,9] although confounding factors were not fully controlled for.

LBP is often a recurrent condition,[10,11] but evidence of the role of workload[12,13] or health-related factors in recurrent LBP is inconsistent. For example, obesity may increase the probability of recurrent LBP,[14] but this has not been supported by all studies.[15] Likewise, no clear associations have been reported for smoking[12,14] and leisure-time physical activity.[12] Depressive symptoms may also be a prognostic factor for LBP.[16] Overall, it is not known whether the risk factors for the development of LBP are also prognostic factors of LBP.

Exposure to heavy physical workload may lead to changes in lifestyle behaviors that may mediate the association between work exposures and LBP. For instance, persons with physically demanding jobs may decrease, while persons with sedentary jobs may increase their leisure-time physical activity.[17] Persons with physically strenuous jobs are also more likely to gain more weight than persons with physically light jobs.[18] However, no study has formally examined whether the associations between physical workload factors and incident LBP are mediated by health-related risk factors.

In this study, we examined whether exposure to physical workload and health-related risk factors are associated with incident and recurrent LBP. We also examined whether health-related factors are mediators of the association between physical workload and incident LBP.

Materials and Methods

Study population

We used data from the Swedish Longitudinal Occupational Survey of Health (SLOSH) study, which is a longitudinal study of working age population with repeated measures of work environment and health.[19] The first SLOSH survey was conducted in 2006 with two possible self-completion questionnaires; one for workers (working 30% or more), and the other for non-workers (working less than 30% or not at all). Follow-up surveys have been conducted every other year and the cohort now includes 40,877 individuals of which 28,672 (70 %) have responded more than once. Sex and age of the participants are from national registers.

For this study, we used data from the four latest surveys (2010-2016) for workers. For the main analyses, we formed repeated data including participants responding to LBP question in any two subsequent surveys (Figure 1.). In total, we included 30,490 observations from 17,962 participants. To identify risk factors of incident LBP, we included the participants free of LBP at baseline (N=12,222 participants, 20,837 observations). To identify prognostic factors for LBP, we included the participants reporting LBP at baseline (N=5,740 participants, 9,653 observations).

For the mediation analyses, two panels of participants responding to three subsequent surveys were included. The first panel included participants responding to questions regarding physical workload (exposure) in 2010 (T_1), behavior-related factors (mediators) in 2012 (T_2), and LBP (outcome) in 2010, 2012 and 2014 (T_3). The second panel included participants responding to the corresponding factors in 2012 (T_1), 2014 (T_2), and 2012, 2014 and 2016 (T_3). After excluding those with LBP at T_1 or T_2, the analytical sample included 3,516 individuals (5,212 observations). The Regional Research Ethics Board in

Stockholm approved the study and written informed consent was obtained from each cohort participant.

Workload factors

Physical work exposures were similarly requested in each of the workers' questionnaires.[20] *Occupational lifting* was assessed by asking: "Do you have to lift at least 15 kilos several times a day?", and *working in twisted positions* was assessed by asking: "Is your work such that you have to use bent, twisted or otherwise unsuitable positions?" For both exposures, the response alternatives were: 1) nearly all the time; 2) ¾ of working time; 3) ½ of working time; 4) ¼ of working time; 5) little (~1/10 of working time); 6) not at all. Both variables were categorized into three classes: "none or less than ¼", "¼ to < ¾", and "≥ ¾" of working time includes lifting/working in twisted positions.

Health-related factors

From the questionnaires we collected data on several health-related factors. Body mass index (BMI) was calculated as kg/m^2 from self-reported weight and height, and it was categorized as: "obese" (BMI ≥30), "overweight" (BMI 25.0−29.9), and "normal weight" (the reference group, BMI <25, BMI <18.5=0.8%). Smoking status was based on a question: "Do you smoke?" and it was dichotomized into "current smokers" (daily smokers) and "non-smokers" (never, past, or occasional smokers, the reference group). Physical activity was categorized as "never or seldom" (never or seldom performs physical activity), "sometimes" (active every now and then), and "regularly" (the reference group, regularly physically active).

