SUBAS NEUPANE

Multi-site Musculoskeletal Pain among Industrial Workers

Occurrence, determinants and consequences for work ability and sickness absence

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ACADEMIC DISSERTATION
To be presented, with the permission of
the board of the School of Health Sciences
of the University of Tampere,
for public discussion in the Auditorium of
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IV

Neupane S, Virtanen P, Leino-Arjas P, Miranda H, Siukola A, Nygård C-H.

Multi-site musculoskeletal pain and sickness absence at work due to musculoskeletal diagnosis among white-collar and blue-collar employees.

(Submitted)

Abbreviations

ACR	American College of Rheumatology
AIDS	Acquired Immune Deficiency Syndrome
AMA	American Medical Association
BMI	Body Mass Index
CI	Confidence Interval
CWP	Chronic Widespread Pain
EU	European Union
GDP	Gross Domestic Product
GEE	Generalized Estimating Equation
GLM	Generalized Linear Model
IASP	International Association for the Study of Pain
ICD	International Classification of Diseases
IRR	Incidence Rate Ratio
JCQ	Job Content Questionnaire
LBP	Low Back Pain
LTSA	Long Term Sickness Absence
MSD	Musculoskeletal Diagnosis
MSP	Multi-site Musculoskeletal Pain
OECD	Organization for Economic Cooperation and Development
OR	Odds Ratio
PRR	Prevalence Rate Ratio
RR	Rate Ratio
SPSS	Statistical Package for Social Sciences
VDU	Visual Display Unit
WAI	Work Ability Index
WHO	World Health Organization
WMSDs	Work related Musculoskeletal Disorders

Abstract

Musculoskeletal pain at multiple body sites is very common among working-age people and has been strongly linked to severe work disability. Little is known of the work-related physical and psychosocial factors contributing to multi-site pain and the consequences of multi-site pain among the industrial population. The overall aim of this study was to evaluate the occurrence of multi-site musculoskeletal pain, its determinants and consequences for work ability and sickness absences among food industry employees.

A questionnaire survey (Studies I–III) was conducted among the entire personal of one of the leading food processing companies in Finland in spring 2005 (N = 1201) and spring 2009 (N = 1398). A total of 734 employees were followed from 2005 to 2009. Sickness absence data (Study IV) for this study was based on the companies' sickness absence register. The information on age, gender and causes of sickness absence of all those employed in 2005–2008 was obtained through the personnel register. Information on multi-site musculoskeletal pain (pain in at least two anatomical areas out of four), physical and psychosocial work exposures, information on self-assessed work ability (current work ability on a scale from 0 to 10; ≤ 7 = poor work ability), leisure-time physical activity, body mass index, and physical and psychosocial exposures was elicited by questionnaire. The risk of multi-site pain related to the single and combined effects of work exposures and the separate and combined effects of multi-site pain and work exposures on work ability at follow-up among subjects with good work ability at baseline were assessed by logistic regression. Generalized Linear Models (GLM) with negative binomial distribution assumption was used to determine associations between the occurrence of multi-site pain (0–4 pain sites) and long-term sickness absence (≥ 4 days) due to any medical reason and sickness absence spells and days due to any musculoskeletal diagnosis (MSD).

The mean age of the employees was 40.95 years, ranging from 20–66 years. Of the employees who participated in the follow-up study, 65% were female and 71% were involved in blue-collar occupations. About 40% had sickness absence spells (≥ 4 days) at least once due to MSD. At baseline, 56% had pain at more than one site, and 50% at 4-year follow-up. Forty percent of all employees had multi-site pain throughout follow-up. Among those with multi-site pain at baseline, 69% had multi-site pain at follow-up. Physical factors including biomechanical factors at baseline increased the risk of multi-site pain at follow-up by more than 4-folds. Psychosocial factors (low job satisfaction, poor team spirit and poor opportunities to exert influence at work) also strongly predicted multi-site pain at follow-up. Multi-site pain at baseline increased the risk of poor work ability at follow-up, allowing for age, gender, occupational class, body mass index and leisure-time physical activity. The separate effects of the work exposures on work ability were somewhat smaller than those of multi-site pain. Multi-site pain had an interactive effect with work environment and awkward postures, such that no association of multi-site pain with poor work ability was seen when work environment was poor or awkward postures present. Multi-site pain was associated with long-term sickness absence spells and days due to MSD. The associations of MSP with long-term sickness absence spells and days due to MSD were found to be strong among both blue-collar and white-collar employees. However, a threshold in the rate ratios was found between two-site and three-site pain, whereas in blue-collar employees the threshold was rather between one-site and two-site pain.

Musculoskeletal pain at multiple sites is a common and persistent phenomenon among industrial workers. Physical and psychosocial factors contribute significantly to multi-site pain. The decline in work ability connected with multi-site pain was not modified by biomechanical or psychosocial exposure at work. Multi-site pain also strongly predicted long-term sickness absence spells and days due to musculoskeletal diagnosis among both white- and blue-collar employees. The occurrence and the impact of multi-site musculoskeletal pain suggest that the prevention of severe occupational outcomes for this group must have a wide focus. Counting the number of concurrent pain sites can serve as a simple method to screen for workers with high risk of work disability in e.g., occupational health care.

