Musculoskeletal pain intensity and risk of long-term sickness absence in the general working population

A prospective cohort study with register follow-up

Skovlund, Sebastian Venge; Bláfoss, Rúni; Calatayud, Joaquín; López Bueno, Rubén; Sundstrup, Emil; Andersen, Lars Louis

Published in:
Preventive Medicine

DOI (link to publication from Publisher):
10.1016/j.ypmed.2023.107636

Publication date:
2023

Document Version
Publisher's PDF, also known as Version of record

Preventive Medicine 174 (2023) 107636

Contents lists available at ScienceDirect

Preventive Medicine

journal homepage: www.elsevier.com/locate/ypmed

Musculoskeletal pain intensity and risk of long-term sickness absence in the general working population: A prospective cohort study with register follow-up

Sebastian Venge Skovlund [a,b,*], Rúni Bláfoss [a,b], Joaquín Calatayud [a,d], Rubén López Bueno [a,e], Emil Sundstrup [a], Lars Louis Andersen [a,c]

[a] National Research Centre for the Working Environment, 2100 Copenhagen, Denmark
[b] Department of Sports Science and Clinical Biomechanics, University of Southern Denmark, 5230 Odense, Denmark
[c] Department of Health Science and Technology, Aalborg University, 9220 Aalborg, Denmark
[d] Exercise Intervention for Health Research Group (EXINH-RG), Department of Physiotherapy, University of Valencia, Valencia, Spain
[e] Department of Physical Medicine and Nursing, University of Zaragoza, Zaragoza, Spain

ARTICLE INFO

Keywords:
Musculoskeletal diseases
Sickness absence
Occupational health
Registry research
Sustainable employment
Workplace

ABSTRACT

Determining predictors of sickness absence could allow for better screening, guidance, and development of preventive efforts aimed at those in increased risk. This study aimed to determine the prospective association between musculoskeletal pain *intensity* and risk of incident register-based long-term sickness absence in the general working population, as well as to determine the population attributable fraction.

Drawing on data from a nation-wide questionnaire survey, this prospective cohort study followed a representative sample of the Danish general working population without recent long-term sickness absence (≥6 consecutive weeks) (n = 69,273) for long-term sickness absence up to two years (mean follow-up: 93 weeks) in a national register. The predictor was musculoskeletal pain intensity in the neck/shoulder and low-back during the preceding three months rated on an 11-point numerical rating scale from 0 to 10.

The weighted incidence of long-term sickness-absence was 8.9% during two-year follow-up (n = 6165). We observed a clear dose-response association between musculoskeletal pain intensity of the neck/shoulder or low-back and the risk of incident long-term sickness absence, with a lower threshold of increased risk of 4 and 3 (scale 0–10) for neck/shoulder (HR (95% CI): 1.25 (1.09–1.42)) and low-back pain (HR (95% CI): 1.13 (1.00–1.29)), respectively. Prevention of pain intensities at or above 4 out of 10 could potentially prevent 17% (population attributable fraction, PAF (95% CI): 16.8 (13.6–20.1)) of the total long-term sickness absence in the general working population. Large-scale interventions to prevent and manage musculoskeletal pain need to be documented and implemented.

1. Introduction

Sickness absence continues to be a major public health concern (Henderson et al., 2005; Virtanen et al., 2018) with serious long-term consequences for the individual worker, workplaces and society as a whole. Prospective studies have shown strong associations between sickness absence and premature exit from the labor market (Kivimaki et al., 2004; Lund et al., 2008; Salonen et al., 2018) and mortality (Kivimäki et al., 2003; Head et al., 2008). Therefore, sickness absence is considered a global measure of health (Kivimäki et al., 2003). In Denmark, long-term sickness absence of >30 days accounts for 39% of all sickness absence (Thorsen et al., 2020). Thus, although only a small minority experiences long-term sickness absence, the disproportionate impact hereof on the total sickness absence and the associated costs due to sickness payment benefits and productivity losses are enormous (Henderson et al., 2005; Thorsen et al., 2020; Bevan, 2015). Long sickness absence spells and total length of sickness absence are particularly strong predictors of both premature exit from the labor market (Kivimaki et al., 2004; Lund et al., 2008; Salonen et al., 2018) and mortality (Kivimäki et al., 2003). Thus, prevention of sickness absence

* Corresponding author at: National Research Centre for the Working Environment, Lersø Parkallé 105, 2100 Copenhagen, Denmark.
E-mail addresses: svs@nfa.dk (S.V. Skovlund), rub@nfa.dk (R. Bláfoss), rlopezbu@unizar.es (R. López Bueno), esu@nfa.dk (E. Sundstrup), lla@nfa.dk (L.L. Andersen).

https://doi.org/10.1016/j.ypmed.2023.107636
Received 29 May 2023; Received in revised form 13 July 2023; Accepted 17 July 2023
Available online 18 July 2023

in general, and of long-term sickness absence in particular, should be a high priority.

