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Master thesis in Human Movement Science

Musculoskeletal pain in relation to risk of disability pension, and the possible modifying role of physical workload and work satisfaction: prospective data from the HUNT Study, Norway

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Abstract

Musculoskeletal pain is a significant cause of years lived with disability, and expenses of examination and treatment, reduced work ability, sickness absence and disability benefits are considerable. A better understanding of work-related factors that can modify the association between pain and disability is essential, in order to develop effective preventive strategies. The aim of the current study was to examine the independent effects of musculoskeletal pain, physical workload and work satisfaction on risk for disability pension, as well as the possible modifying role of physical workload and work satisfaction on the relation between musculoskeletal pain and disability pension risk. Data on 44 713 individuals, originating from the second wave of the Nord-Trøndelag Health Study (HUNT2, 1995-97), was linked to a national registry on incident disability pension from Statistics Norway (FD-trygd, follow-up through 2007). We used Cox regression analyses to estimate adjusted relative risks (RRs) of disability pension associated with musculoskeletal pain and work-related factors. Precision of the estimated associations was assessed by 95% confidence intervals (95% CIs). Additionally, tests of statistical interaction (i.e., deviation from multiplicativity or additivity) were conducted, to explore possible synergistic effects. During the 10-year follow-up, 6764 individuals (15.1 %) became recipients of disability pension. Chronic musculoskeletal pain was strongly associated with risk of disability pension (males: RR 2.06, 95% CI 1.90-2.24; females: RR 2.59, 95% CI 2.40-2.79), and activity-interfering pain increased the risk even further. The independent effects of physical workload and work satisfaction were modest; however, individuals who concurrently experienced chronic pain and had heavy physical work or low work satisfaction were at the highest risk of disability pension. For males and females with pain and heavy physical work, RRs and 95% CIs were 2.60 (2.24-3.02) and 3.37 (2.88-3.95), respectively. For the joint effects of pain and low work satisfaction, RRs and 95% CIs were 2.98 (2.34-3.79) for males and 3.29 (2.67-4.07) for females. Despite the strong associations, there were no statistically significant interaction between these factors, based on p-values from the multiplicative test and RERI estimates with 95% CIs from the additive test. In conclusion, musculoskeletal pain is positively associated with disability pension risk, and work-related factors such as physical workload and work satisfaction may contribute to a further amplification of this risk. Persons with musculoskeletal pain exposed to heavy physical work, or with low work satisfaction, should be given special attention to prevent early work disability.

Sammendrag

Muskel-skjelettsmerter er en vesentlig årsak til år levd med uførhet, og betydelige utgifter er knyttet til undersøkelse og behandling, nedsatt arbeidsevne, sykefravær og uføretrygd. En bedre forståelse av arbeidsrelaterte faktorer som kan modifisere sammenhengen mellom smerte og uførhet er essensielt for å kunne utvikle effektive preventive strategier. Målet med denne studien var å utforske de uavhengige effektene av muskel-skjelettsmerter, fysisk arbeidsbelastning og jobbtilfredshet på risiko for uføretrygd, samt den mulig modifiserende rollen til fysisk arbeidsbelastning og jobbtilfredshet på forholdet mellom muskel-skjelettsmerter og uførerisiko. Data for 44 713 individer, samlet inn i den andre utgaven av Helseundersøkelsen i Nord-Trøndelag (HUNT2, 1995-97), ble knyttet til et nasjonalt register for nye tilfeller av uføretrygd fra Statistisk Sentralbyrå (FD-trygd, oppfølging ut 2007). Vi brukte Cox regresjonsanalyser til å estimere justert relativ risiko (RR) for uføretrygd assosiert med muskel-skjelettsmerter og de arbeidsrelaterte faktorene. Presisjonen til de estimerte assosiasjonene ble vurdert med et 95% konfidensintervall (95% CI). I tillegg ble tester for statistisk interaksjon (avvik fra multiplikativitet eller additivitet) gjennomført, for å utforske mulige synergistiske effekter. I løpet av den 10-årige oppfølgingsperioden ble 6764 individer (15.1 %) mottakere av uføretrygd. Muskel-skjelettsmerter var sterkt assosiert med risiko for uføretrygd (menn: RR 2.06, 95% CI 1.90-2.24; kvinner: RR 2.59, 95% CI 2.40-2.79), og aktivitets-interfererende smerte økte risikoen ytterligere. De uavhengige effektene av fysisk arbeidsbelastning og jobbtilfredshet var beskjedne, men individer som samtidig erfarte smerte og hadde tungt fysisk arbeid eller lav jobbtilfredshet hadde høyest risiko for uføretrygd. For menn og kvinner med smerte og tungt fysisk arbeid var RR og 95% CI henholdsvis 2.60 (2.24-3.02) og 3.37 (2.88-3.95). For de kombinerte effektene av smerte og lav jobbtilfredshet var RR og 95% CI 2.98 (2.34-3.79) for menn og 3.29 (2.67-4.07) for kvinner. Til tross for de sterke sammenhengene var det ingen statistisk signifikant interaksjon mellom disse faktorene, basert på p-verdier fra den multiplikative testen og RERI estimater med 95% CI fra den additive testen. Konklusjonen er at muskel-skjelettsmerter er positivt assosiert med uførerisiko, og arbeidsrelaterte faktorer som fysisk arbeidsbelastning og jobbtilfredshet kan bidra til en ytterligere forsterkning av denne risikoen. Personer med muskel-skjelettsmerter som er eksponert for tungt fysisk arbeid eller har lav jobbtilfredshet bør derfor vies særlig oppmerksomhet for å forebygge tidlig yrkesuførhet.

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1. Introduction

1.1: Disability pension

The official statutory retirement age in Norway is 67 years, and as the population generally lives longer and with better health, many people enter this stage of life with positive expectations. However, a substantial share of the population have to leave the labor market before reaching this age, due to permanent illness or injury. If earning capacity is reduced with more than 50 %, a full or graded disability pension can be offered, depending on the individual's residual work capacity. If the illness or injury is deemed occupational, 30 % reduced earning capacity is sufficient to obtain such rights (Arbeids- og velferdsetaten, 2017). The Norwegian government has a stated goal of having high employment rates, as work ensures income and welfare, counteracts poverty and reduces social inequalities (Arbeids- og sosialdepartementet, 2016). Compared to the average for EU countries, the employment rate in Norway is relatively high (70 and 79 %, respectively). However, nearly one fifth of Norwegian adults receive health related benefits, such as sick pay, work assessment allowance and disability pension. In 2016, 9.5 % of the working population received disability pension, and this percentage has remained stable over the past decade (Arbeids- og velferdsetaten, 2016). In order to maintain high employment rates and prevent individuals from becoming work disabled, it is important to learn more about potential risk factors for disability pension. Factors at workplaces and in the environment are of specific interest, as organizational changes and preventive strategies initiated by employers and authorities may have greater effects than individual initiatives (van Vilsteren et al., 2015).