Key words: multiple sites; widespread pain; musculoskeletal disorders; work disability; musculoskeletal diagnosis

Tiivistelmä

Useammalla kuin yhdellä anatomisella alueella esiintyvä tuki- ja liikuntaelinkipu on hyvin yleistä työikäisessä väestössä, ja kipualueiden määrän ja työkyvyttömyyden välillä on selvä yhteys. Monipaikkaiseen kipuun vaikuttavia työperäisiä fyysisiä ja psykososiaalisia tekijöitä sekä kivun vaikutusta teollisuustyöntekijöihin on kuitenkin tutkittu varsin vähän. Tämän tutkimuksen tarkoituksena on arvioida monipaikkaisen tuki- ja liikuntaelinkivun yleisyyttä, siihen vaikuttavia tekijöitä sekä kivun vaikutuksia työkykyyn ja sairauspoissaolojen määrään elintarviketeollisuuden työntekijöiden keskuudessa.

Kyselytutkimus (Artikkelit I–III) tehtiin kaikille suuren suomalaisen elintarvike-yrityksen työntekijöille keväällä 2005 (N = 1201) ja keväällä 2009 (N = 1398). Kaikkiaan 734 työntekijää seurattiin vuodesta 2005 vuoteen 2009. Sairauspoissaolo-tiedot (Artikkeli IV) koottiin yrityksen sairauspoissaolorekisteristä, ja henkilö-tietorekisteristä koottiin lisäksi tiedot kaikkien työntekijöiden iästä, sukupuolesta ja sairauspoissaoloihin johtaneista diagnooseista vuosilta 2005–2008. Kyselyllä kerättiin tietoa monipaikkaisesta tuki- ja liikuntaelinkivusta (kipua esiintyi ainakin kahdella neljästä kehon alueesta), työperäisistä fyysisistä ja psykososiaalisista riskitekijöistä, muista fyysisistä ja psykososiaalisista riskitekijöistä, vapaa-ajan fyysisestä aktiivi-suudesta ja painoindeksistä. Lisäksi työntekijät arvioivat kyselyssä senhetkistä työ-kykyään asteikolla 0–10, jossa ≤ 7 = heikko työkyky. Tutkimuksessa arvioitiin toisaalta työperäisiin riskitekijöihin liittyvää monipaikkaisen kivun riskiä, toisaalta monipaikkaiseen kipuun ja työperäisille riskitekijöille altistumiseeen liittyvää huonontuneen työkykyvyn riskiä niillä työntekijöillä, joiden työkyky oli hyvä vuonna 2005. Arvioinnissa käytettiin logistista regressioanalyysiä. Monipaikkaisen kivun (0–4 kipualuetta) sekä mistä tahansa syystä aiheutuneiden pitkien sairauspoissaolojen (≥ 4 päivää) ja tuki- ja liikuntaelinsairauksista johtuneiden sairauspoissaolojen välisten yhteyksien määrittelemiseen käytettiin yleistettyä lineaarista mallia negatiivisella binomijakaumaoletuksella.

Työntekijöiden keski-ikä oli 40,95 vuotta ja ikähaarukka 20–66 vuotta. Vuoden 2009 tutkimukseen osallistuneista työntekijöistä 65% oli naisia ja 71% teollisuus-työntekijöitä. Noin 40% oli ollut seuranta-aikana sairauslomalla (≥ 4 päivää) ainakin kerran tuki- ja liikuntaelinsairauden takia. Vuoden 2005 tutkimuksessa 56%:lla ja vuoden 2009 tutkimuksessa 50%:lla työtekijöistä oli kipua useammassa kuin yhdessä paikassa; kaikista työntekijöistä 40% koki kipua useassa paikassa koko seurantajakson ajan. Monipaikkaisesta kivusta vuoden 2005 tutkimuksessa raportoineista työntekijöistä 69% raportoi monipaikkaisesta kivusta myös vuoden 2009 tutkimuksessa. Jos työntekijä altistui vuoden 2005 tutkimuksessa fyysisille riskitekijöille, esim. biomekaanisille riskitekijöille, monipaikkaisen kivun todennäköisyys oli nelinkertainen vuoden 2009 tutkimuksessa. Myös psykososiaalisille riskitekijöille (tyytymättömyys työhön, huono yhteishenki ja heikot mahdollisuudet vaikuttaa työhön) altistuminen ennakoi selvästi monipaikkaista kipua jatkotutkimuksessa. Monipaikkainen kipu ensimmäisessä tutkimuksessa myös nosti heikentyneen työkyvyn todennäköisyyttä jatkotutkimuksessa riippumatta työntekijän iästä, sukupuolesta, ammattiluokasta, painoindeksistä ja vapaa-ajan fyysisestä aktiivisuudesta. Työperäisten riskitekijöiden erillisvaikutukset työkykyyn olivat kuitenkin hieman vähäisemmät kuin monipaikkaisen kivun. Monipaikkaisen kivun ja työympäristön ja työasentojen välillä oli yhdysvaikutus, siten että kipu ei liittynyt heikentyneeseen työkykyyn, jos työympäristö tai työskentelyasennot olivat huonot. Monipaikkaisella kivulla huomattiin myös olevan yhteys tuki- ja liikuntaelinsairauksista johtuviin sairauspoissaoloihin niin teollisuustyöntekijöillä kuin toimihenkilöilläkin. Toimihenkilöillä poissaolot aiheutuivat kuitenkin yleensä kahden tai kolmen alueen kivuista, kun työntekijöillä poissaoloon johti yhden tai kahden alueen kipu.