Sleep problems were assessed based on the sleep disturbance scale of the Karolinska Sleep Questionnaire[21,22] with questions on difficulties falling asleep, restless sleep, repeated nocturnal awakenings, and premature awakening. For each question, there

were six response alternatives: 1) never; 2) rarely; 3) few times per month; 4) 1-2 times per week; 5) 3-4 times per week; and 6) 5 or more times per week. Presence of "sleep problems" was defined as having one or more sleep problems 3-4 times a week or more often, which is often regarded as a clinical definition of insomnia.[23]

Symptoms of depression were assessed using a six-item subscale of the (Hopkins) Symptom Checklist (SCL) resulting in SCL-Core Depression scale.[24,25] Respondents were instructed to score the extent that they 1) felt blue, 2) had no interests in things, 3) were lethargy or low in energy, 4) were worrying too much about things, 5) blamed oneself for things, and 6) felt everything is an effort. The response alternatives were: 1) not at all; 2) little; 3) moderately; 4) a lot; and 5) extremely. We summed the responses for each item to get a continuous scale assessing the severity of depression. For the analyses, we formed a binary variable for depressive symptoms using a cut-off score of ≥ 17, which has been suggested as a suitable threshold value for major depression in epidemiological research.[24]

Low back pain

In all surveys we asked whether the participants had LBP in the past three months. The question was in line with recommendations for pain prevalence studies, combining the assessment of pain with functioning, disability or interference with daily activities.[26] Four response options were available: 1) no pain, 2) pain, but it does not affect my life at all, 3) pain that affects my life a little, and 4) pain that affects my life a lot. Many people experience pain that does not affect their work ability or quality of life. Thus, we focused on LBP that affects life at least to some degree, by dichotomizing the pain responses as: "no LBP" (no pain or pain that does not affect life) and "LBP" (pain that affects life a little or a lot).[27] For

additional analyses we formed a pain variable dichotomized as “no LBP” (no pain) and “any LBP” (any form of pain).

Statistical analysis

We used generalized estimating equation models for repeated measures data with binomial regression (GENMOD procedure in SAS) that excludes individuals with missing observations. First, we ran age-, sex- and survey-adjusted models for each risk and prognostic factor. Then we added education (self-reported: “low”=comprehensive school, “intermediate”=high school, “high”=college/university), occupational lifting, twisting, BMI, smoking, physical activity, depressive symptoms and sleep problems in the models. Because twisting and lifting were moderately correlated (correlation coefficient 0.60), estimates for twisting were not controlled for lifting, and estimates for lifting were not controlled for twisting. In an additional model we included both workload factors with all other variables. The main findings are presented for LBP, and additional analyses were run for any LBP. The results are presented as risk ratios (RR) with 95% confidence intervals (CI).

For the mediation analysis we used a SAS macro presented by Valeri[28] and VanderWeele.[29] Unlike in standard mediation analysis, an interaction between exposure and mediator is allowed and ruled out. For these analyses, all health-related variables were dichotomized and their mediation effects were examined by using logistic regression, while the direct effects between workload factors and incident LBP were examined using binomial regression. The mediating effects can be assessed based on the natural indirect effect through the mediators that refers to the excess risk of incident LBP among the participants with physical workload that is due to their less favorable health-related factors. The macro also calculates the proportion (%) of the total effect between a workload factor and incident LBP

that the mediator explains. All analyses were performed using SAS 9.4 statistical software (SAS Institute Inc).

Results

Of the total study population, 57% were women; 55% of the sample free from LBP and 61% of those with LBP at baseline. Mean age of the total study population was 54.1 (SD=11.3) years. Other descriptive characteristics of the study sample are presented in Table 1.

Incident LBP

Of the 12,222 participants free from LBP at baseline, 16% experienced LBP during the follow-up. In the age- and sex-adjusted models, all examined risk factors were associated with incident LBP (Table 2). Working in twisted positions (RR 1.65, 95% CI 1.49, 1.83) and lifting (RR 1.65, 95% CI 1.45, 1.87) ¾ or more of the working time were similarly associated with incident LBP. After further adjustments, the risk ratios attenuated, and smoking and physical activity were no longer associated with LBP (Table 2). When working in twisted positions and lifting were included in the same model along with all other risk factors, the risk ratios reduced to 1.36 (95% CI 1.19, 1.57) for working in twisted positions, and to 1.22 (95% CI 1.03, 1.45) for lifting. In the additional analyses, 28% of the 8,345 participants free from any LBP at baseline, experienced any LBP during the follow-up. The associations for any LBP were similar but weaker than those for LBP (Supplemental Table 1, http://links.lww.com/BRS/B424).

