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Multisite musculoskeletal pain predicts medically certified disability retirement among Finns

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Abstract

Background: Musculoskeletal pain at several sites (multisite pain) is more common than single-site pain. Little is known on its effects on disability pension (DP) retirement.
Methods: A nationally representative sample comprised 4071 Finns in the workforce aged 30 to 63. Data (questionnaire, interview, clinical examination) were gathered in 2000–2001 and linked with national DP registers for 2000–2011. Pain during the preceding month in 18 locations was combined into four sites (neck, upper limbs, low back, lower limbs). Hazard ratios (HR) of DP were estimated by Cox regression.
Results: The HR of any DP ($n = 477$) was 1.6 (95% confidence interval 1.2–2.1) for one, 2.5 (1.9–3.3) for two, 3.1 (2.3–4.3) for three and 5.6 (4.0–7.8) for four pain sites, when adjusted for age and gender. When additionally adjusted for clinically assessed chronic diseases, the HRs varied from 1.4 (1.0–1.8) to 3.5 (2.5–4.9), respectively. When further adjusted for physical and psychosocial workload, education, body mass index, smoking, exercise and sleep disorders, the HRs were 1.3 (0.9–1.7), 1.6 (1.2–2.2), 1.8 (1.3–2.5) and 2.5 (1.8–3.6). The number of pain sites was especially strong in predicting DPs due to musculoskeletal diseases (HRs in the full model; 3.1 to 4.3), but it also predicted DPs due to other somatic diseases (respective HRs 1.3 to 2.3); pain in all four sites was also predictive of DPs due to mental disorders (full model HR 2.2).
Conclusions: The number of pain sites independently predicted DP retirement. Employees with multisite pain may need specific support to maintain their work ability.

1. Introduction

Leaving the labour market permanently due to health problems usually decreases the income level of the individual, increases the risk of social exclusion and causes a substantial burden to society in terms of disability beneficiary costs and lost production. In the countries of the Organisation for Economic Cooperation and Development (OECD), an average of 6% of the working-age population (8% in Finland) received disability benefits in 2008 (OECD, 2010). The two most common medico-legal causes of disability pension (DP) are musculoskeletal and mental disorders (OECD, 2010). Non-medical risk factors of DP include female gender and higher age (OECD, 2010), low socio-economic status (Bruusgaard et al., 2010;

What's already known about this topic?

- The occurrence of musculoskeletal pain at multiple sites concurrently (multisite pain) is a common phenomenon among the working population, but reports on its consequences for disability retirement are scarce.

What does this study add?

- Among the Finnish workforce in a nationally representative sample, the number of musculoskeletal pain sites at baseline predicted disability pension awards, even when clinically assessed diseases, physical and psychosocial workload, health-related lifestyle and socio-demographic factors were adjusted for.

Leinonen et al., 2011), smoking (Husemoen et al., 2004; Neovius et al., 2010), low leisure-time physical activity (Robroek et al., 2013), high body mass index (Neovius et al., 2010; Robroek et al., 2013), sleep problems (Sivertsen et al., 2006; Lallukka et al., 2011), high physical workload (Labriola et al., 2009; Lahelma et al., 2012) and adverse psychosocial factors at work (Sinokki et al., 2010; Lahelma et al., 2012; Mäntyniemi et al., 2012; Canivet et al., 2013).

Pain is a leading symptom of most musculoskeletal disorders. Recently, of a total of 289 diseases, low back pain was ranked as the first, neck pain as the fourth and other musculoskeletal disorders as the sixth most important cause of years lived with disability in 2010 (Vos et al., 2012). Low back pain and neck pain affect particularly the population at working age (Palazzo et al., 2014). Current epidemiological evidence suggests that musculoskeletal pain at several sites is more common than single-site pain (Croft et al., 2007; Grotle and Croft, 2010; Coggon et al., 2013). However, few studies have examined the relationship of multisite pain with work ability. In these studies, mostly self-reported outcomes have been used (Kamaleri et al., 2009a; Miranda et al., 2010; Neupane et al., 2013). An increasing number of pain sites was found to be associated with reduced physical and mental work ability and subject's own prognosis of poor future work ability (Miranda et al., 2010). The number of pain sites predicted a change to poor perceived work ability in a 4-year follow-up among food industry workers (Neupane et al., 2013), and among a sample of the population in a Norwegian municipality, it was a strong predictor of self-reported DPs 14 years later (Kamaleri et al., 2009a).