Monipaikkainen tuki- ja liikuntaelinkipu on yleistä varsinkin teollisuustyöntekijöillä, ja fyysiset ja psykososiaaliset riskitekijät vaikuttavat kivun määrään selvästi. Biomekaanisille tai psykososiaalisille riskitekijöille altistuminen töissä ei kuitenkaan heikentänyt monipaikkaisen kivun alentamaa työkykyä. Monipaikkainen kipu lisää selvästi niin pitkien sairauslomien kuin tuki- ja liikuntaelinsairauksista johtuvien sairauspoissaolojen todennäköisyyttä sekä teollisuustyöntekijöillä että toimihenkilöillä. Monipaikkaisen kivun taustalla olevat monet riskitekijät tulee ottaa huomioon, kun pyritään ehkäisemään siitä aiheutuvia vakavia seurauksia. Työterveyshuollossa kipupisteiden määrän laskeminen voi toimia yksinkertaisena toimenpiteenä, jonka avulla voidaan tunnistaa suurentuneen työkyvyttömyysriskin työntekijät.

Avainsanat: Monipaikkainen kipu, tuki- ja liikuntaelinsairaudet, työkyky, sairauspoissaolo, psykososiaaliset työolot, fyysiset työolot

1. INTRODUCTION

Musculoskeletal diseases are extremely common and have important implications for the individual, employers and society at large. This is a heterogeneous group of diseases and conditions in the musculoskeletal system (i.e. in the tendons, muscles, nerves, bones, or other supporting structures of the body) that results in pain and functional impairment. The term musculoskeletal pain is defined as an unpleasant sensory and emotional experience that occurs with or without the presence of actual or potential tissue damage in the musculoskeletal system. Musculoskeletal pain is common in general populations in industrialized countries (Buckle and Devereux, 2002; Walker-Bone et al. 2004; Haldeman et al. 2010) and is one of the most common causes for long-term sick leave (Hansson and Jensen 2004; Waddell, 2006) among employees. Musculoskeletal diseases are also the single largest category of work-related illness, representing more than a third of all registered occupational diseases (Pope et al. 1991). In Finland, one fifth of visits to primary care physicians are due to musculoskeletal pain (Mäntyselkä et al. 2001; Rekola et al. 1993).

Risk factors for musculoskeletal pain are multifactorial and include physical and psychosocial factors at work and also cultural and personal factors, and this complex model needs to be understood in order to modify the risks. The role of these physical and psychosocial risk factors in musculoskeletal pain has been extensively studied. However, most of the studies on musculoskeletal pain have focused primarily on localized pain areas such as the low back or neck and shoulder. Having pain in one part of the body is evidently associated with the likelihood of having pain in another body area (Croft et al. 2007). Consequently many people with musculoskeletal pain report pain at more than one site (Adamson et al. 2007; Carnes et al. 2007; Kamaleri et al. 2008a). Recent epidemiological studies (Kamaleri et al. 2008a; Miranda et al. 2010) among the general population and working population (Haukka et al. 2006; Solidaki et al. 2010) emphasize the importance of the number of pain sites. Multi-site musculoskeletal pain has been found to be a predictor of poor quality of life (Bergman et al. 2004; IJzelenberg and Burdorf, 2004), poor self-assessed work ability (Miranda et al. 2010; Saastamoinen et al. 2006) and early disability retirement (Markkula et al. 2011).

This dissertation examined employees working from 2005 to 2009 in one of the leading food processing companies in Finland. The food industry was chosen to represent a field involving high levels of exposure to physical and psychosocial load as well as enough variation in these exposures. Although food processing is a widespread industry, the occurrences of musculoskeletal disorders among food industry workers have been hugely understudied. This study aimed to evaluate firstly the occurrence and determinants of multi-site musculoskeletal pain among the workers. Secondly, it aimed to investigate the consequences of multi-site pain for future work ability and thirdly the consequences for sickness absence.

It was hypothesized in this dissertation that most musculoskeletal pain is reported at multiple anatomical sites, and that the associations of physical and psychosocial factors with multiple-site pain are strong. It was also expected that multi-site pain would result in poor work ability and long-term sickness absence due to MSD.

2. REVIEW OF THE LITERATURE

2.1 Overview

The International Association for the Study of Pain (IASP) formulated pain definition as follows "Pain is an unpleasant sensory and emotional experience associated with actual or potential tissue damage, or described in terms of such damage" (Bonica, 1979). This definition is the most widely accepted. It implies that pain is always subjective in nature, an unpleasant sensation with both physical and emotional components. Pain is associated with a wide range of injuries and diseases; it is sometimes a disease itself and warrants immediate medical intervention.

Pain can frequently be acute, which is defined as a type of pain that is directly related to soft tissue damage such as a sprained ankle or a paper cut and typically lasts less than three to six months. This type of pain generally comes on suddenly, for example, after trauma or surgery, and may be accompanied by anxiety or emotional distress. The cause of acute pain can usually be diagnosed and treated, and the pain is self-limiting, i.e., it is confined to a given period of time and severity. In some rare instances, it can become chronic. Chronic pain on the other hand is widely believed to constitute a disease itself. It can be much exacerbated by environmental and psychological factors. Chronic pain, in general, like any pain that has persisted for longer than three months can – and often does – cause sufferers severe problems.