1.2: Musculoskeletal pain

According to the Global Burden of Disease Study, musculoskeletal pain is a significant cause of years lived with disability, particularly among middle-aged and older adults. In 2015, low back and neck pain was proclaimed the leading global cause of disability (GBD 2015 Disease and Injury Incidence and Prevalence Collaborators, 2016). In Norway, musculoskeletal pain is the most common reason for consulting traditional and alternative health services (Steinsbekk et al., 2007). During a month, 75-80 % of adults will have experienced pain in structures belonging to the musculoskeletal apparatus, such as bones, joints, ligaments, muscles and tendons (Ihlebæk et al., 2007). Although many of these cases are acute and transient, and do not require medical treatment, a considerable share develop chronic and persistent conditions, often defined as lasting longer than three months (Cimmino et al., 2011). Results from the Norwegian HUNT Study have shown an age-adjusted incidence of musculoskeletal complaints of 8 % (Hagen et al., 2006), while 51 % of the population reported pain lasting longer than three months (Holth et al., 2008). A recent report estimates that overall socioeconomic costs related to musculoskeletal pain, including expenses of examination and treatment as well as health related benefits, constitute between NOK 69 and 73 billion (Lærum et al., 2013). Additionally, individuals affected by such conditions may experience reduced quality of life, and inability to function at work and in everyday life (Ihlebæk and Lærum, 2004). Thus, the consequences of pain are substantial, for the individual as well as the society.

There are several studies on the relation between musculoskeletal pain and permanently reduced work ability (Haukka et al., 2015, Øverland et al., 2012, Ropponen et al., 2013), and despite methodological differences between studies, the observed associations have been relatively strong. This is reflected in statistics on disability diagnoses: in 2013, 29.4 % of recipients had a musculoskeletal disorder, which makes it the second largest diagnosis category, following mental disorders (Ellingsen, 2015). These recent statistics are also in agreement with previous reports; musculoskeletal disorders are more common among women than men, and become more frequent as age increases (Andersen et al., 2009, Rustøen et al., 2005). Other factors that have been associated with musculoskeletal complaints are pain characteristics (Mallen et al., 2007), low socioeconomic status (Hagen et al., 2005) and physical inactivity (Holth et al., 2008). Continued investigation of these relations are of importance, in order to reveal factors with the potential of promoting health and preventing pain, disease and disability.

1.3: Physical workload and work satisfaction

Work-related factors have been extensively studied in relation to outcomes such as musculoskeletal pain, impaired function in daily life and sickness absence. A cross-sectional study from the Netherlands compared workers who stayed at work despite chronic musculoskeletal pain with sick-listed workers, and found that perceived workload significantly predicted group affiliation, whereas work satisfaction did not (de Vries et al., 2012). Other studies have shown that high physical workload and high job demands increased the risk of sickness absence in a middle-aged working population and the risk of impaired function among older adults (Neupane et al., 2015, Lilje et al., 2015). Objectively measured sickness absence has also been shown to predict future illness and disability pension, particularly if episodes were long-lasting (Marmot et al., 1995, Kivimaki et al., 2004). An association between work-related factors and disability pension could therefore be expected. However, few studies have been conducted on this association, and those completed had either few participants, short follow-up or limited control for possible confounders (Bergstrom et al., 2014, Labriola et al., 2009a), or a highly selected sample (Ropponen et al., 2014). It is also conceivable that there is an interplay between physical workload, work satisfaction and chronic musculoskeletal pain on work ability. To our knowledge, possible synergistic or modifying effects between work-related factors and chronic pain on disability pension risk have not been examined in previous studies.

1.4: Aim and hypothesis

The aim of this master thesis is to examine the independent effects of musculoskeletal pain, physical workload and work satisfaction on risk for disability pension, as well as the possible modifying role of physical workload and work satisfaction on the relation between musculoskeletal pain and disability pension. We hypothesize that there will be an association between pain and disability, and that high physical workload or low work satisfaction will strengthen this association.

2. Methods

2.1: Study population

The Nord-Trøndelag Health Study (HUNT) is the largest collection of health data in Norway. The data was obtained through three population studies: HUNT1 (1984-86), HUNT2 (1995-97) and HUNT3 (2006-08). The participants completed questionnaires and attended medical examinations. Altogether, 120 000 people have completed the health survey, and about 80 000 have submitted blood samples. This master project is based on data from HUNT2, which was partly a follow-up of HUNT1, but also a study comprising a larger scientific program than the previous (Holmen et al., 2003). A total of 94 194 individuals residing in Nord-Trøndelag aged 20 years and older were invited, and 65 145 participated (~70%). Further information about the study population and procedures can be found at the following website: http://www.ntnu.edu/web/hunt/about-hunt.

For the purpose of this prospective study on risk of disability pension, we first excluded individuals who were above 65 years at baseline (n = 15 049), since these would most likely receive retirement pension within the next two years. Secondly, we excluded 5193 people who at baseline answered "yes" to the question "Are you currently retired/on social security?". Finally, people who had missing data on the question "During the last year, have you had pain and/or stiffness in your muscles and limbs that has lasted for at least three consecutive months?" were excluded (n = 190). Thus, a total of 44 713 participants were included for further analysis.

2.2: Dependent variable

Data on incident disability pension were provided through a national event database from Statistics Norway (FD-Trygd), and linked to HUNT2-data using the personal identification numbers of all Norwegian citizens. Participants were followed from date of inclusion in HUNT2 to December 31, 2007, although censored if they became recipients of contractual early retirement or old-age retirement, emigrated, or died during the follow-up. Information on date of emigration and death was obtained by linkage to the central person registry. We had no information on the primary diagnoses of individuals who became recipients of disability pension during follow-up. Consequently, when referring to disability pension throughout the master thesis, this means disability pension from all causes.

2.3: Independent variables

Information on most independent variables originates from the self-completion of HUNT2 Questionnaire 1, except information on work satisfaction, which originates from Questionnaire 2. Height and weight was measured at a clinical examination by trained personnel using calibrated equipment. Questionnaire 1 was delivered along with the invitation, and returned by the participants when they met at the screening stations, whereas Questionnaire 2 was given to the participants at the screening stations with instructions to return it by mail. Thus, there are somewhat more missing data on items from Questionnaire 2 due to a lower response rate.