We are aware of only one previous prospective study on the association between multisite pain and DP retirement, by Øverland et al. that used register-based information on DPs (Øverland et al., 2012). They found that chronic widespread musculoskeletal pain strongly predicted incident DPs among Norwegian subjects. In the current study among the Finnish workforce, we examined the number of pain sites, without the requirement of chronicity or predetermined distribution, as a predictor of incident DP retirement due to all medical causes and by major diagnostic categories (musculoskeletal diseases, other somatic diseases and mental disorders) based on a register linkage over an 11.5-year follow-up.

2. Materials and methods

2.1 Procedure and participants

The current study was based on the Health 2000 study, carried out in Finland between August 2000 and June 2001 in order to achieve an overall view of the population's health. Data were collected using questionnaires, a face-to-face home interview, a clinical examination and laboratory and functional capacity tests described in detail elsewhere (Heistaro, 2008). The Ethics Committee of Epidemiology and Public Health of the Hospital district of Helsinki and Uusimaa approved the study. All the participants signed a written informed consent (Heistaro, 2008).

A representative sample of Finnish adults aged 30 or over was drawn by a two-stage cluster sampling. The original sample consisted of 8028 subjects aged between 30 and 99. Of these, 51 died before interview, 6986 were interviewed (87.6%) and 6354 (79.7%) participated in the health examination (Aromaa and Koskinen, 2004). In this work, analyses were restricted to the subjects between 30 and 63 years of age who belonged to the workforce and participated in the clinical examination ($n = 4071$). These persons were actively working during the year preceding the baseline in a full-time or part-time job, or were unemployed or laid off. Also, participants who were on sick leave, maternity/paternity or nursing leave, or under temporary job sharing arrangements were included. Information for the years 2000–2011 on all pension awards and dates of death were linked from national registers to the data set using the unique personal identification number.

2.2 DP retirement

The pension register data included information on the dates of award and main diagnoses of all permanent, temporary and part-time DPs. The main outcome in the study was the first occurrence of any DP granted from the date of the subject's clinical examination until 31 December 2011. DPs due to major diagnostic categories (musculoskeletal diseases, other somatic diseases and mental disorders) were analysed separately.

The Finnish pension system consists of a guarantee pension to ensure minimum security, a residence-based national pension and a statutory earnings-related pension that accrues from work and provides security for old age and in the event of disability. The special features of the pension benefits of the earnings-related pension scheme are the same regardless of type of work. Pension also accrues on the basis of certain unpaid periods (e.g., unemployment, parental leave). People can retire flexibly on old-age pension between the ages of 63 and 68. Thus, pensions granted after the age of 63 years are no longer based on disability but on age alone (Finnish Centre for Pensions, 2013).

Independent pension institutions may grant a DP due to a chronic illness, handicap or injury if it reduces the subject's work ability by at least 60% (full-time DP). If the loss in work ability is between 40% and 60%, a part-time DP may be awarded. Before the decision, people must have received sickness allowance for the maximum period of 300 working days and his/her incapacity for work has been estimated to last for at least a year (Finnish Centre for Pensions, 2013). In some cases, a long unemployment period instead of a sickness allowance period may precede the DP decision (Laaksonen et al., 2014).The DP may be awarded until further notice or temporarily if it can be expected that the person's work ability can be restored and return to work seems plausible (Finnish Centre for Pensions, 2013). Disability is determined based on a medical certificate and coded according to the International ICD-10 (WHO, 2010). The Finnish Centre for Pensions coordinates all earnings-related pensions for permanent residents and provides virtually complete data on DP awards.

2.3 Number of musculoskeletal pain sites

The number of musculoskeletal pain sites was the main determinant. It was assessed in the interview carried out before the health examination. Pain (yes/no) during the preceding month in 18 body locations was inquired. The items were combined to represent four sites: the neck (the neck and the areas between neck and shoulders), upper limbs (shoulders, elbows, wrists, fingers), low back and lower limbs (hips, knees, ankles, feet). A manikin illustrated the body sites. Pain in the upper and lower limbs included left, right or both sides. If at least one site in the category of upper and lower limbs was defined as 'yes', the combined variable was defined as 'yes'. A determinant variable with five categories was created (0 = no pain to 4 = pain in four sites) (Miranda et al., 2010; Haukka et al., 2013).