Pain can be discussed under several headings with emphasis on its origin, for example, physiological, inflammatory and neuropathic pain (Woolf, 1987), or nociceptive (musculoskeletal) pain, peripheral or central neurodysfunctional pain, idiopathic pain (unknown pain mechanism), and psychological pain (Lidbeck, 2002). Nociceptive or musculoskeletal pain affects the muscles, ligaments and tendons, along with the bones.

2.2 Musculoskeletal pain

A generally accepted definition for the term "musculoskeletal pain" is difficult to find. There are several closely related, but not synonymous, terms used in the literature to describe the conditions involved, including "musculoskeletal pain", "musculoskeletal disorders", "musculoskeletal symptoms" and "musculoskeletal conditions". An important distinction between "pain" and "symptoms", "disorders" and "conditions" is that pain does not include symptoms such as numbness or tingling. Musculoskeletal pain in itself is not a disease, but if it is persistent and if it negatively affects health, it becomes a healthcare issue. Musculoskeletal pain is prevalent in most populations, but not all perceived pain affects the everyday life of an individual. A few short periods of musculoskeletal pain during a lifetime are not normally viewed as a disease.

Musculoskeletal pain in this thesis is considered as a public health or occupational health interest when it leads to impaired work ability and sickness absence.

2.2.1 Burden of musculoskeletal pain

Musculoskeletal pain constitutes a major public health burden due to its high impact on disability (Picavet and van den Bos, 1997; Badley et al. 1994), sickness absence and work disability (Leijon et al. 1998) especially in the industrialized countries. In general each adult experiences one or more brief episodes of musculoskeletal pain associated with injury or overuse. Recurrent and chronic musculoskeletal pain problems are also common (IASP, 2009). However, prevalence rates vary across studies of a given condition due to different case definitions, time periods and population studied. The lifetime prevalence of back disorders among general population in different countries has varied between 30% and 84% and that of neck disorders has been about 70% (Riihimäki, 2005).

Musculoskeletal problems are highly prevalent and their impact is extensive. The global burden of diseases and injuries due to occupational factors estimated that, the annual incidence of MSDs accounts for 31% of all occupational diseases estimated in the world in 1994 (Leigh et al. 1999). At any time 30% of American adults are affected by musculoskeletal pain (The Consensus Document, 1998). Musculoskeletal disorders are also the most common health problem at work in Europe, affecting millions of workers. Across the European Union (EU 27), 25% of workers complain of backache and 23% report muscular pains (Takala, 2008). In some European states, 40% of the costs of workers' compensation are caused by work related musculoskeletal disorders (WMSDs) accounting for up to 1.6% of the gross domestic product (GDP) of such countries (Takala, 2008). In Finland more than a million workers suffer from acute musculoskeletal disorders related to work. The sickness absenteeism caused by musculoskeletal disorders has been increasing. The costs caused by musculoskeletal disorders consist of premature retirement costs and loss of work input, amounting to close to 2 billion Euros a year (Rantanen and Malmivaara, 1996). According to Finnish statistics in 2011, diseases of the musculoskeletal system were the most common reason for receiving retirement pension accounting for a total of 35% of all persons who had retired. In 2011, the Social Insurance Institution of Finland granted approximately 5.3 million full sickness benefit days due to musculoskeletal diseases at a total cost of 2.3 billion euro (Finnish Centre for Pensions 2011; The Social Insurance Institution 2011).

Musculoskeletal pain is experienced by many people around the world more than any other category of pain. The problem is very complex and extensive; it includes many different types of pain, including neck pain, joint pain, limb pain, low back pain, bone pain and chronic widespread pain (IASP, 2009).

2.2.2 Pathophysiology of musculoskeletal pain

Many efforts have been undertaken to account for the neurophysiology and neurochemistry of musculoskeletal pain, yet the pathophysiology is still not completely clear. Also, relatively little is known about the pathophysiology underlying most persistent pain syndromes. Nonetheless, it is widely accepted that persistent pain may be sustained by different types of mechanisms (AMA, 2007). There are basically three major pain categories: nociceptive, neuropathic and idiopathic pain. Stimulation of tissue nociceptors produces nociceptive pain. Neuropathic pain is caused by a peripheral or central nervous system injury or dysfunction. Idiopathic pain refers to a pain condition without any explicit physical cause, and is often related to mental, emotional, or behavioral factors.

Pain distinguishes sensory and affective components, with the aim of extending the focus from the perception of pain to the pain experience. In Riley and Wade's model the first stage of pain processing is the perceived intensity of the pain sensation, which is then followed by an individual's immediate affective response. In the third phase of pain processing longer-term cognitive processes with extended pain effect emerge. The extraction of sensory and affective dimensions of pain has a neurophysiological basis with growing evidence of underlying neural processes (Main et al. 2008).

Nociceptive pain may be acute (short-lived) or persistent (long-lived, chronic). The distinction between acute and persistent pain is particularly relevant. Acute pain is characteristically of recent onset and is anticipated to have a relatively short duration – no more than days or weeks. Pain is usually considered persistent if it continues for more than 3 to 6 months. Acute pain is highly prevalent and is the hallmark of some disease for e.g. haemophilia and some subsets of headache. Nearly all patients with progressive disease for e.g. cancer and AIDS, also experience repeated episodes of acute pain which may be related to the disease or unrelated processes. Patients with persistent pain commonly experience intermittent episodes of acute pain which may occur spontaneously or in association with a particular activity.