Knowing prognostic factors for sickness absence that are amenable to change could guide preventive efforts at both micro, *meso*, and macro levels. Multiple risk factors for sickness absence have been reported, including lifestyle factors such as overweight/obesity, smoking, low physical activity during leisure (Virtanen et al., 2018; Troelstra et al., 2019; López-Bueno et al., 2020), as well as psychosocial and physical working conditions (Thorsen et al., 2020; Andersen et al., 2022a; Andersen et al., 2018). Moreover, studies from a variety of countries and job groups have reported increased risks of sickness absence among workers with musculoskeletal disorders, i.e. osteoarthritis of the hip or knee and low-back pain (Morken et al., 2003; Andersen et al., 2011; Andersen et al., 2012a; Andersen et al., 2012b; Saastamoinen et al., 2009; Lallukka et al., 2014; Hubertsson et al., 2013; Lallukka et al., 2020; Bergström et al., 2007; Sundstrup and Andersen, 2017). Musculoskeletal disorders are hence not just highly prevalent globally (Safiri et al., 2020), but also a dominant reason for sickness absence from work (Virtanen et al., 2018). However, previous studies linking musculoskeletal disorders with sickness absence are limited by small or selected populations, e.g. selected age groups (Lallukka et al., 2014; Lallukka et al., 2020) or job groups (Morken et al., 2003; Andersen et al., 2012a; Bergström et al., 2007), relying solely on self-reported sickness absence data (Morken et al., 2003), limited accounting for potential confounding factors (Hubertsson et al., 2013), or do not stratify by age, gender, and educational level. This limits the possibility of targeting effective preventive strategies at the population level. In addition, the intensity of pain caused by musculoskeletal disorders varies substantially between individuals and fluctuates over time, and is touted a strong prognostic factor for poor outcomes, e.g. impaired ability to work, as well as sickness absence and disability pension (Andersen et al., 2012a; Sundstrup and Andersen, 2017; Holtermann et al., 2010; Bláfoss et al., 2021). Still, the existing literature lacks large and well-designed prospective cohort studies linked to high-quality national registers assessing the importance of musculoskeletal pain *intensity* for the risk of long-term sickness absence in the general working population.

Determining critical thresholds of musculoskeletal pain intensities associated with increased risks of sickness absence could allow for better screening and guidance of preventive efforts aimed at those in increased risk of sickness absence. It seems practically relevant for both primary care and occupational health and safety practitioners to distinguish subpopulations of patients/workers to prevent the consequences of musculoskeletal pain caused by musculoskeletal disorders. Furthermore, nationally representative estimates of the association between musculoskeletal pain intensity and long-term sickness absence could help guide evidence-based policy development and preventive efforts at higher levels.

In this prospective cohort study, we determined the association between musculoskeletal pain intensity and register-based long-term sickness absence on >69,000 wage earners. To estimate potentials for preventive strategies across population groups, we calculated population attributable fractions from moderate to high pain intensities stratified by age, gender and educational attainment.

2. Methods

2.1. Study design and population

This prospective cohort study with register follow-up is based on 'Work Environment and Health in Denmark' (WEHD) (Andersen et al., 2018), a nationwide and comprehensive questionnaire survey conducted every second year from 2012 until 2018 that has been described extensively previously (Andersen et al., 2022a; Andersen et al., 2021). In brief, he present study utilized all four waves of the survey and linked it to the Danish Register for Evaluation of Marginalisation (DREAM) using an anonymous code representing the unique personal identification number (CPR) given to all Danish citizens. In each round of WEHD, Statistics Denmark invited probability samples of Danish residents aged 18–64 years employed for ≥35 h per month with a monthly income ≥3000 DKK (∼ €400) in the past three months. Between 2012 and 2018, invitations were sent to 228,173 individuals of which 127,882 (56%) replied. In this study, we included currently employed wage earners (confirmed on the questionnaire, n = 110,357 responses) free of long-term sickness absence during the 52 weeks preceding baseline (Roelen et al., 2011), first occasion responses for individuals participating in several WEHD waves (n = 73,298 unique individuals), and those replying to the questions about musculoskeletal pain intensity (n = 69,273 unique individuals). When constructing the weight variable used to make the estimates representative of the general working in Denmark, 124 had non-positive weights and could not be included in the analyses using the weight variable. As not all participants filled in all survey questions, the exact number of participants for each analysis varies accordingly. This study follows the STROBE reporting guidelines for cohort studies (von Elm et al., 2008). In accordance with Danish law, questionnaire- and register data can be used for scientific purposes without collecting informed consent or approval by ethical and scientific committees. Statistics Denmark depersonalized and stored all data on their servers, and researchers performed analyses through remote access.

2.2. Musculoskeletal pain intensity (predictor)

Respondents rated musculoskeletal pain intensity on the validated 11-point numerical rating scale from 0 to 10 (Dworkin et al., 2005): "On a scale from 0 to 10, where 0 is no pain and 10 is worst possible pain, rate the worst pain you have had in your neck/shoulder during the last three months". The same question was posed for low-back pain. For the main analyses, we defined an additional variable, 'maximal pain intensity', as the highest pain intensity reported by the worker in either the low-back or neck/shoulder, which we used to calculate the population attributable fractions of pain for long-term sickness absence.

2.3. Long-term sickness absence (outcome)

Survey responses were linked to the DREAM register using the CPR number. In Denmark, the first 30 days of sickness absence from work are financially covered by the employer, whereupon the municipality can reimburse additional days. DREAM contains information about reimbursement of sickness absence payments and is based on the municipalities' actual payments (Andersen et al., 2022a; Andersen et al., 2021). The DREAM register is highly valid as the employer has a strong economic incentive to receive the reimbursement (Stapelfeldt et al., 2012). Long-term sickness absence was defined as having registered a period of ≥6 consecutive weeks of sickness absence in DREAM for a period of up to 2 years, starting the week after replying to the survey (Andersen et al., 2022a; Andersen et al., 2021). For the last WEHD wave (2018), the follow-up period was limited to about 1.5 years (until the end of 2019) in order to end before the COVID-19 pandemic started.