2.3.1: Musculoskeletal pain

Information on musculoskeletal pain was obtained using the initial question "During the last year, have you had pain and/or stiffness in your muscles and limbs that has lasted for at least three consecutive months?". This gives an overview of the number of people with chronic pain, according to definitions that are based on three months' duration (Cimmino et al., 2011). People who answered "yes" to this question, were then asked about localization (neck, shoulder, wrist/hand, chest/stomach, upper back, lower back, hip, knee, ankle/feet). In case of pain at multiple sites, they were asked to circle the most long-lasting one, and then specify the duration in months or years. Additionally, they were asked if the pain had caused them to reduce their leisure activities. People who answered "yes" to this question were classified as having activity-interfering pain, based on the assumption that reduced activity could indicate more severe pain (Lier et al., 2016).

2.3.2: Physical workload and work satisfaction

The participants answered a number of questions about their work situation. One of them, "If you have paid or unpaid employment, how would you describe your job?", had four possible answers: "mostly sedentary work", "much walking at work", "much walking and lifting at work", and "heavy physical work". As few people would describe their work as heavy, the third and fourth alternative were merged, and the physical workload variable used in the statistical analyses had three categories: 1 = sedentary work, 2 = much walking, and 3 = heavy physical work.

To investigate work satisfaction, the participants were asked “All things considered, how much do you enjoy your work?”. The possible answers were “a great deal”, “a fair amount”, “not much” and “not at all”. The last two alternatives were merged, as only a small percentage reported not to enjoy their work. Consequently, the three categories that were analyzed were: 1 = enjoys work a great deal, 2 = enjoys work a fair amount, and 3 = does not enjoy work.

In order to assess the joint effects of chronic musculoskeletal pain and physical workload or work satisfaction on risk for disability pension, combined variables were constructed. The “pain and physical workload” variable consisted of the following six categories: (I) no pain and sedentary work, (II) no pain and much walking, (III) no pain and heavy physical work, (IV) pain and sedentary work, (V) pain and much walking, and (VI) pain and heavy physical work. The “pain and work satisfaction” variable had six categories as well: (I) no pain and enjoys work a great deal, (II) no pain and enjoys work a fair amount, (III) no pain and does not enjoy work, (IV) pain and enjoys work a great deal, (V) pain and enjoys work a fair amount, and (VI) pain and does not enjoy work.

2.3.3: Possible confounders

Information on variables that could possibly confound the association between chronic musculoskeletal pain and disability pension was obtained from HUNT2 Questionnaire 1. *Age*, originally a continuous variable, was recoded into the following categories: 1 = 19-29 years, 2 = 30-39 years, 3 = 40-49 years, 4 = 50-59 years, and 5 = 60-65 years. *Body mass index* (BMI) was calculated by converting measured height in centimeters and measured weight in hectograms to meters and kilograms, before dividing kilograms with meters squared (kg/m^2). The variable was further categorized as follows: 1 = underweight (<18.5), 2 = normal weight (18.5-24.9), 3 = overweight (25.0-29.9), and 4 = obesity (>30). Due to a small number of participants being underweight, the first two groups were merged. Consequently, the final categories were: 1 = underweight and normal weight, 2 = overweight, and 3 = obesity. *Education* was assessed by asking participants: “What is your highest level of education?”.

The variable originally had five categories, but due to a small proportion of people with higher education, the number of categories was reduced to three: 1 = primary school, 2 = high school/vocational school/junior college, and 3 = college/university. *The "Hospital Anxiety and Depression Scale"* (HADS), a measure of symptom burden of anxiety and depression, was embedded in the HUNT2 questionnaire under the heading "How do you feel?". The variable "HADS total", originally a continuous variable summarizing the scores for anxiety and depression, was recoded into a dichotomous variable, using a cut-off value at 15 to distinguish between the presence or absence of disease. *Physical activity* was assessed with two questions: 1) "Average hours of low physical activity per week in the last year?" and 2) "Average hours of vigorous physical activity per week in the last year?". The answers from the two questions were combined into a new variable with four categories, considering both low and vigorous physical activity: 0 = no activity, 1 = low (less than three hours of light activity), 2 = medium (more than three hours of light activity, or less than one hour of hard activity), and 3 = high (any light activity, or more than one hour of hard activity). For all confounders, missing values were classified as a separate category. The proportion of missing values ranged from 0.6 % for BMI to 4.2 % for physical activity.

2.4: Statistical analyses

Baseline characteristics of the participants were explored through descriptive statistics, stratified by gender and presence/absence of chronic pain. Means and standard deviations were reported for continuous variables, whereas characteristics of categorical variables were reported as percentages. We used Cox regression analyses to obtain hazards ratios as estimates of relative risk (RR) with 95% confidence intervals (95% CIs). First, we estimated independent effects of chronic musculoskeletal pain, activity-interfering pain, physical workload, and work satisfaction on risk for disability pension, using no pain, sedentary work, and high work satisfaction as reference categories, respectively. Next, we estimated joint effects of pain and physical workload, and of pain and work satisfaction, using no pain and sedentary work, and no pain and high work satisfaction, as reference. To determine whether pain and reduced participation in leisure activities led to a further increase in risk, joint effects of activity-interfering pain and physical workload or work satisfaction were explored as well. After estimating the crude associations, all RRs were adjusted for possible confounders by age ("19-29 years", "30-39 years", "40-49 years", "50-59 years" or "60-65 years"), BMI ("underweight and normal weight", "overweight", "obesity" or "unknown"), education (“primary school”, “high school/vocational school/junior college”, “college/university” or “unknown”), HADS-score (“< 15”, “>15” or “unknown”), and physical activity (“no activity”, “low activity”, “medium activity”, “high activity” or “unknown”). All analyses were stratified by gender. We tested possible statistical interaction on a multiplicative scale, stratified by either physical workload or work satisfaction categories. Interaction tests were also done on an additive scale, and estimated as relative excess risk due to interaction (RERI). The RERI estimates with 95% confidence intervals were calculated from the following equation: $RERI = RR_{pain\_physwork} – RR_{pain} – RR_{physwork} + 1$ (Andersson et al., 2005). RERI > 0 indicates a synergistic effect between chronic pain and physical workload beyond additivity. The same approach was used to assess possible interaction between chronic pain and work satisfaction ($RR_{pain\_worksat}$). As sensitivity analysis, the main analyses were repeated after excluding the first two years of follow-up. This was done with the purpose of reducing the possibility for bias due to reverse causation from participants already in the process of receiving disability pension, as results from a previous Norwegian study have shown a mean rehabilitation time of two years before disability pension is granted (Støver et al., 2012). Furthermore, to explore whether pain localization could influence the risk estimates, site-specific analyses were done for three localizations where pain occurred frequently among participants (low back, neck, shoulder). The proportional hazards assumption was assessed by graphical procedures (log-log-plots). All statistical analyses were performed in SPSS for Windows, version 24.0.