Pain is inherently subjective in nature and patient self-reports are the gold standard in assessment. Ideally, the description of the pain should be characterized by its temporal relations, intensity, location, quality and factors that relieve it.

2.2.3 Multi-site musculoskeletal pain

'Multi-site' or 'multiple site' musculoskeletal pain is a relatively new concept in musculoskeletal pain research. Both terms refer to pain at more than one body site concurrently or within a defined time period. There is no clearly established definition of multi-site pain so far. The American College of Rheumatology (ACR) developed a definition for chronic widespread pain (CWP) in 1990. According to this definition, CWP requires the presence of pain in the axial skeleton, on the left and right, above and below the waist for at least three months (Wolfe et al. 1990). This definition was based on the diagnostic criteria for fibromyalgia. Hunt et al. (1999) proposed another definition, the so-called "Manchester definition" of widespread pain, which states that 'pain which has been present for at least three months in at least two sections of two contra-lateral limbs and in the axial skeleton'. The second definition is more associated with psychosocial distress, fatigue and sleep disruption. However, pain at multiple sites does not meet the criteria and classification of the above definitions but may also be associated with increased pain, disability, work absenteeism (Davies et al. 1998), quality of life and health care utilization (Carnes et al. 2007). Studies on CWP often use case definitions restricted by pain duration (e.g. more than 3 months), pain distribution requirements, or "cut-offs" (Croft et al. 2003; Bergman, 2005). Multi-site pain, however, is measured by using pain duration for e.g. one week, one month, three months and more.

Musculoskeletal pain is a common phenomenon (Natvig et al. 1995). People with musculoskeletal pain often report the pain at several body sites concurrently (Kamaleri et al. 2008a; Markkula et al. 2009; Schmidt and Baumeister, 2007; Allison et al. 2002; Haukka et al. 2006; Picavet and Schouter, 2003; Rustoen et al. 2004). About three quarters of the people with musculoskeletal pain reported chronic pain at multiple body sites (two or more sites) out of a possible count of ten (Carnes et al. 2007). Among a Greek working group of people, two-thirds reported musculoskeletal pain at more than one body site in the past 12 months (Solidaki et al. 2010). The three-month prevalence of pain among female kitchen workers in Finland was reported as 14% workers with pain at only one body site while 73% of all subjects reported pain at more than one site (Haukka et al. 2006). One-third of the general population of Finns reported the pain at more than one site (Miranda et al. 2010). Several studies have reported that multi-site musculoskeletal pain (MSP) is even more frequent than single site pain both in general population (Miranda et al. 2010; Carnes et al. 2007; Kamaleri et al. 2008a) and in working population (Haukka et al. 2006; Solidaki et al. 2010; Molano et al. 2001; Alexopoulos et al. 2004; Ijzelemberg and Burdof, 2004).

Among schoolchildren, month prevalence of widespread pain varied between 8% (Adamson et al. 2007) and 15% (Jones et al. 2003), depending on the criteria used to measure the widespread pain. Paananen et al. (2010) found that among schoolchildren 21% of boys and 24% of girls reported pain at two anatomical sites. This shows that multi-site musculoskeletal pain is already common in school age (Auvinen et al. 2009). The average number of pain sites appears to be settled by age 20 and little variation seems to occur thereafter (Croft, 2009; Kamaleri et al. 2009).

It can be seen from the above that multi-site pain seems to be more common than single-site or localized pain. This suggests that pain in one anatomical area should generally not be seen in isolation but that assessment of pain at multiple sites should be considered (Haukka et al. 2006). Nonetheless, most of the earlier studies on musculoskeletal disorders have concentrated exclusively on single-site pain and considered risk factors as distinct and exclusive to each pain area or disorder (Grotle and Croft, 2010). Although multi-site pain occurs as frequently as single-site pain, the different risk factors of multi-site pain are not well understood.

2.2.4 Assessment of musculoskeletal pain in epidemiological studies

In the epidemiology of musculoskeletal pain steady progress has been made in recent decades, but longitudinal and case-control studies are still scarce in this field. The occurrence of the pain has been the most common outcome measure in epidemiological studies on musculoskeletal pain (Riihimäki, 2005). The occurrence parameter has been one week, one, three, or 12 months or lifetime prevalence or cumulative incidence in follow-up studies. Epidemiological data on musculoskeletal pain are mainly collected with questionnaires, interviews and clinical examinations. However the assessment is difficult because of the subjective nature of pain (Guzman et al. 2008). Pain perception is person-dependent and can be modified by several factors, such as prior experience, culture, coping mechanisms etc. In this study, musculoskeletal pain was measured by a questionnaire, i.e. no objective measurement was made. Nevertheless, a self-report method appears to be the best and practically the only way of assessing pain in epidemiological studies because of its complex and subjective nature (Crombie et al. 1999; Natvig et al. 2001).