2.4. Control variables

Our models were adjusted for the following variables previously associated with sickness absence (Virtanen et al., 2018; López-Bueno et al., 2020; Andersen et al., 2022a; Sundstrup and Andersen, 2017; Andersen et al., 2021): age, gender, year of survey reply, educational attainment, occupation, psychosocial work factors, smoking habits, body mass index (BMI), leisure-time physical activity, and depressive symptoms. Age (continuous variable) and gender (categorical: man, woman) were drawn from the Central Person Register of Denmark. Year of survey reply was entered as a categorical variable (2012, 2014, 2016, 2018). Educational attainment and occupation were drawn from a national register and included as categorical variables, e.g. shorter education (unskilled and skilled work) and longer education (further education), and occupation was based on the Danish version of the International Standard Classification of Occupations (DISCO, 1st digit). The psychosocial work factors was adapted from the Copenhagen Psychosocial Questionnaire (Pejtersen et al., 2010), and included influence at work (two items) and job strain (scale of 0–100, 100 = best), and entered as continuous variables. Smoking status was entered as a categorical variable ('Yes, daily', 'Yes, once in a while', 'Ex-smoker', 'No, never'), whereas BMI (kg/m^2), leisure-time physical activity (total weekly hours of leisure physical activity), and depressive symptoms (Major Depression Inventory, scale 0–50) were included as continuous variables. As some of these variables may be potential mediators and could lead to over-adjustment, we present both minimally and fully adjusted models.

2.5. Statistical analyses

We used the Proc SurveyPhreg procedure (SAS version 9.4., SAS institute) with model-assisted weights based on information from high-quality national registers on age, gender, occupational industry, highest completed education, family income and type, and origin. The Proc SurveyPhreg procedure is a Cox proportional hazard model with weights that accounts for the survey design and ensures representative estimates for the general working population without recent long-term sickness absence. Musculoskeletal pain intensity was the predictor variable, and long-term sickness absence during follow-up was the outcome variable (time to first event). Visual inspection of the proportional hazards assumption showed no indications of violation. We censored in case of reaching the end of the follow-up period, early retirement, disability pension, statutory retirement, emigration, or death. We did not impute missing data as applying the weight variable solves both non-response and deviations of the probability sample from the general working population. Model 1 was adjusted for age, gender, and year of survey reply, and model 2 was additionally adjusted for educational level, DISCO group, psychosocial work factors, BMI, smoking, leisure-time physical activity, and mental health (MDI). In the fully adjusted analyses of pain in each individual region, we adjusted for pain intensity in the other region, i.e. neck/shoulder pain adjusted for low-back pain and vice versa. Results are reported as HR with 95% confidence intervals (CI).

Based on the lower threshold maximal pain intensity of increased risk of long-term sickness absence, the population attributable fraction (PAF) attributable to moderate to high (≥4 out of 10) vs. no or low (<4 out of 10) maximal pain was calculated from HRs and proportions exposed (Pe) in the fully adjusted model: $PAF = \Sigma Pe(HRe - 1)/(\Sigma Pe (HRe - 1) + 1) \times 100\%$. This was done for the whole sample and in subgroups of age, gender and education.

3. Results

Table 1 shows descriptive baseline characteristics of the included participants. The sample ($n = 69{,}273$) was on average 46 years, and 53% were women. Average (worst) pain intensity during the past three months was 2.6 and 2.3 in the neck/shoulder and low-back, respectively. During up to two years of follow-up (mean: 93 weeks), the weighted incidence of long-term sickness-absence was 8.9% ($n = 6165$).

Table 2 shows the minimally and fully adjusted association between neck/shoulder and low-back pain intensity and long-term sickness absence. After both minimal and full adjustment, the higher the pain intensity, the higher the risk of long-term sickness absence (trend-test: $p < 0.001$). In the fully adjusted model, the risk of long-term sickness absence was significantly increased by at least 13–14% at and above pain intensities of 4 and 3 out of 10 in the neck/shoulders and low-back, respectively. Weighted data showed that 34% of the population had neck/shoulder pain intensity at or above 4, whereas 39% reported low-back pain intensity at or above 3.

Table 1
Descriptive baseline characteristics of the study sample of Danish wage earners.

Variable	n	%	Mean	SD
WEHD wave				
2012	19,843	28.6		
2014	15,082	21.8		
2016	17,979	26.0		
2018	16,369	23.6		
Age (years)	69,273		46.0	10.8
Gender	69,273			
Men	32,850	47.4		
Women	36,423	52.6		
Educational attainment	68,830			
Shorter education	37,677	54.7		
Longer education	31,153	45.3		
Smoking	68,763			
Yes, daily	9990	14.5		
Yes, once in a while	3560	5.2		
Ex-smoker	19,918	29.0		
No, never	35,295	51.3		
BMI	68,342		25.7	4.4
Musculoskeletal pain during the preceding three months (0–10)				
Neck/shoulder pain	68,961		2.6	2.8
Low-back pain	68,956		2.3	2.9
Psychosocial work factors (0−100)				
Job strain	69,178		46.3	16.3
Influence at work	69,116		78.8	19.0
Major depression inventory (0–50)	68,861		8.0	7.3
Leisure-time physical activity (hours/week)	68,762		5.2	3.3

WEHD: Work Environment and Health in Denmark, n: number, SD: standard deviation, BMI: body mass index.

Table 3 shows the minimally and fully adjusted association between maximal pain intensity in the neck/shoulders or low-back and risk of long-term sickness absence. After full adjustment, a positive dose-response association existed between maximal pain intensity and long-term sickness absence (trend-test: $p < 0.001$), with a significantly increased risk of at least 25% at and above a maximal pain intensity of 4 out of 10 compared to not having pain (pain intensity of 0). Weighted data showed that 46% of the population had a maximal pain intensity in the neck/shoulder or low-back at or above 4 out of 10. Fig. 1 shows the weighted incidence of long-term sickness absence stratified by maximal pain intensity in the neck/shoulders or low-back. The figure shows a clear trend, where the higher the maximal pain intensity, the higher the incident long-term sickness absence.

Table 4 shows the association and population attributable fractions between maximal pain intensity and long-term sickness absence stratified by age, gender, and educational attainment. Across all participants, having moderate to high pain intensity of above 4 out of 10 was associated with a 44% increased risk (HR (95% CI): 1.44 (1.35–1.55)) of long-term sickness absence compared to having low or no pain (maximal pain intensity below 4 out of 10). No significant differences in HR or PAF existed between strata.