2.4 Covariates

The covariates included in the analyses were chosen on the basis of previous knowledge of factors, which could confound the association between the number of pain sites and DP. The covariates have been presented in more detail elsewhere (Heistaro, 2008). As having chronic diseases often involves pain, we considered the contribution of chronic diseases to the relationship of interest separately. In further modelling, socio-demographic and lifestyle-related factors, including sleep disorders and hazards at work, were also adjusted for.

2.4.1 Demographic factors

Information on age (continuous), gender and education (≤9, 10–12 and ≥13 years) was collected in the home interview.

2.4.2 Chronic musculoskeletal, cardiovascular and other somatic diseases

Chronic diseases were diagnosed in the clinical examination of the Health 2000 study by specially trained physicians according to a standardized written protocol with uniform diagnostic criteria. The diagnoses were based on disease histories, symptoms and clinical findings (Heistaro, 2008). The occurrence (at least one disease in the category) of chronic musculoskeletal, cardiovascular and other somatic diseases was considered. Musculoskeletal diseases (yes/no) covered chronic neck, low back and shoulder syndromes, chronic epicondylitis and carpal tunnel syndrome, hip and knee osteoarthritis, inflammatory arthritis, amputations and injuries to knee and ankle ligaments, and other musculoskeletal diseases. Cardiovascular diseases (yes/no) included angina pectoris, myocardial infarction, cardiac insufficiency, hypertension, arrhythmia, valvular disease, intermittent claudication, cerebrovascular disease and other cardiovascular diseases, and having had coronary surgery. The category of other somatic diseases (yes/no) included respiratory diseases (asthma, chronic obstructive pulmonary disease, allergic rhinoconjunctivitis and other respiratory disease), as well as diabetes, hyperlipidaemia, Parkinson's disease, cataract, glaucoma, chronic eczema, hypothyroidism, other defined somatic disease and cancer (the information on cancer history was, as an exception, collected during the home interview) (Haukka et al., 2013).

2.4.3 Common mental disorders

Common mental disorders (yes/no) were assessed using the computerized version of the Composite International Diagnostic Interview (CIDI; WHO, 1990; Wittchen et al., 1998) in the clinical health examination. This programme is based on the operationalized criteria for diagnoses in the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV; APA, 1994) enabling the estimation of DSM-IV diagnoses for major mental disorders. The subjects were categorized as having a common mental disorder if they fulfilled the criteria for depressive (i.e., major depressive or dysthymic disorder) or anxiety disorder (i.e., panic disorder with or without agoraphobia, generalized anxiety disorder, social phobia not otherwise specified or agoraphobia without panic disorder).

2.4.4 Physical workload

Physical workload was assessed in the home interview by inquiring whether the subjects had been exposed (yes/no) in their current or past jobs to heavy physical work involving lifting or carrying heavy objects, or excavating, digging or pushing. They were also asked about the duration (years) of their jobs. The cumulative sum of years of exposure was classified into three categories; 'none', <15 and ≥15 years.

2.4.5 Psychosocial workload

Psychosocial workload was measured by the Karasek's Job Content Questionnaire (Karasek et al., 1998).The indicator of job demands consisted of five items (Cronbach's alpha, $\alpha = 0.79$) and that of job control of nine (Cronbach's alpha, $\alpha = 0.84$), both had a 5-point response scale. The sum scores were dichotomized at their median to indicate high (>16) and low (≤16) job demands, and low (>20) and high (≤20) job control. Using the questionnaire, the subjects were also asked whether they are provided with adequate support from their supervisor and co-workers when needed. The original five categories (1 = fully agree, 2 = quite agree, 3 = do not agree or disagree, 4 = quite disagree, 5 = completely disagree) were dichotomized as high (1–2) or low (3–5) supervisor and co-worker support (Haukka et al., 2013).