In epidemiological studies of musculoskeletal pain, the accuracy of the measurement of pain and exposure is of value only if current exposure is relevant with regard to the study objective (Riihimäki, 2005). Also, if current exposure can be considered as a proxy of past exposure, direct measurement of the exposures is then reliable. In longitudinal epidemiological studies on musculoskeletal pain, the multidimensional aspects of pain have to be captured in only a few variables in order to ensure a better assessment. Therefore multi-item instruments for pain assessments are not plausible in an epidemiological survey. A questionnaire with a limited number of pain questions, which is commonly employed in epidemiological studies, is the Nordic questionnaire (Kuorinka et al. 1987). The validity and reliability of these questionnaire methods has been compared in different studies (Tielemans et al. 1999; Nordstrom et al. 1998; Kromhout et al. 1987). In the Nordic Questionnaire diagnosis was used as the gold standard. Good predictive validity was found for the Nordic Questionnaire regarding the number of pain sites and association with work disability and disability pension (Kamaleri et al. 2009).

2.3 Risk factors for multi-site musculoskeletal pain

Pain is a very complex process influenced by genetic, environmental and cultural factors as well as socio-economic status and psychological factors (Brooks, 2005). Several comprehensive reviews of risk factors of a single anatomical site have been published (Murphy et al. 2003; Andersen et al. 2011). However, there are no systematic reviews available for multi-site pain. One important area of uncertainty is whether the relative importance of risk factors differs for pain occurring at multiple sites. Solidaki et al. (2010) found that the relative importance of psychosocial versus physical risk factors is different for widespread pain compared to localized pain. However, the work-related physical and psychosocial risk factors may be common to both localized and multi-site pain. What is known about the risk factors for multi-site pain in our study is based on single-site pain. It has been estimated that about 40% of all upper limb disorders in the total US employed population were attributable to occupational exposure (Punnet and Wegman, 2004). Upper limb disorders rank high among compensated occupational diseases or injuries (Hagberg and Wegman 1987). Globally, 37% of low back pain (LBP) is caused by occupation and work-related pain is responsible for the loss of 818,000 disability-adjusted life-years annually (Punnett et al. 2005). Grotle and Croft (2010) explained that the reasons for the development and persistence of multi-site pain could be shared risk factors: mechanical overuse or injury or lifestyle factors such as obesity or low physical activity may affect different body sites and increase the likelihood that an individual exposed to those factors will cumulatively develop musculoskeletal pain at multiple sites.

Epidemiological evidence suggests that both physical and psychosocial factors at work and individual factors play a role. However, the mechanisms involved in the development of musculoskeletal pain are not well understood. In addition to the separate effects of these physical and psychosocial factors, experimental evidence and biomechanical theory suggest that they may interact and produce a higher risk of musculoskeletal pain (Marras et al. 1995; Dolan and Adams, 1998). Work-related physical risk factors for multi-site pain can be categorized into two groups, environmental exposures and biomechanical exposures. Environmental exposures in some reports have also been called physical exposures. In the same way, the work-related psychosocial risk factors studied in this dissertation are job satisfaction, team spirit, leadership and opportunities to exert influence. Among the other individual factors, gender, age, occupational status, body mass index (BMI) and physical activity have been used in this research.

2.3.1 Physical risk factors

2.3.1.1 Environmental exposures

Many studies have shown that environmental exposures are an important risk factor for musculoskeletal pain, both localized and multi-site. Many of these earlier studies have, however, used environmental exposure in terms of physical workload, repetitive movements and awkward posture (Miranda et al. 2001; Cagnie et al. 2007; Hales et al. 1994; Ryan and Bampton, 1988; Wang et al. 2007; Harcombe et al. 2010). In this study these factors such as repetitive movements and awkward posture have been described as biomechanical exposures. Environmental exposure used in this study includes draughts, noise, poor indoor climate, poor lighting, heat, cold and restless work environment (Lehto and Sutela, 2009). Environmental exposures have also been studied as risk factors for musculoskeletal pain in terms of 'environmental discomfort' (Magnavita et al. 2011) or 'body discomfort'. In a study among workers in food processing industries in Finland Sormunen et al. (2009) reported that draughts, moisture and noisy work environment were rated to be harmful by more than 70% of the respondents. Harkness et al. (2004) found that among the workplace environmental factors, those working in cold conditions had a lower risk of onset of widespread pain. In a review by Hildebrandt et al. (2002), epidemiological evidence about the relationship between climatic factors at work, such as cold, draughts and changes of temperature, and musculoskeletal symptoms was concluded to be weak, even though the association was considered plausible by the researchers and the subjects themselves. Poor climatic factors (cold, draughts, dampness and changes of temperature) were significantly associated with musculoskeletal pain (Sormunen et al. 2009) in more than one anatomical site of the body (Hildebrandt et al. 2002). However the underlying pathophysiological mechanisms between musculoskeletal pain and climatic factors are still uncertain (Hildebrandt et al. 2002).