4. Discussion

The main finding of this study is the clear dose-response relation between musculoskeletal pain intensity of the neck/shoulder or low-back and the risk of long-term sickness absence. Population attributable fraction analyses indicate that one sixth of the long-term sickness absence were attributable to moderate to high levels of musculoskeletal pain (≥4 on a scale from 0 to 10). These findings were comparable across age groups, gender, and workers with shorter and longer educations, emphasizing the large potential of pain prevention programs across the general working population.

Table 2
Association between neck/shoulder and low-back pain intensity and long-term sickness absence among Danish wage earners.

	Neck/shoulder pain				Low-back pain			
			Model 1	Model 2			Model 1	Model 2
Pain intensity	n	%	HR (95% CI)	HR (95% CI)	n	%	HR (95% CI)	HR (95% CI)
0	31,016	45.6	1	1	36,153	52.4	1	1
1	1993	3.0	1.11 (0.91–1.36)	1.01 (0.81–1.25)	2028	3.1	0.99 (0.79–1.23)	0.96 (0.77–1.20)
2	4497	6.8	1.01 (0.87–1.17)	0.96 (0.82–1.11)	3723	5.6	**1.17 (1.01–1.36)**	1.08 (0.92–1.26)
3	7043	10.1	**1.25 (1.12–1.40)**	1.09 (0.97–1.23)	5574	8.0	**1.26 (1.12–1.42)**	**1.13 (1.00–1.29)**
4	5301	7.6	**1.41 (1.26–1.58)**	**1.14 (1.01–1.29)**	4501	6.5	**1.52 (1.34–1.73)**	**1.26 (1.09–1.44)**
5	5674	8.0	**1.62 (1.45–1.82)**	**1.30 (1.15–1.46)**	4811	6.9	**1.47 (1.30–1.66)**	**1.21 (1.07–1.37)**
6	4366	6.2	**1.63 (1.45–1.84)**	**1.26 (1.11–1.44)**	3624	5.3	**1.68 (1.49–1.90)**	**1.32 (1.16–1.50)**
7	4273	6.0	**1.93 (1.72–2.17)**	**1.43 (1.26–1.62)**	3630	5.2	**2.15 (1.91–2.41)**	**1.63 (1.44–1.85)**
8	3159	4.5	**2.41 (2.13–2.72)**	**1.75 (1.54–2.00)**	2952	4.3	**2.17 (1.92–2.46)**	**1.61 (1.41–1.84)**
9	973	1.4	**2.42 (1.98–2.95)**	**1.60 (1.28–2.00)**	1209	1.8	**2.47 (2.08–2.94)**	**1.69 (1.40–2.03)**
10	544	0.8	**3.19 (2.55–4.00)**	**1.96 (1.54–2.50)**	629	0.9	**3.31 (2.65–4.14)**	**2.20 (1.70–2.84)**

n: number, %: weighted percentage of the population, HR: hazard ratio, 95% CI: 95% Confidence Interval.
Statistically significant associations marked with bold.
Model 1: Adjusted for age, gender, and year of survey reply.
Model 2: Additionally adjusted for educational level, occupational group (DISCO), psychosocial work factors (job strain and influence at work), lifestyle (BMI, smoking, leisure-time physical activity), mental health, and pain intensity in the other body region.

Table 3
Association between maximal pain intensity in the neck/shoulders or low-back and risk of long-term sickness absence among Danish wage earners.

			Model 1	Model 2
Pain intensity	n	%	HR (95% CI)	HR (95% CI)
0	24,013	35.3	1	1
1	1503	2.3	0.94 (0.71–1.25)	0.91 (0.68–1.23)
2	4360	6.4	1.02 (0.86–1.19)	0.99 (0.84–1.17)
3	7288	10.3	**1.21 (1.07–1.37)**	1.12 (0.98–1.27)
4	5904	8.4	**1.48 (1.31–1.68)**	**1.25 (1.09–1.42)**
5	6576	9.3	**1.51 (1.34–1.70)**	**1.27 (1.12–1.43)**
6	5404	7.8	**1.61 (1.43–1.81)**	**1.30 (1.15–1.47)**
7	6030	8.5	**2.11 (1.90–2.35)**	**1.62 (1.44–1.82)**
8	5061	7.3	**2.39 (2.14–2.67)**	**1.79 (1.59–2.02)**
9	1955	2.8	**2.72 (2.35–3.15)**	**1.85 (1.58–2.17)**
10	1055	1.5	**3.63 (3.04–4.34)**	**2.41 (1.97–2.95)**

n: number, %: weighted percentage of the population, HR: hazard ratio, 95% CI: 95% Confidence Interval.
Statistically significant associations marked with bold.
Model 1: Adjusted for age, gender, and year of survey reply.
Model 2: Additionally adjusted for educational level, occupational group (DISCO), psychosocial work factors (job strain and influence at work), lifestyle (BMI, smoking, leisure-time physical activity), and mental health.

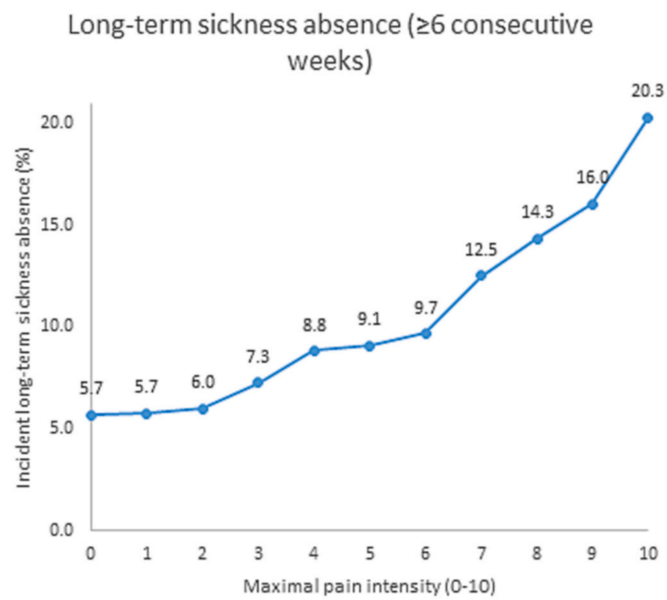

Fig. 1. Weighted incidence of long-term sickness absence by maximal pain intensity (neck/shoulder or low-back) among Danish wage earners.