2.4.6 Lifestyle factors

Body mass index (BMI, kg/m^2) was based on measured weight and height and classified as ≤ 24.9 (normal), 25–29.9 (overweight) and ≥30.0 (obese; WHO, Global Database on Body Mass Index). Smoking was assessed during home interview and the data on different modes of tobacco use were summed. Smoking intensity was calculated as the daily number of cigarettes + pipefuls + cigars/20. Pack-years were calculated as regular smoking time (years) × intensity (NCI). Smoking was classified as never, ex-/occasional smokers and current smokers smoked <15 and ≥15 pack-years. Leisure-time physical activity was inquired by questionnaire as follows: 'How much do you exercise and strain yourself physically during your leisure-time?' The original four categories were dichotomized to inactive ('reading, watching television, doing minor activities that do not strain physically') and active ('walking, cycling or moving in other ways ≥4 hours/week', 'vigorous physical activity >3 hours/week', or 'competitive sports'; Mäkinen et al., 2010; Haukka et al., 2013). Sleep disorders were assessed by asking: 'Have you had insomnia or sleeping disorders during the past month?' The original five categories were classified to 'no', 'sometimes' and 'often' (Haukka et al., 2013).

2.5 Statistical methods

All statistical analyses were performed using STATA version 11.

2.5.1 The risk of DP retirement during follow-up

Follow-up for the DP began on the first day when the subject participated in the Health 2000 Study and ended when (s)he was granted a disability or other pension, attained age of 65, died or at the end of the follow-up (31 December 2011), whichever came first.

To analyse the effects of the number of pain sites on DPs, Cox's proportional hazard regression was used to calculate hazard ratios (HR) and their 95% confidence intervals (CI) by using the STATA MIM stcox command. The Wald test was used to analyse linear trends in these effects. The first model was adjusted for age and gender (when not stratified), the second additionally for chronic musculoskeletal, cardiovascular and other somatic diseases, and common mental disorders, and the final model included also physical and psychosocial workload (job demands, job control, supervisor and co-worker support), education, body mass index, smoking, leisure-time physical activity and sleep disorder. The time-dependent interaction between the number of pain sites, all covariates, and follow-up period was statistically non-significant in all three models, supporting that the proportional hazards assumption was justified. The risk for all-cause and diagnosis-specific DPs (musculoskeletal diseases, other somatic diseases and mental disorders) was analysed separately. Gender-stratified analysis of all-cause DPs was performed secondarily.

All p-values were two-sided and $p < 0.05$ was considered as statistically significant.

2.5.2 Missing data and multiple imputation

The number of missing values in the determinant and covariates varied from 0% to 11% being at highest (17.5%) in the fully adjusted model among the total sample. Missing data mostly occurred in psychosocial factors at work (job demands 11%, job control 10%, supervisor support 11% and co-worker support 10%), while the other variables included less than 2.5% missing values. The pattern of missing data was examined using STATA 'mistables'. The analysis supported the assumption that the data were missing at random and we used the approach of multiple imputation by chained equations (MICE) to deal with missingness by using the ICE command (Sterne et al., 2009; White et al., 2011). The MIM command with mcerror was used to test White et al.'s (2011) three conditions for the Monte Carlo error, and if they did not meet, we increased the number of imputations. Fifty separate datasets were created for the final analyses. In the imputation model, we included all variables (determinant, covariates, outcomes) used in the models, e.g., age (years), gender, the number of pain sites (being four original binary variables in ICE), musculoskeletal (binary variable), cardiovascular (binary variable) and other somatic diseases (three binary variables), mental disorders (two binary variables), physical workload (two continuous variables), psychosocial workload: job demands (five categorical variables), job control (nine categorical variables), supervisor (binary variable) and co-worker support (the original five categorical variables), education (years), body mass index (kg/m^2), smoking (pack-years), leisure-time physical activity (the original four categorical variables), sleep disorder (the original five categorical variables) and DP (all-cause or DPs due to musculoskeletal disorders, other somatic diseases or mental disorders, whichever was the case), and the natural logarithm of time to event (days). We used logistic regression models for binary variables, multinomial logistic regression models for categorical variables and linear regression for continuous variables in the imputation models.

2.5.3 Sensitivity analyses

As a sensitivity analysis, we ran all the analyses based on the original data, i.e., without imputation. There were no major differences between the imputed and non-imputed results, and we only report those based on the imputed data. The description of characteristics of the study material in Table 1 was based on the original data, however.