2.3.1.2 Biomechanical exposures

It has been postulated that biomechanical factors are important in the aetiology of acute localized pain and individual psychosocial factors are important in the aetiology of persistent and generalized pain (Schierhout et al. 1995; Magni et al. 1994; Toomingas et al. 1997). However, there is evidence that exposure to repetitive motion patterns, forceful exertion and non-neutral body postures (both dynamic and static) may cause musculoskeletal disorders at one or more anatomical sites (Punnett and Wegman, 2004). Several other studies have also found that repetitive movements and manual handling activities with e.g. high perceived physical workload among dentists increased the risk of co-occurring musculoskeletal pain with odds ratios of 2.5, 3.1 and 4.4 for two, three and four pain areas respectively (Alexopoulos et al. 2004). In a two-year prospective study among kitchen workers in Finland (Haukka et al. 2012) heavy physical workload at baseline was an independent predictor of MSP (OR = 3.8, 95% CI 1.7–8.5). In another cross-sectional study among a representative sample of the occupational groups from Greece, a combination of various physical exposures had a strong and graded relationship with the number of pain sites (Solidaki et al. 2010). In a 2-year follow-up study among newly employed workers, lifting and poor work postures predicted the onset of widespread pain (Harkness et al. 2004). Moreover, in a sample of general population, manual material handling and repetitive work and awkward postures increased the risk of chronic widespread pain three years later (McBeth et al. 2001). Repetitive work movements also increased the risk of future episodes of forearm pain co-occurring with other regional pain 3–4-fold (Macfarlane et al. 2000). The high occurrence of pain at multiple body sites due to pattern of workload and repetitive work was also reported among female kitchen workers (Haukka et al. 2006).

2.3.2 Psychosocial environment

In many studies psychosocial aspects were found to be more strongly predictive of pain and its progression than mechanical exposures (Jansen et al. 2004; Eriksen et al. 2004). Several studies have also reported that psychosocial factors contribute to the development of multi-site pain. However, the number of prospective studies investigating the role of work-related exposures in multi-site pain is limited. Among kitchen workers, low job control and low supervisor support were the strongest predictors of multi-site pain 3 months later (Haukka et al. 2011). Moreover, adverse changes in psychosocial factors, especially in job control over a two-year follow-up period were associated with a higher risk of having persistent multi-site pain (Haukka et al. 2011). In a two-year follow-up study among newly employed subjects in 12 diverse occupational settings, the risk of onset of chronic widespread pain was associated with work-related psychosocial factors, such as low job satisfaction, low social support, and monotonous work, as well as with several mechanical and posture exposures. The strongest independent predictors of symptom onset, however, were psychosocial factors (Harkness et al. 2004). Solidaki et al. (2010) also found that among Greek workers job satisfaction, support and beliefs in work were associated with multi-site pain. Low social support at work was one of the 11 generic prognostic factors associated with pain in at least two regions of the body in a review by Mallen et al. (2007).

Adverse work related psychosocial factors were associated with pain at several anatomical sites in a cross-sectional study (Nahit et al. 2001). Another occupation based cohort study with one year follow-up reported that high levels of psychosocial distress at baseline were associated with an approximate doubling of the risk of reporting pain at follow-up (Nahit et al. 2003). Exposures relating to job demands support and job satisfaction increased the odds between 1.4 and 1.7 (Nahit et al. 2003).

2.3.3 Health related factors

A number of review studies have found that overweight, obesity (Shiri et al. 2010a) and smoking (Shiri et al. 2010b; Kauppila, 2009) were associated with LBP. Earlier studies have also found that subjects with metabolic syndrome were more likely to have neck pain (Mäntyselkä et al. 2010) and pain symptoms (Han et al. 2009). Some studies have analysed the relationship of health related factors to multi-site pain among working population. Among the general rural population, current smoking was associated with an increased risk of chronic pain at multiple locations and with CWP in both genders (Andresson et al. 1998). In one of the recent 2-year prospective follow-up studies among kitchen workers in Finland, Haukka et al. (2012) found that moderate (OR = 2.4, 95% CI 1.2–4.9) or low (OR = 2.3, 95% CI 1.1–4.7) physical activity predicted persistent MSP. Obesity also predicted MSP in the same study. General health and sleep quality were strongly associated with the number of pain sites in earlier studies (Natvig et al. 2001; Nordin et al. 2002; Stordal et al. 2003; Vandvik et al. 2004; Von Korff et al. 2005). A linear relationship between number of pain sites and deterioration in overall health, sleep quality and psychological health was found among Norwegian general population (Kamaleri et al. 2008b). Low physical activity, overweight (higher BMI) and smoking status (smokers) were also associated with number of pain sites (Kamaleri et al. 2008b; Walker-Bone et al. 2004). However, smoking and physical activity were no longer associated with number of pain sites in a multivariate model (Kamaleri et al. 2008b). Kamaleri et al. (2009) also found no significant association of BMI with the number of pain sites 14 years later among municipal employees. Among Finnish adolescents, high level of physical activity, sitting for 8 hours or more per day, sleeping 7 hours or less and smoking were associated with overweight (BMI 24.37–29.43 kg/m^2). These factors were also associated with pain at three or four locations both for boys and girls (Paananen et al, 2010).

Painful symptoms commonly occur together with many other diseases. Most times a comorbid patient will have one or more painful conditions. The more persistent the pain, the more enduring is its effect on its patient. Several studies have found the presence of pain to be associated with anxiety symptoms (Dersh et al. 2002). Depression and pain share biological mechanisms and neurotransmitters, which has implications for the treatment of both concurrently (Bair et al. 2003). Earlier studies have reported that patients with spinal pain are more likely than those without spinal pain to report the presence of another chronic pain condition (von Korff et al. 2005; Gureje et al. 2007). Chronic pain was also independently associated with low self-rated health among general population in Finland (Mäntyselkä et al. 2003). Among Finnish kitchen workers with axial pain 52% reported concurrent pain in the neck and in the low back and 44% of those with upper limb pain had concurrent pain in the shoulders and in the forearms or hands (Haukka et al. 2006). Co-morbidity is also related to disability in general population (Rigler et al. 2002).