2.5: Ethics

The study was approved by the Regional Committees for Medical and Health Research Ethics, and carried out in accordance with the Declaration of Helsinki. All participants gave their written informed consent.

3. Results

In this prospective study of 44 713 participants, 15.1 % (n = 6764) became recipients of disability pension during the mean follow-up time of 9.8 person-years. A somewhat larger percentage of females (17.3 %) than males (12.8 %) obtained such rights.

Table 1: Baseline characteristics of HUNT2 participants, stratified by gender and presence/absence of chronic musculoskeletal pain

	Males		Females	
Characteristic	Pain	No pain	Pain	No pain
Number of persons	8379	13168	10257	12909
Mean age, years (SD)	44.6 (10.8)	40.1 (11.7)	44.0 (11.0)	39.0 (11.8)
Physical workload, percent				
1. Sedentary work	26.7	31.8	22.6	24.9
2. Much walking	21.8	22.8	31.6	35.1
3. Heavy physical work	47.6	39.9	35.4	29.2
Work satisfaction, percent				
1. Enjoys work a great deal	19.0	23.5	25.1	28.6
2. Enjoys work a fair amount	49.7	44.5	46.4	41.2
3. Does not enjoy work	6.0	3.9	4.4	2.8
Mean BMI, kg/m^2 (SD)	26.6 (3.4)	26.2 (3.4)	26.2 (4.4)	25.3 (4.1)
Percent high education[a]	18.5	26.8	21.4	28.9
Percent high physical activity[b]	31.7	38.6	20.9	29.0
Percent HADS $\geq$ 15	13.3	5.9	15.0	6.0

SD = standard deviation, BMI = body mass index, HADS = Hospital Anxiety and Depression Scale
[a]High education defined as college/university level
[b]High physical activity defined as performing any light activity or more than one hour vigorous physical activity per week

Table 1 shows baseline characteristics of all included participants, stratified by gender and presence/absence of chronic musculoskeletal pain. A higher percentage of females (44.2 %) than males (38.9 %) reported chronic pain, and individuals with pain were on average 4-5 years older than those who were pain-free. The majority of those with pain reported to have heavy physical work, and to enjoy their work a fair amount. Few participants reported not to enjoy their work, although percentages were somewhat higher for those in pain. Additionally, individuals reporting chronic pain had slightly higher body mass index, were less educated, were less physically active, and had higher symptom-levels of anxiety and depression.

Table 2 shows the independent effects of chronic musculoskeletal pain, activity-interfering pain, physical workload and work satisfaction on risk for disability pension, stratified by gender. After adjustment for age, BMI, education, HADS-score and physical activity, individuals with chronic pain had approximately twice the risk of disability pension, compared to those who were pain-free (with RRs of 2.06 (95% CI 1.90-2.24) in men and 2.59 (95% CI 2.40-2.79) in women). For participants experiencing activity-interfering pain, the risk was further increased, and gender differences became more apparent (males: RR 2.63, 95% CI 2.41-2.88; females: RR 3.52, 95% CI 3.25-3.81). With sedentary work as reference, greater workloads seemed to increase the risk of disability pension in a moderate, dose-dependent manner. Heavy physical work was associated with RRs for disability pension of 1.32 (95% CI 1.19-1.47) for males and 1.31 (95% CI 1.19-1.44) for females. Compared to individuals reporting to enjoy their work “a great deal”, men who reported not to enjoy their work had a RR for disability pension of 1.46 (95% CI 1.22-1.75), whereas the corresponding RR for women was 1.35 (95% CI 1.14-1.60).

Table 3 shows the joint effects of chronic musculoskeletal pain and physical workload or work satisfaction on risk for disability pension, stratified by gender. Compared to their sedentary counterparts, pain-free individuals with heavy physical work had a RR of 1.25 (95% CI 1.06-1.48) in men and 1.27 (95% CI 1.06-1.51) in women. The presence of pain amplified the risk and accentuated gender differences: males with chronic pain and heavy physical work had a RR for disability pension of 2.60 (95% CI 2.24-3.02), whereas the corresponding RR for females was 3.37 (95% CI 2.88-3.95). When comparing pain-free males who reported to enjoy their work to those who did not enjoy it, the latter had a RR for disability pension of 1.72 (95% CI 1.26-2.34). For females, the corresponding RR was 1.38 (95% CI 0.96-1.97). The presence of pain strengthened the risk estimates: RRs and 95% CIs were 2.98 (2.34-3.79) for males and 3.29 (2.67-4.07) for females who reported chronic musculoskeletal pain and were unsatisfied with their work.

Table 2: Independent effects of chronic musculoskeletal pain, activity-interfering pain, physical workload, and work satisfaction on crude and adjusted risks for disability pension (DP), stratified by gender. Relative risks (RRs) and 95% confidence intervals (95% CIs).

Variable	Males				Females			
	n DP	n total	RR^{crude}	$RR^{adjusted}$* (95% CI)	n DP	n total	RR^{crude}	$RR^{adjusted}$* (95% CI)
Pain								
No	1033	13168	1.00	1.00 (ref.)	1159	12909	1.00	1.00 (ref.)
Yes	1721	8379	2.96	2.06 (1.90-2.24)	2851	10257	3.51	2.59 (2.40-2.79)
Activity-interfering pain								
No	1033	13168	1.00	1.00 (ref.)	1159	12909	1.00	1.00 (ref.)
Yes	1205	4753	3.78	2.63 (2.41-2.88)	2063	5832	4.74	3.52 (3.25-3.81)
Physical workload								
1. Sedentary work	625	6421	1.00	1.00 (ref.)	745	5533	1.00	1.0 (ref.)
2. Much walking	601	4825	1.30	1.20 (1.07-1.35)	1334	7774	1.35	1.16 (1.05-1.28)
3. Heavy physical work	1316	9237	1.48	1.32 (1.19-1.47)	1373	7392	1.49	1.31 (1.19-1.44)
Work satisfaction								
1. Enjoys work a great deal	482	4690	1.00	1.00 (ref.)	965	6266	1.00	1.00 (ref.)
2. Enjoys work a fair amount	1287	10026	1.30	1.08 (0.97-1.21)	1737	10075	1.18	1.00 (0.92-1.09)
3. Does not enjoy work	182	1011	1.88	1.46 (1.22-1.75)	186	820	1.60	1.35 (1.14-1.60)

*Adjusted for age ("19-29 years", "30-39 years", "40-49 years", "50-59 years" or "60-65 years"), BMI ("underweight and normal weight", "overweight", "obesity" or "unknown"), education ("primary school", "high school/vocational school/junior college", "college/university" or "unknown"), HADS-score ("< 15", ">15" or "unknown"), and physical activity ("no activity", "low activity", "medium activity", "high activity" or "unknown").