In the Finnish system, also those not actively working although included in the workforce (e.g., the unemployed, laid off, under temporary job sharing arrangement, those on maternity/paternity/nursing leave) are entitled to a DP in the circumstance of demonstrable decreased work ability due to disease or injury. The amount of subjects not actively working during the year preceding baseline assessment among those awarded a DP during follow-up was 21% of all-cause DPs. As a second sensitivity analysis, we studied only participants actively working in the year preceding the baseline assessment ($n = 3481$). These results were consistent with the ones presented here based on the workforce at large ($n = 4071$).

3. Results

During an average follow-up time of 9.2 years, altogether 477 subjects (12%) were granted a DP. Of the DPs, 76% were awarded due to somatic diseases (both musculoskeletal and other somatic diseases accounting for 38% each), while 24% were due to mental disorders. Of the DP recipients, 55% were women.

Characteristics of the subjects are described in Table 1. At baseline, 34% of the subjects were free of pain, 31% reported pain in one site and 35% had pain in multiple sites. Four-fifths of the subjects had a physician-diagnosed musculoskeletal or other somatic disease and 9% had mental disorders. Every second reported high job demands and low job control and a third suffered often from sleep disorder. Over 60% were overweight or obese.

3.1 The number of pain sites in relation to all-cause DPs

As seen in Table 2, the number of pain sites was in a graded association with subsequent all-cause DP awards. In the model adjusted for age and gender, the HR was 1.6 (95% CI 1.2–2.1) for one, 2.5 (1.9–3.3) for two, 3.1 (2.3–4.3) for three and 5.6 (4.0–7.8) for four pain sites. The estimates particularly attenuated, when chronic musculoskeletal, cardiovascular and other somatic diseases and mental disorders were also adjusted for (model 2), then ranging from 1.4 (1.0–1.8) for one site, 1.8 (1.4–2.4) for two sites, 2.2 (1.6–3.1) for three sites and 3.5 (2.5–4.9) for four pain sites. When further physical and psychosocial workload, education, body mass index, smoking, leisure-time physical activity and sleep disorders were included in the model, the effects for pain in multiple sites still remained, being 1.6 (1.2–2.2) for two pain sites, 1.8 (1.3–2.5) for three sites and 2.5 (1.8–3.6) for pain in four sites ($p_{\text{linear trend}} \leq 0.001$). Among men, HRs in the full model varied from 1.5 to 2.5 ($p_{\text{linear trend}} \leq 0.001$) and among women from 1.7 to 2.5 ($p_{\text{linear trend}} \leq 0.001$), respectively (Supporting Information Table S1).

Of the covariates, increasing age, chronic musculoskeletal and other somatic diseases, as well as mental disorders and frequent sleep disorders, were statistically significant predictors for DP among both genders, while among men, also, high physical workload (≥15 years) and smoking (≥15 pack-years) and among women low education and low physical activity during leisure time predicted DPs (Supporting Information Table S1).

3.2 The number of pain sites in relation to diagnostic categories of DPs

As expected, the number of pain sites was a strong predictor of DPs especially due to musculoskeletal diseases (Table 2). HRs of DPs from musculoskeletal diseases in the fully adjusted model varied from 3.1 (1.6–5.7) for one to 4.3 (2.1–9.0) for four pain sites ($p_{\text{linear trend}} \leq 0.001$). Regarding other somatic diseases, fully adjusted HRs were from 1.3 (0.8–1.9) to 2.3 (1.3–4.2, $p_{\text{linear trend}} = 0.003$). Pain in all four sites also predicted DPs due to mental disorders (HR 2.2, 1.1–4.2).

4. Discussion

Among the Finnish workforce, we found that the risk of DP retirement depended on the number of musculoskeletal pain sites in a dose-response manner. Such a linear trend between pain sites and DPs may be assumed because many diseases that commonly decrease work ability give rise to pain. However, the association was only moderately attenuated when also chronic musculoskeletal, cardiovascular, other somatic

Table 1 Characteristics of the 4071 subjects at baseline 2000–2001 according to disability pension retirement based on national records during 2000–2011.