4.1. Previous findings

This large prospective cohort study with register-based follow-up elaborates on previous studies showing increased risk of sickness absence among workers with musculoskeletal disorders (Morken et al., 2003; Andersen et al., 2011; Andersen et al., 2012a; Andersen et al., 2012b; Saastamoinen et al., 2009; Lallukka et al., 2014; Hubertsson et al., 2013; Lallukka et al., 2020; Bergström et al., 2007; Sundstrup and Andersen, 2017). Adding to previous reports showing increased risk of impaired work functioning (Mine et al., 2020; Skovlund et al., 2020) and disability pension (Bláfoss et al., 2021) at higher pain intensities, our study aligns with previous studies (Andersen et al., 2012a; Sundstrup and Andersen, 2017; Holtermann et al., 2010), confirming pain intensity in the neck/shoulders or low-back as an important prognostic factor for future long-term sickness absence; the higher the pain intensity, the higher the risk of long-term sickness absence. The risk of long-term sickness absence was significantly increased at and above threshold pain intensities in the neck/shoulder and low-back of 4 and 3, respectively, whereas a maximal pain intensity at or above a threshold of 4 out of 10 was associated with a significantly increased risk of long-term sickness absence. In comparison, Holtermann and colleagues investigated prognostic factors for register-based long-term sickness absence (≥3 weeks) among a representative sample of workers with average neck/shoulder or low-back pain intensities above 4 out of 9 during the past three months. After full adjustment, every one-point increase in neck/shoulder pain intensity increased the risk of long-term sickness absence by 11%, whereas there was no significant effect of increasing low-back pain intensity above the threshold of 4 (Holtermann et al., 2010), likely due to inadequate statistical power. Sundstrup and coworkers reported a dose-response association between average low-back pain intensity during the last three months and risk for register-based long-term sickness absence (≥6 weeks) among workers with both light and hard physical work, with increased risk of long-term sickness absence noted above pain intensity levels of 3–4 out of 9 (Sundstrup and Andersen, 2017). In the fully adjusted model (model 4), increased risks of 30 and 60% was reported among workers with pain intensities 3–4 out of 9 and light and hard physical work, respectively, compared to workers with no or low pain (0–2 out of 9) and light work. Furthermore, Andersen and coworkers reported increasing risk of register-based long-term sickness absence (≥8 weeks) with increasing pain intensities in neck/shoulder, low-back, and knees among female

Table 4
HRs and population attributable fractions from moderate to high pain intensity (≥4/10) vs no to low (<4/10) maximal pain intensity among Danish wage earners, stratified for age, gender and educational level.

	Maximal pain intensity ≥ / < 4/10 (%)	HR (95% CI)	PAF (95%CI)
All	46 / 54	**1.44 (1.35–1.55)**	16.8 (13.6–20.1)
≥ 50 years	48 / 52	**1.38 (1.25–1.52)**	15.3 (10.7–19.9)
< 50 years	44 / 56	**1.47 (1.34–1.62)**	17.3 (13.0–21.6)
Men	41 / 59	**1.52 (1.35–1.72)**	17.6 (12.6–22.6)
Women	51 / 49	**1.38 (1.27–1.51)**	16.3 (12.0–20.6)
Shorter education	51 / 49	**1.42 (1.30–1.56)**	17.8 (13.2–22.4)
Longer education	38 / 62	**1.45 (1.30–1.61)**	14.5 (10.2–18.9)

%: weighted percentage of the population with pain intensity at and above and below 4 out of 10 within subgroup, HR: hazard ratio, 95% CI: 95% Confidence Interval.
Statistically significant associations marked with bold.
Fully adjusted for age, gender, year of survey reply, educational level, occupational group (DISCO), psychosocial work factors (job strain and influence at work), lifestyle (BMI, smoking, leisure-time physical activity), and mental health.

healthcare workers (Andersen et al., 2012a). However, after full adjustment for age, BMI, smoking, leisure-time physical activity, seniority, and physical and psychosocial work conditions, a significantly increased risk was noted at threshold pain intensities in both the neck/shoulder and low-back associated at 7 out of 9 (Andersen et al., 2012a), which is considerably higher than in our study and the study by Holtermann. Authors argued that adjusting for work conditions could represent an over-adjustment if the musculoskeletal pain mediates the relation between work conditions and long-term sickness absence, and suggested the less adjusted model (adjusted for age, BMI, smoking, and leisure-time physical activity) as more relevant. Here, the threshold pain intensities in the neck/shoulder and low-back associated with an increased risk of long-term sickness absence were 4 and 5 out of 9, respectively (Andersen et al., 2012a), which is more in agreement with our and Holtermann and Sundstrup's findings (Sundstrup and Andersen, 2017; Holtermann et al., 2010). Notably, Andersen and co-workers reported 44 and 47% increased risk of long-term sickness absence at the threshold pain intensities of 5 and 4 out of 9 in the low-back and neck/shoulders (Andersen et al., 2012a), which is a considerably higher risk than the 13–14% increased risk at the threshold pain intensities in the low-back and neck/shoulder observed in our study. These data collectively indicate that even moderate pain levels may increase the risk of long-term sickness absence, and that threshold pain intensities associated with increased risk of long-term sickness absence may be job-specific.