Table 3: Joint effects of chronic musculoskeletal pain and physical workload or work satisfaction on crude and adjusted risks for disability pension (DP), stratified by gender. Relative risks (RRs) and 95% confidence intervals (95% CIs).

Variable	Males				Females			
	n DP	n total	RR^{crude}	$RR^{adjusted}$* (95% CI)	n DP	n total	RR^{crude}	$RR^{adjusted}$* (95% CI)
Pain and physical workload								
1. No pain, sedentary work	256	4187	1.00	1.00 (ref.)	219	3213	1.00	1.00 (ref.)
2. No pain, much walking	245	2997	1.33	1.23 (1.02-1.48)	422	4536	1.51	1.26 (1.06-1.50)
3. No pain, heavy physical work	422	5251	1.30	1.25 (1.06-1.48)	334	3765	1.40	1.27 (1.06-1.51)
4. Pain, sedentary work	369	2234	2.89	2.14 (1.81-2.53)	526	2320	3.78	2.78 (2.35-3.30)
5. Pain, much walking	356	1828	3.54	2.51 (2.12-2.98)	912	3238	4.96	3.11 (2.65-3.66)
6. Pain, heavy physical work	894	3986	4.05	2.60 (2.24-3.02)	1039	3627	5.13	3.37 (2.88-3.95)
Pain and work satisfaction								
1. No pain, enjoys work a great deal	189	3098	1.00	1.00 (ref.)	288	3690	1.00	1.00 (ref.)
2. No pain, enjoys work a fair amount	437	5863	1.25	1.09 (0.91-1.30)	479	5319	1.19	1.06 (0.91-1.23)
3. No pain, does not enjoy work	59	508	1.93	1.72 (1.26-2.34)	37	365	1.30	1.38 (0.96-1.97)
4. Pain, enjoys work a great deal	293	1592	3.31	2.32 (1.92-2.80)	677	2576	3.69	2.80 (2.42-3.24)
5. Pain, enjoys work a fair amount	850	4163	3.80	2.35 (1.99-2.77)	1258	4756	3.89	2.55 (2.23-2.92)
6. Pain, does not enjoy work	123	503	4.75	2.98 (2.34-3.79)	149	455	5.09	3.29 (2.67-4.07)

*Adjusted for age ("19-29 years", "30-39 years", "40-49 years", "50-59 years" or "60-65 years"), BMI ("underweight and normal weight", "overweight", "obesity" or "unknown"), education ("primary school", "high school/vocational school/junior college", "college/university" or "unknown"), HADS-score ("< 15", ">15" or "unknown"), and physical activity ("no activity", "low activity", "medium activity", "high activity" or "unknown").

Tests of statistical interaction (i.e., deviation from multiplicativity) between musculoskeletal pain and physical workload resulted in p-values of 0.41 for men and 0.65 for women, whereas the p-values for the interaction between musculoskeletal pain and work satisfaction were 0.12 for men and 0.42 for women. Similarly, there were no evidence of a synergistic effect beyond additivity. For the interaction between pain and physical workload, the estimates showed a small additive effect, although not statistically significant: RERI estimates and 95% CIs were 0.21 (-0.12-0.54) for males and 0.31 (-0.07-0.69) for females. For the interaction between pain and work satisfaction, RERI estimates and 95% CIs were -0.04 (-0.87-0.78) for males and 0.04 (-0.72-0.79) for females.

The same analysis as the one shown in table 3 was also done for the joint effects of activity-interfering pain and physical workload or work satisfaction on risk for disability pension (see table 4 in appendix). Although these analyses gave somewhat stronger RRs, the results remained largely similar as in the main analyses. Compared to their sedentary counterparts, pain-free individuals with heavy physical work had RRs for disability pension of 1.25 (95% CI 1.06-1.48) in men and 1.28 (95% CI 1.07-1.53) in women. Those experiencing pain had further increased risk: RRs and 95% CIs for males and females with activity-interfering pain and heavy physical work were 3.26 (2.79-3.82) and 4.65 (3.95-5.48), respectively. Similar tendencies were found for the combination of activity-interfering pain and work satisfaction as well: pain-free males who reported not to enjoy their work had higher risk of disability pension than those who enjoyed it (RR 1.71, 95% CI 1.25-2.33), whereas the corresponding RR for females was 1.40 (95% CI 0.98-2.00). The presence of pain strengthened the risk estimates: RRs and 95% CIs were 3.20 (2.46-4.17) for males and 4.07 (3.23-5.12) for females who reported activity-interfering pain and were unsatisfied with their work.

The sensitivity analysis was conducted by repeating similar procedures as the ones shown in table 2 and 3. They were done on a slightly smaller selection (n = 42 121), as participants with shorter follow-up than two person-years were excluded with the purpose of reducing the possibility for bias due to reverse causation. Risk estimates were somewhat attenuated, although showing the same trends as the main analyses. For further details, see table 5 and 6 in appendix.

The site-specific analyses revealed increased risk of disability pension among participants experiencing chronic pain in low back, neck or shoulder, compared to pain-free individuals. After adjusting for possible confounders, neck pain entailed the highest risk for males, with a relative risk of 2.59 (95% CI 2.36-2.84). For females, low back pain led to the largest risk estimate (RR 3.15, 95% CI 2.90-3.42). These associations are somewhat stronger than those found for overall pain. Further details can be explored in table 7 in appendix.

4. Discussion

4.1: Main findings

The aim of this study was to examine the independent effects of chronic musculoskeletal pain, physical workload and work satisfaction on risk for disability pension, as well as the possible modifying role of physical workload and work satisfaction on the relation between musculoskeletal pain and disability pension. The main results show that chronic musculoskeletal pain was strongly associated with increased risk of disability pension. More severe pain, as indicated by activity-interfering pain, increased the risk of disability pension even further. The independent effects of physical workload and work satisfaction on disability risk were modest. However, when combined with musculoskeletal pain, heavy physical work and low work satisfaction led to stronger risk estimates than for chronic pain alone. Nevertheless, there were no statistically significant interaction between these factors.