Recurrent LBP

Of the 5,740 participants with LBP at baseline, 66% reported recurrent LBP. In the age- and sex-adjusted models, all examined prognostic factors except smoking were associated with

recurrent LBP (Table 3). Risk ratios were 1.21 (95% CI 1.16, 1.27) for working in twisted positions, and 1.15 (95% CI 1.09, 1.22) for lifting ¾ or more of the working time. Further adjustments had minor effects on the associations. A simultaneous adjustment for working in twisted positions and lifting attenuated the risk ratio for working in twisted positions to 1.11 (95% CI 1.01, 1.22), and that for lifting to 1.06 (95% CI 0.95, 1.19). Of the 9,617 participants with any LBP at baseline, 76% had recurrent any LBP. The associations for recurrent any LBP were similar but weaker than those for recurrent LBP (Supplemental Table 2, http://links.lww.com/BRS/B424).

Mediation

The associations for lifting or twisting at work with incident LBP were not mediated by the examined health-related factors. None of the natural indirect effects of workload factors on incident LBP via the possible mediators was statistically significant (Table 4).

Discussion

These findings suggest that physical workload factors increase the incidence of LBP, and that the risk of incident LBP increases with spending a greater proportion of working time lifting heavy loads or working in twisted positions. Overweight and obesity, depressive symptoms, and sleep problems also increased the incidence of LBP. However, none of the health-related factors mediated the associations between workload factors and incident LBP. Moreover, our findings do not support any meaningful effect for any of the studied factors in the prognosis of LBP.

Prior studies have shown that physical work tasks increase the risk of LBP.[2,3,12] However, only few studies have explored both risk and prognostic factors in the same data. In line with a prospective cohort study,[12] we found that workload factors were weak to moderate

risk factors of incident LBP, but their role as prognostic factors was practically non-existent. A possible explanation for the lack of associations with recurrent LBP may be that those who had LBP and physically heavy work, selected out of the labor market because of these conditions,[30] while some robust employees continued working in similar tasks. Another possibility is that the work tasks were modified for those with LBP so that the physical load reduced during the follow-up.

In line with our findings, prior reviews have concluded that overweight and obesity increase the risk of non-specific LBP,[5] radiating LBP,[31] lumbar radicular pain,[32] and sciatica.[32,33] However, these reviews did not examine the role of obesity as a prognostic factor. Our findings suggest that the role of obesity in recurrent LBP is minor. The mechanisms for stronger effect of obesity on incident LBP than on recurrent LBP are not known. Obese persons who develop LBP may get advice from physician to increase leisure time physical activity to alleviate symptoms of LBP. Exposure to workload factors may also have changed for obese persons with LBP.

Like obesity, smoking has been reported to increase the risk of non-specific LBP,[4] lumbar radicular pain,[34] and sciatica.[33] In these data smoking was neither a risk nor a prognostic factor of LBP. The prevalence of daily smoking in the study population was lower than in the Swedish general population.[35] The low prevalence could be due to healthy worker effect or underreporting of smoking. Moreover, our reference group included never, past and occasional smokers which may partly explain the lower risk related to smoking because past and occasional smokers are at a higher risk of LBP than never smokers.[4,34] However, our sensitivity analysis distinguishing between never, past and occasional (3% of all participants), and daily smokers did not change the results.

In line with a recent meta-analytic review,[6] the present study indicated that the frequency of leisure time physical activity does not protect against incident LBP. ~~Moreover,~~

Frequency of leisure physical activity did neither ~~not~~ reduce the probability of recurrent LBP, which ~~also~~ agrees with prior findings.[12]

Systematic reviews suggest that depressive symptoms act as moderately strong risk factors[8] and weak prognostic factors[16] of LBP, although original studies included in those reviews, particularly studies on prognostic factors, did not control for potential confounders. We controlled for several confounders, after which the prior conclusions were confirmed. In contrast to depressive symptoms, the association between sleep problems and LBP has been less studied. A study among working adults[7] showed that sleep problems increase the incidence of LBP. This is in line with the present study, although we additionally controlled for workload factors.

This study is among the first to examine whether health-related factors mediate the associations between workload factors and incident LBP. No evidence of such mediation was observed in data where information on the exposure, mediator and outcome were collected in chronologically correct order. However, the 2-year interval between the surveys may have diluted the associations.