	Disability pension		
	Yes[a] (*n* = 477)	No[a] (*n* = 3594)	Total[a] (*n* = 4071)
Determinant			
No. of pain sites, *n* (%)			
0	85 (18)	1257 (35)	1342 (34)
1	115 (24)	1123 (32)	1238 (31)
2	127 (27)	694 (20)	821 (20)
3	77 (16)	328 (9)	405 (10)
4	68 (14)	138 (4)	206 (5)
Covariates			
Age, years, mean (SD)	48 (6.9)	44 (8.6)	44 (8.5)
Gender, female, *n* (%)	261 (55)	1873 (52)	2134 (52)
Education, years, *n* (%)			
≥13	132 (28)	1739 (49)	1871 (46)
10–12	170 (36)	1134 (32)	1304 (32)
≤9	171 (36)	700 (19)	871 (22)
Common mental disorder, *n* (%)	90 (19)	285 (8)	375 (9)
Musculoskeletal disease, *n* (%)	250 (52)	988 (28)	1238 (30)
Cardiovascular disease, *n* (%)	127 (27)	502 (14)	629 (15)
Other somatic disease, *n* (%)	222 (47)	1155 (32)	1377 (34)
Physical workload, years, *n* (%)			
None	212 (45)	2120 (59)	2332 (58)
<15	98 (21)	777 (22)	875 (22)
≥15	164 (35)	677 (19)	841 (21)
Psychosocial workload			
High job demands, *n* (%)	217 (56)	1404 (43)	1621 (45)
Low job control, *n* (%)	213 (54)	1498 (46)	1711 (47)
Low supervisor support, *n* (%)	140 (36)	1008 (31)	1148 (32)
Low co-worker support, *n* (%)	88 (22)	575 (18)	663 (18)
Body mass index (BMI, kg/m^2), *n* (%)			
≤24.9	136 (28)	1367 (38)	1503 (37)
25–29.9	228 (48)	1673 (47)	1901 (47)
≥30.0	113 (24)	553 (15)	666 (16)
BMI, mean (SD)	27.5 (5.4)	26.3 (4.4)	26.4 (4.5)
Smoking, *n* (%)			
Never	109 (23)	965 (27)	1074 (26)
Ex-/occasional smoker	192 (40)	1740 (48)	1932 (48)
<15 pack-years	52 (11)	453 (13)	505 (12)
≥15 pack-years	123 (26)	426 (12)	549 (14)
Leisure-time physical activity (inactive), *n* (%)	154 (33)	848 (24)	1002 (25)
Sleep disorder, *n* (%)			
No	134 (29)	1591 (45)	1725 (43)
Sometimes	104 (22)	1041 (29)	1145 (28)
Often	232 (49)	937 (26)	1169 (29)

SD, standard deviation.

[a]Based on original data including missing values, i.e., without imputation.

diseases and mental disorders were adjusted for. In the full model with additional adjustment for physical workload and psychosocial factors at work, lifestyle-related variables, sleep disorders and education, multisite pain retained as a significant predictor of DPs, while pain in one site not remained statistically significantly different from having no pain.

The widespreadness of pain has been approached in various ways in the literature, ranging from the American College of Rheumatology (Wolfe et al., 1990) and Manchester (Hunt et al., 1999) criteria to simple counts of pain sites (Schmidt and Baumeister, 2007). Recently, Coggon et al. (2013) reported in a large multinational cluster of samples that any two of

Table 2 Number of musculoskeletal pain sites as a determinant of all-cause and disease-specific disability pensions (DP), based on national registers covering the years 2000 to 2011 among 4071 Finns. Cox proportional hazard regression, hazards ratios (HR) with their 95% confidence intervals (CI).