4.2: Comparison with previous findings

When comparing the prevalence of chronic pain and incident disability pension in the current study population to previous findings, it may seem as participants in the current study are more frequently affected by pain. In a prospective study from Finland, 28 % of the participants reported pain lasting longer than three months, while 42 % in our study had chronic pain due to the same criterion. Additionally, 9.8 % of females and 8.4 % of males received disability pension during follow-up in the Finnish study, whereas the corresponding percentages in our study were 17.3 % and 12.8 %, respectively (Saastamoinen et al., 2012). Explaining such differences is complex, but selection of study participants might provide at least part of the answer. While the Finnish study was carried out among workers in the City of Helsinki, with 24 % reporting heavy physical work, our study was done among workers residing in a Norwegian county without major cities, where about 38 % reported heavy physical work. Despite such demographic and occupational differences, risk estimates in the Finnish study turned out to be quite similar to ours for the association between chronic pain and all-cause disability pension. Unlike our study, the Finnish researchers were able to assess the association between chronic pain and disability pension due to musculoskeletal diseases, which resulted in a stronger risk estimate. For future studies, it may thus be advisable to explore both all-cause and disease-specific disability pension, in order to obtain precise risk assessments.

Strong associations between musculoskeletal pain and disability pension were also found in two prospective studies using chronic widespread pain and multisite pain as dependent variables. Chronic widespread pain was defined as pain lasting for at least three consecutive months, originating from the trunk, upper limbs and lower limbs simultaneously (Øverland et al., 2012). Among middle-aged workers residing in the county of Hordaland, Norway, a multi-adjusted hazard ratio of 2.44 was found for all-cause disability pension. Similarly, multi-adjusted hazard ratios for the association between multisite pain (defined as pain in 0-4 sites during the preceding month) and all-cause disability pension among Finnish workers ranged from 1.26 for one site to 2.53 for four sites (Haukka et al., 2015). Although it has been suggested that widespread/multisite pain may predict risk of disability pension better than single-site pain, the risk estimates from these two studies were on the same level as those found for low back, neck and shoulder pain in the current study. Unlike our study, however, these studies were able to obtain proper adjustment for comorbidity, such as musculoskeletal, cardiovascular or gastrointestinal diseases. As some residual confounding may be present in the current study due to unmeasured or unknown factors, risk estimates should be interpreted with caution.

The independent effects of physical workload on disability risk were modest in our study; heavy physical work increased the risk of disability pension by approximately 30 % for both genders. These are somewhat weaker associations than found in some previous studies. A prospective study from Denmark reported hazard ratios of 1.56 for males and 1.90 for females with physically demanding work (Labriola et al., 2009b), while a Finnish study reported 70 % higher risk of disability pension for both men and women exposed to heavy physical work (Lahelma et al., 2012). There is reason to assume, however, that these estimates would have been attenuated with more extended control for possible confounders; while the Danish study had self-reported BMI, smoking status and influence on decision-making as covariates, the Finnish researchers only adjusted for working conditions and occupational class. This assumption is supported by the findings from a well-conducted prospective study among Finnish twins (Karkkainen et al., 2013). After adjusting for a number of possible confounders (age, gender, BMI, education, socioeconomic and marital status), as well as familial effects (by including only discordant twin pairs), the risk of disability pension due to musculoskeletal disorders was increased by 40 % among people with heavy physical work. The authors also found other work-related factors to be associated with disability pension, including much lifting and carrying at work. In our study, we chose to merge these two categories, as few participants would describe their work as heavy. This is in line with recommendations from certain epidemiology experts: *"the key issue to addressing the scientific goal is (...) including sufficient numbers of subjects across a range of the variable that modifies the association"* (Rothman et al., 2014). Although it is possible that such methodological approaches may slightly influence the estimated associations, it is a small price to pay compared to the alternative, jeopardizing scientific generalization because of the uneven distribution of participants (Rothman et al., 2013).

Few studies have been conducted on the association between work satisfaction and disability pension in general working populations. A prospective study from Denmark used a similar question as ours ("Are you satisfied with your work?"), but dichotomized into categories of "high" and "low" satisfaction (Labriola et al., 2009a). They found approximately similar associations between work satisfaction and disability pension as the current study. Other studies have chosen variables such as job demands, job control and social support to investigate the association between psychosocial exposures and disability pension (Karasek, 1979, Sarason et al., 1987). A well-conducted prospective study from Denmark found no association for job strain (high job demands + low job control) and twice the risk for lack of social support. When combined with musculoskeletal pain, risk estimates became stronger, particularly if pain occurred in the upper and lower body simultaneously (Sommer et al., 2016). This corresponds well with our findings. However, risk estimates for the joint effect analyses in both the Danish study and our study should be interpreted with caution, since few participants in some of the categories could have resulted in chance findings.

Few studies have attempted to assess possible statistical interaction between musculoskeletal pain and work-related factors. A prospective study from Finland aimed to examine whether the relationship between musculoskeletal pain and sickness absence was modified by the level of physical or psychosocial workloads (Neupane et al., 2015). Physical workload was defined as having history of strenuous work or a number of current physical workload factors. Psychosocial workload was assessed through three variables: job demands, job control, and supervisor/coworker support. The p-values obtained through multiplicative interaction tests ranged from 0.18 for pain and job control to 0.87 for pain and history of strenuous work. Consequently, all values indicated no statistically significant interaction between independent variables. The authors speculated that the reasons for not being able to identify work-related modifiers could be the assessment methods of pain and work exposures, or the outcome measure (number of sickness absence periods ≥ 10 workdays). Others have suggested that the role of physical workload in relation to disability pension may be larger than what their estimates indicated (Sommer et al., 2016). Such explanations, in addition to the strong and independent effect of musculoskeletal pain, may hold true for our findings as well. Continued investigation of possible statistical interaction is important, as public health policies rely on information about factors that can promote health or prevent disease in the population.

4.3: Strengths and limitations

The strengths of the current study are the prospective design, the large and relatively unselected cohort, the mean follow-up of nearly 10 years, and the opportunity to adjust for a number of possible confounders. Linkage to national registries ensured complete follow-up of participants concerning disability pension, as well as other events that led to censoring of person-years. To assess possible bias due to reverse causation, i.e. that being in the process of receiving disability pension could influence the reporting of pain and work-related factors, we excluded the first two years of follow-up. Although the results remained largely similar to the main analyses, a slight attenuation may suggest that reverse causation could have a minor influence on the overall results. Possible statistical interaction was tested in two different ways, which may have provided us with more reliable information than if only one of them had been completed. Additionally, it has been suggested that additive interaction is of higher biological relevance than previous methods (Andersson et al., 2005).