There are some limitations in this study. First, we used self-reported data on all the exposures as well as LBP, which may cause common method bias. This means that those who report high values on the exposure measures also report high values on the outcome. To reduce this bias, we used exposure and outcome data from subsequent study waves. Second, we did not collect data on severity and chronicity of LBP. Although we dichotomized LBP according to interference with daily activities, the associations may be stronger for chronic or severe LBP.[4,6] Third, we had no information on exposure to other occupational physical risk factors such as prolonged standing, or on factors that might influence recall bias regarding LBP, like job satisfaction, that might slightly attenuate the findings. The major strengths of this study include the use of a large study sample from the general working population,

although the findings may not be generalizable to distinct working cultures. The analyses for incident LBP were restricted to those with no LBP at baseline, and the analyses for recurrent LBP were restricted to those reporting LBP at baseline.

In conclusion, occupational lifting and twisting as well as health-related factors were independently associated with incident LBP, but they did not have meaningful effects on recurrent LBP. Moreover, the studied health-related factors did not mediate the associations between workload factors and incident LBP.

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Figure legends

Figure 1. Sample selection for the main association analyses.

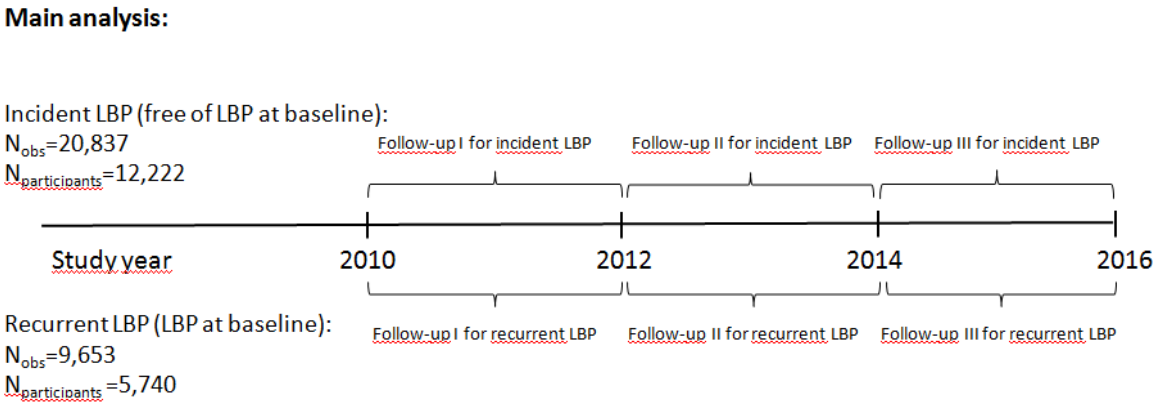

Table 1. Descriptive statistics of the included participants of the Swedish Longitudinal Occupational Survey of Health Study.

	All		No baseline low back pain[a]			With baseline low back pain[a]		
Variable	N= 17 962	%	N= 12 222	%	missing	N= 5 740	%	missing
Sex								
Men	7 738	43	5 494	45		2 244	39	
Women	10 224	57	6 728	55		3 496	61	
Education								
Low	6 264	35	4 067	33		2 197	38	2
Intermediate	4 051	23	2 699	22		1 352	24	
High	7 642	42	5 453	45		2 189	38	
Low back pain[a] at T2								
No	12 189	68	10 221	84		1 968	34	
Yes	5 773	32	2 001	16		3 772	66	
Twisting (proportion of working time)								
None or < ¼	10 131	72	7 386	77		2 745	61	
¼ - ½	2 273	16	1 354	14		919	20	
¾	1 713	12	860	9	2 622	853	19	1 223
Lifting (proportion of working time)								
None or < ¼	11 629	82	8 219	86		3 410	76	
¼ - ½	1 526	11	887	9		639	14	
¾	973	7	501	5	2 615	472	10	1 219
Body mass index								
Normal	7 918	47	5 576	49		2 342	44	
Overweight	6 482	39	4 377	39		2 105	39	
Obese	2 308	14	1 413	12	856	895	17	398
Smoking								
No	16 375	92	11 231	93		5 144	90	
Daily	1 447	8	897	7	94	550	10	46
Physical activity								
Regularly	3 275	18	2 060	17		1 215	21	
Sometimes	6 015	34	3 943	32		2 072	36	
Never or seldom	8 600	48	6 171	51	48	2 429	43	24
Depressive symptoms								
No	15 356	86	10 934	90		4 422	77	
Yes	2 504	14	1 217	10	71	1 287	23	31
Sleep problems								
No	14 600	81	10 378	85		4 222	74	
Yes	3 362	19	1 844	15		1 518	26	

Table 2. Risk Ratios (RR) and 95% confidence intervals (CI) for the associations of physical workload factors and health-related factors with the incident low back pain.