As long-term sickness absence has major negative consequences at both personal, workplace, and societal level in terms of for instance disability pension (Kivimaki et al., 2004; Lund et al., 2008; Salonen et al., 2018) and mortality (Kivimäki et al., 2003; Head et al., 2008), an important take-home from this study is the comparable HRs and PAFs across strata. These data indicate a comparable risk of long-term sickness absence attributable to pain-inducing musculoskeletal disorders and a universal preventive potential of preventing or reducing musculoskeletal pain across the general working population. Neck/shoulder, low-back pain, and other musculoskeletal disorders are extremely prevalent globally (Safiri et al., 2020). Our weighted data indicated that about 34% and 39% of the population experienced neck/shoulder and low-back pain intensity levels at or above the threshold pain intensities of 3 and 4 out of 10 associated with increased risk of long-term sickness absence, highlighting the large magnitude of the preventive potential.

The lack of statistically significant differences in PAF between educational strata were somewhat unexpected. Although the HR of shorter and longer educated workers were not significantly different, the PAF appeared marginally larger for shorter educated workers, which could be due to the markedly higher prevalence of moderate to high pain intensity among this group compared to longer educated workers (51% vs. 38%, respectively). It is well-established that typically shorter educated workers in manual jobs are at increased risk of musculoskeletal disorders (da Costa and Vieira, 2010) and sickness absence (Andersen et al., 2018), and therefore these findings could be particularly important. Notably, workers with musculoskeletal disorders *and* physically demanding manual jobs are also at increased risk of sickness absence (Bláfoss et al., 2021; Roelen et al., 2011; Sundstrup et al., 2017) and disability pension (Hubertsson et al., 2017) compared to workers with musculoskeletal disorders having more sedentary jobs, indicating particularly high consequences of musculoskeletal disorders among manual workers. This and the higher threshold-specific risk estimates reported by Andersen can likely partially be explained by the high physical work demands and the fact that the body is the primary work tool in these jobs.

4.2. Practical implications

It is almost inevitable to experience musculoskeletal pain now and then. However, these critical thresholds of musculoskeletal pain intensities associated with increased risks of long-term sickness absence could allow for better screening and guidance of preventive efforts aimed at those in increased risk of sickness absence. This could be especially relevant in primary health care and for occupational health and safety practitioners, allowing distinguishing subpopulations of patients/workers to prevent the consequences of musculoskeletal pain. These findings call for action and implementation of large-scale effective preventive programs aimed at primary prevention and management of musculoskeletal pain. The reported dose-response relation could suggest that even smaller reductions in pain intensity could be worthwhile pursuing.

The workplace has proven a promising arena for health promotion, and these and previous findings suggest a preventive potential of reorganizing the work, proper use of technical assistive devices, and accommodating work demands among workers with musculoskeletal disorders in order to create a better match between work capacity and demands (Holtermann et al., 2010; Skovlund et al., 2020; Hubertsson et al., 2017). Alternatively, regularly performing micro-exercises at the workplace during working hours has shown an effective and simple means to increase physical capacity and reduce musculoskeletal pain (Sundstrup et al., 2020) and even risk of long-term sickness absence (Andersen et al., 2022b) among both sedentary and manual workers. In principle, all workers irrespective of physical fitness, educational attainment, income level, and work demands can perform these short, simple, and non-sweaty exercises at the workplaces. However, both offer and use hereof is still limited at the population level, emphasizing an unexploited potential, especially among shorter educated workers (Andersen et al., 2022b), who is at increased risk of musculoskeletal disorders and sickness absence. Importantly, each individual workplace will likely benefit most from multi-faceted approaches tailored to their needs and resources.

4.3. Strengths and limitations

Our study has several strengths. First, drawing random samples and applying model-assisted weights based on information from high-quality registers make the estimates representative of wage earners from the general working population without recent long-term sickness absence in Denmark. Second, the outcome, long-term sickness absence, was derived from a highly valid national register, ensuring no loss to follow-up (Stapelfeldt et al., 2012). Third, we adjusted our analyses for multiple covariates previously associated with sickness absence and excluded workers with recent prior sickness absence (Roelen et al., 2011). Our study also comprises methodological limitations. First, although musculoskeletal pain intensity is per se a subjective experience suitably obtained through self-reported data, our predictor variable may suffer from recall bias and other biases typical for self-reported data (Podsakoff et al., 2003). Unfortunately, the DREAM register does not contain reason or specific disease underlying the long-term sickness absence, and the latter is thus an unspecific proxy for poor health. Although we controlled for multiple possible covariates, unmeasured or residual confounding may still have influenced our results by e.g. weakening the associations, i.e. other types of chronic disease (Sundstrup et al., 2017). Our outcome variable, incidence of long-term sickness absence, was categorical (yes/no), and not sickness absence duration as a continuous variable, and our results thus cannot be generalized to sickness absence of shorter duration (<6 weeks) that are highly prevalent (Thorsen et al., 2020). However, musculoskeletal disorders have previously shown stronger associations to long(er)-term sickness absence compared to shorter-term sickness absence (Saastamoinen et al., 2009; Lallukka et al., 2020) more commonly associated with for instance seasonal infectious disease.

5. Conclusion

We observed a dose-response relation between musculoskeletal pain intensity of the neck/shoulder or low-back and the risk of register-based long-term sickness absence. Population attributable fraction analyses indicated that about one sixth of the long-term sickness absence could potentially be prevented, if musculoskeletal pain was alleviated or reduced among those with moderate to high pain levels. The associations were comparable across age groups, gender, and educational attainment levels, emphasizing the universal potential of preventing or reducing musculoskeletal pain in terms of long-term sickness absence across the entire general working population.

Acknowledgements and disclosures

The authors would like to thank data managers from The National Research Centre for the Working Environment and Statistics Denmark for data management. This manuscript was possible due to a grant from The Danish Working Environment Research Fund for this project (Arbejdsmiljøforskningsfonden, grant number 20195100758). The funder had no role in the study design, collection, analysis and interpretation of data, in the writing of the manuscript, nor in the decision to submit the manuscript for publication. The authors declare no conflicts of interest.