About 70 % of those who were invited to the HUNT2 study chose to participate. This participation rate is relatively high compared to previous studies (Saastamoinen et al., 2012, Øverland et al., 2012); however, it allows for the presence of some selection bias. Non-participation analyses revealed that the participation was lowest in the youngest age group

(20-29 years), particularly among men (Holmen et al., 2003). The most common reasons they gave for not attending the survey were being too busy or having moved out of the county. Few reported being too sick/immobilized to attend, which reduces the likelihood of non-participants experiencing more musculoskeletal pain than those who participated. In general, people who choose to participate in health surveys are assumed to be more health conscious than those who do not (Rothman, 2012b). However, the necessity of representativeness in order to make valid risk assessments has been debated thoroughly by epidemiologists over the last years (Rothman et al., 2013, Stang and Jockel, 2014, Rothman et al., 2014).

Self-reported information obtained through questionnaires is known to introduce the possibility of misclassification, which complicates the interpretation of results (Rothman, 2012a). Since pain is mainly a subjective experience (Coghill, 2010), it is difficult to determine whether people are misclassified on the initial pain variable. Other variables could more easily have become subject to misclassification; for instance, one could imagine the possibility that participants with musculoskeletal pain are more likely to report heavy physical work than those who are pain-free. Exhaustion is common for prolonged pain conditions (Grossi et al., 2009), and may reduce the relative working capacity of individuals, or cause them to perceive their work as heavier than it actually is. Another example is self-reported physical activity, which is known to be less accurate than more objective measures, such as accelerometers (Ainsworth et al., 2015). The validity of the two questions on leisure-time physical activity in the HUNT2 questionnaire was examined in a sub-sample of men aged 20-39 years; the “vigorous activity” question had acceptable validity, whereas the correlations between the “low activity” question and objective measures were weaker (Kurtze et al., 2007). Such phenomena are difficult to account for in the data analysis; therefore, risk estimates need to interpreted with caution.

At baseline, participants were asked about musculoskeletal pain, physical workload, work satisfaction and other covariates. Information on these variables was not re-collected during the 10-year follow-up, meaning that potential changes over time cannot be accounted for. However, two prospective studies investigating pain stability with repeated measurements found that pain characteristics remained relatively stable during 6 and 14 years of follow-up, respectively (Ropponen et al., 2013, Kamaleri et al., 2009). Further research is needed to determine whether the same applies for work-related factors, especially as the working life has become more dynamic over the recent decades (Heerwagen et al., 2016). The HUNT2 questionnaires did not ask about pain intensity, a factor shown to have prognostic value for musculoskeletal pain in primary care (Mallen et al., 2007). Instead, we created the activity-interfering pain variable, and used it to indicate pain severity. Given the statistically increased risk of disability pension when being exposed to this pain characteristic, one can assume that it is serving its purpose as an indicator of pain severity throughout the study. We excluded participants who had missing data on the initial pain variable; missing values on other covariates were explored, although considered being too small to initiate statistical procedures such as multiple imputations. This may have led to some residual confounding.

4.4: Conclusion

Chronic musculoskeletal pain was positively associated with risk of disability pension, and those who had restricted their leisure activities because of pain were at particularly high risk. Heavy physical work and low work satisfaction was moderately associated with risk of disability pension. In combination with chronic musculoskeletal pain, these factors amplified the risk of disability pension. However, there was no clear effect modification resulting in synergistic effects of these factors on disability pension risk. Nevertheless, the results from this study suggest that particular attention should be given to workers with chronic musculoskeletal pain who are exposed to high physical work demands, or have low work satisfaction, in order to prevent early work disability.

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6. Appendix

Table 4: Joint effects of activity-interfering pain (AIP) and physical workload or work satisfaction on crude and adjusted risks for disability pension (DP), stratified by gender. Relative risks (RRs) and 95% confidence intervals (95% CIs).

	Males				Females			
Variable	n DP	n total	RR^{crude}	$RR^{adjusted}$* (95% CI)	n DP	n total	RR^{crude}	$RR^{adjusted}$* (95% CI)
Activity-interfering pain & physical workload								
1. No AIP, sedentary work	256	4187	1.00	1.00 (ref.)	219	3213	1.00	1.00 (ref.)
2. No AIP, much walking	245	2997	1.33	1.22 (1.01-1.47)	422	4536	1.51	1.26 (1.06-1.50)
3. No AIP, heavy physical work	422	5251	1.30	1.25 (1.06-1.48)	334	3765	1.40	1.28 (1.07-1.53)
4. AIP, sedentary work	259	1234	3.74	2.78 (2.32-3.34)	396	1340	5.22	3.81 (3.18-4.55)
5. AIP, much walking	255	1068	4.47	3.21 (2.67-3.85)	627	1777	6.64	4.26 (3.60-5.03)
6. AIP, heavy physical work	618	2245	5.17	3.26 (2.79-3.82)	761	2079	6.90	4.65 (3.95-5.48)
Activity-interfering pain & work satisfaction								
1. No AIP, enjoys work a great deal	189	3098	1.00	1.00 (ref.)	288	3690	1.00	1.00 (ref.)
2. No AIP, enjoys work a fair amount	437	5863	1.25	1.09 (0.91-1.30)	479	5319	1.19	1.06 (0.91-1.23)
3. No AIP does not enjoy work	59	508	1.93	1.71 (1.25-2.33)	37	365	1.30	1.40 (0.98-2.00)
4. AIP, enjoys work a great deal	216	851	4.79	3.25 (2.65-3.99)	492	1439	5.08	3.95 (3.39-4.61)
5. AIP, enjoys work a fair amount	577	2348	4.66	2.95 (2.48-3.51)	895	2649	5.25	3.53 (3.07-4.07)
6. AIP, does not enjoy work	94	346	5.42	3.20 (2.46-4.17)	116	290	6.66	4.07 (3.23-5.12)

*Adjusted for age (“19-29 years”, “30-39 years”, “40-49 years”, “50-59 years” or “60-65 years”), BMI (“underweight and normal weight”, “overweight”, “obesity” or “unknown”), education (“primary school”, “high school/vocational school/junior college”, “college/university” or “unknown”), HADS-score (“< 15”, “>15” or “unknown”), and physical activity (“no activity”, “low activity”, “medium activity”, “high activity” or “unknown”).