No. of musculoskeletal pain sites	All-cause DP[a] (n = 477) HR	95% CI	DP due to musculoskeletal[a] diseases (n = 182) HR	95% CI	DP due to other somatic[a] diseases (n = 181) HR	95% CI	DP due to mental disorders[a] (n = 114) HR	95% CI
Model 1[b]								
0	1.00	Ref	1.00	Ref	1.00	Ref	1.00	Ref
1	1.56	1.18–2.07	4.19	2.27–7.73	1.46	0.96–2.24	0.63	0.36–1.11
2	2.51	1.90–3.31	6.02	3.27–11.1	2.21	1.44–3.38	1.46	0.88–2.42
3	3.13	2.30–4.28	10.0	5.35–18.8	2.47	1.48–4.09	1.07	0.53–2.17
4	5.60	4.04–7.77	11.2	5.68–22.1	4.47	2.61–7.64	4.84	2.75–8.53
$p_{\text{linear trend}}$[e]		$p \leq 0.001$		$p \leq 0.001$		$p \leq 0.001$		$p \leq 0.001$
Model 2[c]								
0	1.00	Ref	1.00	Ref	1.00	Ref	1.00	Ref
1	1.38	1.04–1.83	3.37	1.82–6.27	1.33	0.86–2.04	0.61	0.35-1.09
2	1.83	1.37–2.44	3.98	2.12–7.48	1.75	1.12–2.75	1.06	0.62–1.81
3	2.23	1.60–3.10	6.13	3.20–11.7	2.04	1.19–3.50	0.78	0.37–1.62
4	3.49	2.46–4.94	6.23	3.06–12.7	2.95	1.66–5.22	3.13	1.69–5.80
$p_{\text{linear trend}}$[e]		$p \leq 0.001$		$p \leq 0.001$		$p \leq 0.001$		$p \leq 0.001$
Model 3[d]								
0	1.00	Ref	1.00	Ref	1.00	Ref	1.00	Ref
1	1.26	0.94–1.68	3.05	1.64–5.69	1.26	0.81–1.94	0.56	0.31–1.00
2	1.61	1.20–2.16	3.44	1.82–6.48	1.59	1.01–2.50	0.95	0.56–1.63
3	1.75	1.25–2.45	4.67	2.41–9.05	1.69	0.98–2.93	0.63	0.30–1.35
4	2.53	1.76–3.64	4.34	2.10–8.97	2.29	1.26–4.16	2.18	1.14–4.18
$p_{\text{linear trend}}$[e]		$p \leq 0.001$		$p \leq 0.001$		$p = 0.003$		$p = 0.054$

[a]The results are based on imputed data.
[b]Model 1: adjusted for age and gender.
[c]Model 2: model 1 + chronic musculoskeletal, cardiovascular and other somatic diseases and common mental disorders.
[d]Model 3: model 2 + physical and psychosocial workload (job demands, job control, supervisor and co-worker support), education, body mass index, smoking, leisure-time physical activity and sleep disorder.
[e]Wald test for linear trend.

the 10 pain sites studied occurred together more often than expected, but the strongest associations were between the corresponding sites bilaterally as well as adjacent sites in the neck and upper limb. Our classification of the 18 pain sites represented in our data takes this into account, by first combining sites in the upper versus the lower limbs as well as those in the neck versus the lower back. The number of larger sites (0–4) performed well with a monotonic increase in risk in predicting consequences of the widespreadness of pain on work ability.

The effect of the number of pain sites on DP retirement was rather similar in both genders. Increasing age, chronic diseases and sleep disorders also predicted DPs among both genders, while physical workload and smoking were important in men and low education and low leisure-time physical activity in women (see Supporting Information Table S1). As expected, the number of pain sites strongly predicted DPs due to musculoskeletal diseases, but had an independent effect also on DPs due to other somatic diseases. Further, subjects with pain at all four sites had a twofold risk for DP due to mental disorders compared to those without pain.

Our study is among the first prospective studies examining the number of pain sites as a determinant of subsequent register-based DPs. A previous study by Øverland and colleagues (Øverland et al., 2012) defined widespread pain as a dichotomy: chronic pain lasting for at least three consecutive months during the past year and concurrently occurring in the trunk, upper limbs and lower limbs. They observed that after adjustment for socio-economic status, a set of self-reported medical conditions and health-related behaviour, widespread pain predicted DPs with a HR of 3.5. Within the group with widespread pain, the authors further found that the number of pain sites had a curvilinear relationship with DP risk. They also provided a figure to show that the number of pain sites (none, 1–2 sites, ≥3 sites) was associated with the hazard of DP award; this was only adjusted for gender, however. Despite the methodological differences in definition of pain (in our study there was no chronicity criterion) and widespreadness, our results are well in line with the findings of Øverland et al. (2012). The Health 2000 Survey has the strength of enabling adjustment for medical diseases based on clinical examination by field physicians, which may provide more valid estimates of the effect sizes. We also took psychosocial factors at work into account in the analyses. A further difference between the studies is in the examined age range. In the Norwegian study (Øverland et al., 2012), this was rather narrow (40–46 years at baseline) while we studied the subjects between 30 and 63 years of age at baseline.