CRediT authorship contribution statement

Sebastian Venge Skovlund: Methodology, Writing – original draft, Writing – review & editing, Visualization. **Rúni Bláfoss:** Writing – review & editing. **Joaquín Calatayud:** Writing – review & editing. **Rubén López Bueno:** Writing – review & editing. **Emil Sundstrup:** Conceptualization, Methodology, Writing – review & editing, Supervision, Project administration. **Lars Louis Andersen:** Conceptualization, Methodology, Formal analysis, Writing – review & editing, Supervision, Project administration, Funding acquisition.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data used in this study cannot be shared publicly due to the data protection regulation. All data are stored on a protected server hosted by Statistics Denmark and can be accessed by researchers registered at Statistics Denmark and meeting the criteria for access to confidential data. The data are available for research upon reasonable request and with permission from the Danish Data Protection Agency.

References

Andersen, L.L., Mortensen, O.S., Hansen, J.V., Burr, H., 2011 Aug. A prospective cohort study on severe pain as a risk factor for long-term sickness absence in blue- and white-collar workers. Occup. Environ. Med. 68 (8), 590–592.

Andersen, L.L., Clausen, T., Burr, H., Holtermann, A., 2012 Jul 20. Threshold of musculoskeletal pain intensity for increased risk of long-term sickness absence among female healthcare Workers in Eldercare. PLoS One 7 (7), e41287.

Andersen, L.L., Clausen, T., Mortensen, O.S., Burr, H., Holtermann, A., 2012 Aug 1. A prospective cohort study on musculoskeletal risk factors for long-term sickness absence among healthcare workers in eldercare. Int. Arch. Occup. Environ. Health 85 (6), 615–622.

Andersen, L.L., Thorsen, S.V., Flyvholm, M.A., Holtermann, A., 2018 Oct. Long-term sickness absence from combined factors related to physical work demands: prospective cohort study. Eur. J. Pub. Health 28 (5), 824–829.

Andersen, L.L., Pedersen, J., Sundstrup, E., Thorsen, S.V., Rugulies, R., 2021 May 10. High physical work demands have worse consequences for older workers: prospective study of long-term sickness absence among 69117 employees. Occup. Environ. Med 78 (11), 829–834 oemed-2020-107281.

Andersen, L.L., Vinstrup, J., Thorsen, S.V., Pedersen, J., Sundstrup, E., Rugulies, R., 2022 Jun 1. Combined psychosocial work factors and risk of long-term sickness absence in the general working population: prospective cohort with register follow-up among 69 371 workers. Scand. J. Work Environ. Health 4035.

Andersen, L.L., Skovlund, S.V., Vinstrup, J., Geisle, N., Sørensen, S.I., Thorsen, S.V., et al., 2022 Feb 10. Potential of micro-exercise to prevent long-term sickness absence in the general working population: prospective cohort study with register follow-up. Sci. Rep. 12 (1), 2280.

Bergström, G., Bodin, L., Bertilsson, H., Jensen, I.B., 2007 Apr. Risk factors for new episodes of sick leave due to neck or back pain in a working population. A prospective study with an 18-month and a three-year follow-up. Occup. Environ. Med. 64 (4), 279–287.

Bevan, S., 2015 Jun 1. Economic impact of musculoskeletal disorders (MSDs) on work in Europe. Best Pract. Res. Clin. Rheumatol. 29 (3), 356–373.

Bláfoss, R., Vinstrup, J., Skovlund, S.V., López-Bueno, R., Calatayud, J., Clausen, T., et al., 2021 Sep 10. Musculoskeletal pain intensity in different body regions and risk of disability pension among female eldercare workers: prospective cohort study with 11-year register follow-up. BMC Musculoskelet. Disord. 22 (1), 771.

da Costa, B.R., Vieira, E.R., 2010 Mar. Risk factors for work-related musculoskeletal disorders: a systematic review of recent longitudinal studies. Am. J. Ind. Med. 53 (3), 285–323.

Dworkin, R.H., Turk, D.C., Farrar, J.T., Haythornthwaite, J.A., Jensen, M.P., Katz, N.P., et al., 2005 Jan. Core outcome measures for chronic pain clinical trials: IMMPACT recommendations. Pain. 113 (1–2), 9–19.

Head, J., Ferrie, J.E., Alexanderson, K., Westerlund, H., Vahtera, J., Kivimäki, M., et al., 2008 Oct 2. Diagnosis-specific sickness absence as a predictor of mortality: the Whitehall II prospective cohort study. BMJ. 337, a1469.

Henderson, M., Glozier, N., Holland, Elliott K., 2005 Apr 9. Long term sickness absence. BMJ. 330 (7495), 802–803.

Holtermann, A., Hansen, J.V., Burr, H., Søgaard, K., 2010 Jan. Prognostic factors for long-term sickness absence among employees with neck-shoulder and low-back pain. Scand. J. Work Environ. Health 36 (1), 34–41.

Hubertsson, J., Petersson, I.F., Thorstensson, C.A., Englund, M., 2013 Mar. Risk of sick leave and disability pension in working-age women and men with knee osteoarthritis. Ann. Rheum. Dis. 72 (3), 401–405.

Hubertsson, J., Turkiewicz, A., Petersson, I.F., Englund, M., 2017 Feb. Understanding occupation, sick leave, and disability pension due to knee and hip osteoarthritis from a sex perspective. Arthritis Care Res. 69 (2), 226–233.

Kivimäki, M., Head, J., Ferrie, J.E., Shipley, M.J., Vahtera, J., Marmot, M.G., 2003 Aug 16. Sickness absence as a global measure of health: evidence from mortality in the Whitehall II prospective cohort study. BMJ. 327 (7411), 364.