	Age- and sex-adjusted			***Full model*** [b]		
	RR	95% CI		RR	95% CI	
Twisting (proportion of working time)						
None or < ¼	1			1		
¼ - ½	1.30	1.18	1.42	1.22	1.11	1.34
¾	1.65	1.49	1.83	1.52	1.37	1.70
Lifting (proportion of working time)						
None or < ¼	1			1		
¼ - ½	1.41	1.27	1.56	1.31	1.17	1.46
¾	1.65	1.45	1.87	1.52	1.32	1.74
Body mass index						
Normal	1			1		
Overweight	1.14	1.06	1.22	1.16	1.07	1.26
Obese	1.43	1.31	1.56	1.40	1.25	1.55
Smoking						
No	1			1		
Daily	1.21	1.09	1.35	1.08	0.94	1.24
Physical activity						
Regularly	1			1		
Sometimes	1.18	1.10	1.26	1.04	0.96	1.13
Never or seldom	1.19	1.10	1.30	1.00	0.90	1.11
Depressive symptoms						
No	1			1		
Yes	1.56	1.44	1.70	1.42	1.29	1.57
Sleep problems						
No	1			1		
Yes	1.47	1.37	1.57	1.38	1.26	1.50

[a] Number of observations: 20,837

[b] Adjustment for age, sex, study survey, education, twisting, lifting, body mass index, smoking, physical activity, depressive symptoms and sleep problems. Estimates for twisting not controlled for lifting and estimates for lifting not controlled for twisting.

Table 3. Risk Ratios (RR) and 95% confidence intervals (CI) for the associations of physical workload factors and health-related factors with the recurrent low back pain.

Exposure	***Age- and sex-adjusted***			***Full model*** [b]		
	RR	95% CI		RR	95% CI	
Twisting (proportion of working time)						
None or < ¼	1			1		
¼ - ½	1.13	1.08	1.18	1.10	1.05	1.16
¾	1.21	1.16	1.27	1.19	1.13	1.24
Lifting (proportion of working time)						
None or < ¼	1			1		
¼ - ½	1.11	1.06	1.17	1.08	1.03	1.14
¾	1.15	1.09	1.22	1.13	1.07	1.20
Body mass index						
Normal	1			1		
Overweight	1.06	1.02	1.10	1.05	1.00	1.09
Obese	1.14	1.09	1.19	1.12	1.07	1.18
Smoking						
No	1			1		
Daily	1.06	1.01	1.11	1.02	0.96	1.09
Physical activity						
Regularly	1			1		
Sometimes	1.05	1.02	1.09	1.03	0.99	1.08
Never or seldom	1.08	1.04	1.13	1.03	0.98	1.08
Depressive symptoms						
No	1			1		
Yes	1.12	1.09	1.16	1.09	1.05	1.14
Sleep problems						
No	1			1		
Yes	1.08	1.05	1.11	1.05	1.01	1.09

[a] Number of observations: 9,653.

[b] Adjustment for age, sex, study survey, education, twisting, lifting, body mass index, smoking, physical activity, depressive symptoms and sleep problems. Estimates for twisting not controlled for lifting and estimates for lifting not controlled for twisting.

Table 4. Natural indirect effects of work-related twisting and lifting on incident low back pain (LPB) through health-related factors as possible mediators, and proportions of the total association mediated.

	Twisting – incident LBP				***Lifting – incident LBP***			
Mediator	Indirect effect through mediator, RR	95% CI		Proportion mediated (%)	Indirect effect through mediator, RR	95% CI		Proportion mediated (%)
Obesity	1.01	1.01	1.01	3	1.01	1.00	1.03	5
Smoking	1.01	1.01	1.02	3	1.01	1.00	1.03	4
Depressive	1.00	1.00	1.00	0	1.00	0.99	1.00	0
Sleep problems	1.00	1.00	1.01	0	1.00	0.99	1.00	1
Physical inactivity	1.00	1.00	1.00	1	1.00	1.00	1.01	1