Table 5: Sensitivity analysis, only including individuals with ≥ 2 person-years of follow-up. Independent effects of chronic musculoskeletal pain, activity-interfering pain, physical workload, and work satisfaction on crude and adjusted risks for disability pension (DP), stratified by gender. Relative risks (RRs) and 95% confidence intervals (95% CIs).

	Males				Females			
Variable	n DP	n total	RR^{crude}	$RR^{adjusted}$* (95% CI)	n DP	n total	RR^{crude}	$RR^{adjusted}$* (95% CI)
Pain								
No	846	12658	1.00	1.00 (ref.)	951	12419	1.00	1.00 (ref.)
Yes	1307	7769	2.73	1.93 (1.77-2.11)	2064	9275	3.25	2.43 (2.24-2.62)
Activity interfering pain								
No	846	12658	1.00	1.00 (ref.)	951	12419	1.00	1.00 (ref.)
Yes	868	4312	3.34	2.39 (2.17-2.63)	1439	5103	4.29	3.25 (2.99-3.54)
Physical workload								
1. Sedentary work	505	6112	1.00	1.00 (ref.)	557	5233	1.00	1.00 (ref.)
2. Much walking	474	4557	1.28	1.19 (1.05-1.36)	1055	7326	1.40	1.21 (1.09-1-34)
3. Heavy physical work	1061	8829	1.45	1.31 (1.17-1.47)	1126	7026	1.53	1.36 (1.22-1.50)
Work satisfaction								
1. Enjoys work a great deal	394	4500	1.00	1.00 (ref.)	751	5963	1.00	1.00 (ref.)
2. Enjoys work a fair amount	1048	9578	1.28	1.08 (0.96-1.21)	1387	9545	1.19	1.03 (0.94-1.12)
3. Does not enjoy work	137	948	1.76	1.40 (1.15-1.72)	145	761	1.57	1.36 (1.13-1.62)

*Adjusted for age (“19-29 years”, “30-39 years”, “40-49 years”, “50-59 years” or “60-65 years”), BMI (“underweight and normal weight”, “overweight”, “obesity” or “unknown”), education (“primary school”, “high school/vocational school/junior college”, “college/university” or “unknown”), HADS-score (“< 15”, “>15” or “unknown”), and physical activity (“no activity”, “low activity”, “medium activity”, “high activity” or “unknown”).

Table 6: Sensitivity analysis, only including individuals with ≥ 2 person-years of follow-up. Joint effects of chronic musculoskeletal pain and physical workload or work satisfaction on crude and adjusted risks for disability pension (DP), stratified by gender. Relative risks (RRs) and 95% confidence intervals (95% CIs).

	Males				Females			
Variable	n DP	n total	RR^{crude}	$RR^{adjusted}$* (95% CI)	n DP	n total	RR^{crude}	$RR^{adjusted}$* (95% CI)
Pain and physical workload								
1. No pain, sedentary work	217	4017	1.00	1.00 (ref.)	174	3100	1.00	1.00 (ref.)
2. No pain, much walking	207	2882	1.35	1.25 (1.03-1.52)	373	4390	1.55	1.31 (1.09-1.56)
3. No pain, heavy physical work	366	5108	1.29	1.26 (1.06-1.50)	295	3661	1.43	1.29 (1.07-1.56)
4. Pain, sedentary work	288	2095	2.71	2.03 (1.70-2.42)	383	2133	3.51	2.60 (2.17-3.12)
5. Pain, much walking	267	1675	3.21	2.32 (1.94-2.78)	682	2936	4.75	3.04 (2.57-3.59)
6. Pain, heavy physical work	695	3721	3.72	2.46 (2.10-2.88)	831	3365	4.95	3.30 (2.79-3.89)
Pain and work satisfaction								
1. No pain, enjoys work a great deal	164	3006	1.00	1.00 (ref.)	246	3600	1.00	1.00 (ref.)
2. No pain, enjoys work a fair amount	383	5691	1.26	1.10 (0.92-1.33)	421	5164	1.22	1.09 (0.93-1.27)
3. No pain, does not enjoy work	45	485	1.78	1.62 (1.16-2.27)	30	348	1.25	1.31 (0.90-1.92)
4. Pain, enjoys work a great deal	230	1494	3.06	2.21 (1.81-2.71)	505	2363	3.46	2.64 (2.26-3.07)
5. Pain, enjoys work a fair amount	665	3887	3.46	2.19 (1.84-2.61)	966	4381	3.68	2.46 (2.13-2.83)
6. Pain, does not enjoy work	92	463	4.15	2.67 (2.05-3.47)	115	413	4.74	3.14 (2.50-3.94)

*Adjusted for age ("19-29 years", "30-39 years", "40-49 years", "50-59 years" or "60-65 years"), BMI ("underweight and normal weight", "overweight", "obesity" or "unknown"), education ("primary school", "high school/vocational school/junior college", "college/university" or "unknown"), HADS-score ("< 15", ">15" or "unknown"), and physical activity ("no activity", "low activity", "medium activity", "high activity" or "unknown").

Table 7: Effects of localized pain (low back, neck, shoulder) on crude and adjusted risks for disability pension (DP). Relative risks (RRs) and 95% confidence intervals (95% CIs).

Variable	Males				Females			
	n DP	n total	RR^{crude}	$RR^{adjusted}$* (95% CI)	n DP	n total	RR^{crude}	$RR^{adjusted}$* (95% CI)
Low back pain								
no	1018	13053	1.00	1.00 (ref.)	1144	12852	1.00	1.00 (ref.)
yes	1007	4181	3.57	2.44 (2.23-2.68)	1701	5229	4.31	3.15 (2.90-3.42)
Neck pain								
no	1021	13095	1.00	1.00 (ref.)	1143	12850	1.00	1.00 (ref.)
yes	1055	3965	4.03	2.59 (2.36-2.84)	1943	6135	4.18	3.02 (2.79-3.27)
Shoulder pain								
no	1018	13091	1.00	1.00 (ref.)	1142	12843	1.00	1.00 (ref.)
yes	1159	4613	3.81	2.33 (2.12-2.55)	2030	6607	4.01	2.82 (2.61-3.06)

*Adjusted for age (“19-29 years”, “30-39 years”, “40-49 years”, “50-59 years” or “60-65 years”), BMI (“underweight and normal weight”, “overweight”, “obesity” or “unknown”), education (“primary school”, “high school/vocational school/junior college”, “college/university” or “unknown”), HADS-score (“< 15”, “>15” or “unknown”), and physical activity (“no activity”, “low activity”, “medium activity”, “high activity” or “unknown”).