Kivimaki, M., Forma, P., Wikstrom, J., Halmeenmaki, T., Pentti, J., Elovainio, M., et al., 2004 Aug. Sickness absence as a risk marker of future disability pension: the 10-town study. J. Epidemiol. Community Health 58 (8), 710–711.

Lallukka, T., Øverland, S., Haaramo, P., Saastamoinen, P., Bjorvatn, B., Sivertsen, B., 2014 Jul. The joint contribution of pain and insomnia to sickness absence and disability retirement: a register-linkage study among Norwegian and Finnish employees. Eur. J. Pain Lond. Engl. 18 (6), 883–892.

Lallukka, T., Hiilamo, A., Oakman, J., Mänty, M., Pietiläinen, O., Rahkonen, O., et al., 2020 May. Recurrent pain and work disability: a record linkage study. Int. Arch. Occup. Environ. Health 93 (4), 421–432.

López-Bueno, R., Sundstrup, E., Vinstrup, J., Casajús, J.A., Andersen, L.L., 2020 May 1. High leisure-time physical activity reduces the risk of long-term sickness absence. Scand. J. Med. Sci. Sports 30 (5), 939–946.

Lund, T., Kivimäki, M., Labriola, M., Villadsen, E., Christensen, K.B., 2008 Jan. Using administrative sickness absence data as a marker of future disability pension: the prospective DREAM study of Danish private sector employees. Occup. Environ. Med. 65 (1), 28–31.
Mine, Y., Fujino, Y., Matsuda, S., 2020 Apr. The interaction between pain intensity and pain self-efficacy in work functioning impairment: a Cross-sectional study in Japanese construction workers. J. Occup. Environ. Med. 62 (4), e149.
Morken, T., Riise, T., Moen, B., Hauge, S.H., Holien, S., Langedrag, A., et al., 2003 Sep 4. Low back pain and widespread pain predict sickness absence among industrial workers. BMC Musculoskelet. Disord. 4, 21.
Pejtersen, J.H., Kristensen, T.S., Borg, V., Bjorner, J.B., 2010 Feb. The second version of the Copenhagen psychosocial questionnaire. Scand. J. Public Health 38 (3 Suppl), 8–24.
Podsakoff, P.M., MacKenzie, S.B., Lee, J.Y., Podsakoff, N.P., 2003 Oct. Common method biases in behavioral research: a critical review of the literature and recommended remedies. J. Appl. Psychol. 88 (5), 879–903.
Roelen, C.A.M., Koopmans, P.C., Schreuder, J.A.H., Anema, J.R., van der Beek, A.J., 2011 Mar. The history of registered sickness absence predicts future sickness absence. Occup. Med. Oxf. Engl. 61 (2), 96–101.
Saastamoinen, P., Laaksonen, M., Lahelma, E., Leino-Arjas, P., 2009 Feb 1. The effect of pain on sickness absence among middle-aged municipal employees. Occup. Environ. Med. 66 (2), 131–136.
Safiri, S., Kolahi, A.A., Cross, M., Hill, C., Smith, E., Carson-Chahhoud, K., et al., 2020 Nov. 4. Prevalence, deaths and disability adjusted life years (DALYs) due to musculoskeletal disorders for 195 countries and territories 1990-2017. Arthritis Rheumatol. Hoboken NJ. 73 (4), 702–714.
Salonen, L., Blomgren, J., Laaksonen, M., Niemelä, M., 2018 May 9. Sickness absence as a predictor of disability retirement in different occupational classes: a register-based study of a working-age cohort in Finland in 2007-2014. BMJ Open 8 (5), e020491.
Skovlund, S.V., Bláfoss, R., Sundstrup, E., Thomassen, K., Andersen, L.L., 2020 Nov 18. Joint association of physical work demands and leg pain intensity for work limitations due to pain in senior workers: cross-sectional study. BMC Public Health 20 (1), 1741.
Stapelfeldt, C.M., Jensen, C., Andersen, N.T., Fleten, N., Nielsen, C.V., 2012 Aug 15. Validation of sick leave measures: self-reported sick leave and sickness benefit data from a Danish national register compared to multiple workplace-registered sick leave spells in a Danish municipality. BMC Public Health 12 (1), 661.
Sundstrup, E., Andersen, L.L., 2017. Hard physical work intensifies the occupational consequence of physician-diagnosed Back disorder: prospective cohort study with register follow-up among 10,000 workers. Int. J. Rheumatol. 2017, 1037051.
Sundstrup, E., Jakobsen, M.D., Mortensen, O.S., Andersen, L.L., 2017. 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 43 (2), 146–154, 01.
Sundstrup, E., Seeberg, K.G.V., Bengtsen, E., Andersen, L.L., 2020 Dec. A systematic review of workplace interventions to rehabilitate musculoskeletal disorders among employees with physical demanding work. J. Occup. Rehabil. 30 (4), 588–612.
Thorsen, S.V., Flyvholm, M.A., Pedersen, J., Bültmann, U., Andersen, L.L., Bjorner, J.B., 2020. Associations between physical and psychosocial work environment factors and sickness absence incidence depend on the lengths of the sickness absence episodes: a prospective study of 27 678 Danish employees. Occup. Environ. Med. 78 (1), 46–53.
Troelstra, S.A., Coenen, P., Boot, C.R., Harting, J., Kunst, A.E., van der Beek, A.J., 2019. 3. Smoking and sickness absence: a systematic review and meta-analysis. Scand. J. Work Environ. Health. 46 (1), 5–18.
Virtanen, M., Ervasti, J., Head, J., Oksanen, T., Salo, P., Pentti, J., et al., 2018 Nov 1. Lifestyle factors and risk of sickness absence from work: a multicohort study. Lancet Public Health 3 (11), e545–e554.
von Elm, E., Altman, D.G., Egger, M., Pocock, S.J., Gøtzsche, P.C., Vandenbroucke, J.P., et al., 2008 Apr. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. J. Clin. Epidemiol. 61 (4), 344–349.