Our results are also in line with the results of a prospective study among a large sample of Swedish twins surveyed twice for pain in three locations (neck, shoulder, back) 6 years apart and followed up from registers for DP for 23 years (Ropponen et al., 2013), since the number of pain sites in the first survey predicted DPs due to musculoskeletal causes. Our results also support the previous findings with self-reported outcomes, showing an association of an increase in the number of pain sites with reduced physical and mental functioning in working life (Saastamoinen et al., 2006; Miranda et al., 2010; Natvig et al., 2010) poor work ability (Neupane et al., 2013) and DPs (Kamaleri et al., 2009a).

Our previous study among the Finnish working population using the same determinant as in this study showed a similar graded association of the number of pain sites with register-based information on sickness absence periods (≥10 workdays), especially with persistently high absenteeism over time (Haukka et al., 2013). The number of pain sites was also associated with self-reported indicators of reduced physical and mental work ability, with the anticipation that work ability will deteriorate, that one is not able to continue working in the current job, and thoughts about retiring early (Miranda et al., 2010). The results of our study support these self-reported perceptions regarding work ability.

Our current results showed that pain, especially in multiple sites, has a strong impact on work ability irrespective of medically detectable diseases, health-related lifestyle, working conditions and socio-demographic factors. Previously, the number of pain sites was shown to be more strongly associated with decreased health-related functioning than the anatomical location or duration of the pain (Saastamoinen et al., 2006). Our findings also showed that the number of pain sites independently predicted DP retirement not only because of musculoskeletal diseases, but also other somatic diseases. Thus, also, our findings support the idea that the total number of pain sites, *per se*, could be useful as a prognostic tool for reduced work ability (Grotle and Croft, 2010) and underlie the need for investigation of preventive initiatives for pain at several sites.

This study has several strengths. Our sample represents the Finnish working population, the participation rate was high and we made use of a longitudinal design with a register-based outcome measure not liable to subjective recall error. We were able to study the effects of the number of pain sites across DP diagnoses. The 11.5-year follow-up time was long enough to reveal a sufficient number of DP cases for appropriate analyses. Data were collected by clinical examination, home interview and questionnaires, where most items were selected on the basis of standardized recommendations or nationally established practice (Heistaro, 2008). Diseases were assessed by specially trained physicians using a detailed protocol and common mental disorders by the structured CIDI interview (WHO, 1990; Wittchen et al., 1998) carried out by trained healthcare workers. Occurrence of pain during the preceding month was inquired, as has been suggested for epidemiological studies to minimize recall bias (Miranda et al., 2010). The assessment of the determinant was comprehensive, with altogether 18 pain locations were considered and combined into four sites. We were also able to take into account a large set of potentially confounding factors.

The statistical analyses to handle missing values, mostly concerning psychosocial factors at work, showed a pattern that supported missingness at random. We used multiple imputations by chained equations and to fulfil the Monte Carlo errors requirements (White et al., 2011), we created 50 imputations. The use of 100 imputations had no effects on Monte Carlo errors. We also ran all analyses with original data without imputation. The results did not differ and no inconsistencies that would lead to different interpretations were observed. Neither did the exclusion of those not actively working during the year preceding the baseline change the results.

It should be considered as a limitation in our study that the number of pain sites and the covariates were measured only once leaving their possible changes over the follow-up period undetected. Although the pattern of reporting pain sites seems to be relatively stable even across 14 years (Kamaleri et al., 2009b), it has been argued that data derived from a survey only at one time point could lead to an underestimation of the effects. It is also possible that a long follow-up period may underestimate the effects. However, the proportional hazards assumption of Cox regression was fulfilled over the entire follow-up.

To conclude, we found among the Finnish workforce that the number of pain sites was a strong predictor of DP retirement independent of musculoskeletal and other diseases, working conditions, health-related lifestyle, sleep disorders and sociodemographic factors. Employees with multisite pain may need specific support to maintain their work ability.

Author contributions

All authors contributed to the conception, design, interpretation of data and writing or critically revising the manuscript. E.H. wrote the first draft of the manuscript and A.O. made the statistical analyses. P. L.-A. obtained funding and is the guarantor of the study.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Table S1. Determinants of all-cause disability pensions among total sample of Finns ($n = 4071$) and stratified by gender (men $n = 1937$, women $n = 2134$), based on national registers covering the years 2000–2011. Cox proportional hazard regression, hazard ratios (HR) with their 95% confidence intervals (CI).