2.3.4 Individual factors

Among general population, women had a significantly higher number of pain sites than men and the proportion of women increased linearly with the total number of pain sites (Kamaleri et al. 2008b). Gender (women had higher risk) and age (younger adults had higher risk) were also associated with the development of musculoskeletal pain at multiple sites in a 14-year follow-up (Kamaleri et al. 2009). Another population study from the UK also showed that women were at higher risk of both chronic widespread and multi-site pain (Carnes et al. 2007). Pain at two or more sites was more frequent in women among the general population of age 40 or higher in Korea (Cho et al. 2012). Cho et al. (2012) also found that the prevalence of widespread pain was 12% (5.5% in men and 16.2% in women). Widespread pain was found to be more common among younger workers involved in different occupations (Harkness et al.

2004). Harkness et al. also found in the same study that the prevalence of widespread pain at baseline was more common in men, whereas chronic widespread pain and fibromyalgia tend to be much more commonly reported in women (Harkness et al. 2004). Pain at multiple locations was also found to be common and increase with age in a study among Swedish rural population (Andersson, 1994). In the same study, women over 35 years of age perceived multiple sites of pain more often than men of the same age (Andersson, 1994). In the UK, widespread pain was three and a half times more common (PRR = 3.6, 95% CI 2.2–5.8) in women than in men (Harkness et al. 2005).

The prevalence of chronic pain varied with socioeconomic status such that the phenomenon was most common among blue-collar workers of all ages (Andresen, 1994). Harkness et al. (2004) found wide variation in the rates of onset of widespread pain by occupational group. However, the prevalence did not differ by occupational status in his study.

Table 1: Association of physical and psychosocial factors with multi-site pain

Reference, Country	Study design	Subjects Industry/sector	Exposure variables	Outcome and assessment	Main findings
Harkness et al. 2004 UK	Prospective cohort, 12 months and 24 months of follow-up	1,081, newly employed subjects in 12 diverse occupations	Physical factors: Manual handling, posture and repetitive movements Psychosocial factors: Job demands, job controls, social support Environmental factors Hot, cold or damp conditions	Widespread pain at follow-up (American College of Rheumatology (ACR) definition of widespread pain)	Manual handling activities associated with an increased risk of widespread pain onset (OR = 2.3, 95% CI 1.3–3.9) Squatting for ≥15 minutes was strong predictor of widespread pain onset (OR = 2.9, 95% CI 1.8–4.9) Monotonous work was associated with increased risk of widespread pain (OR = 2.4, 95% CI 1.5–3.9) Working in cold conditions had a protective effect on symptom onset (OR = 0.5, 95% CI 0.3–0.98)
Miranda et al. 2011 USA	Cross-sectional design	920 staff from 12 nursing home (certified aide, certified medical aide, licensed practical nurse and registered nurse)	Physical assaults at the workplace (hit, kicked, grabbed, shoved, pushed or scratched by patients or patients' visitors) Physical factors at work, moving or lifting heavy loads, rapid and continuous physical activity and awkward postures. Psychosocial factors were job demands, job control, co-worker support and supervisor support from Job Content Questionnaire (JCQ)	Self-reported musculoskeletal symptoms including widespread pain during the preceding 3 months Log-binomial regression method to estimate prevalence ratios (PR)	Widespread pain was three times more prevalent among those reporting three or more physical assaults.
Barrero et al. 2006 China	Community-based cross-sectional study	13,907 rural population of age between 25 and 64 years from Anhui Province China.	Physical stress in their occupation (physical exertion, vibration) self-reported occupation and time pressure	Low back pain + other pain sites Generalized Estimating Equations (GEE) to measure the prevalence and association	Exposure to vibration at work was associated with LBP and pain in other three additional areas of body (OR = 7.1, 95% CI 5.2–9.6). Heavy physical stress was associated with LBP with pain in two additional locations (OR = 1.2, 95% CI 1.0–1.6).

Haukka et al. 2011 Finland	Cluster randomized trial 2-year follow-up	504 kitchen workers from 119 different kitchen	Psychosocial factors at work Low job control, low skill discretion, low supervision support, poor co-worker relationships, hurry at work and mental stress during past month	Multiple site musculoskeletal pain	Low job control (OR = 1.8, 95% CI 1.3–2.5), low supervisor support (OR = 2.1, 95% CI 1.4–3.2), hurry at work (OR=1.4, 95% CI 1.1–1.8), and mental stress (OR = 1.6, 95% CI 1.1–2.3) predicted the occurrence of multiple site pain 3 months later.
Solidaki et al. 2010 Greece	Cross-sectional design	564 workers Nurses, office workers and postal clerks	Physical load, work hours Job satisfaction, job demand, job control, job support, job security, mental health, somatizing symptoms, depression, fear avoidance beliefs, work causation beliefs	Multi-site musculoskeletal pain in past 12 months Nordic Questionnaire on Musculoskeletal Complaints	Higher physical load score (IRR = 4.7, 95% CI 2.6–8.4), worst mental health (IRR = 1.5, 95% CI 1.3–1.7), higher somatizing symptoms (IRR = 2.0, 95% CI 1.8–2.3) and strong work causation beliefs (IRR = 1.3, 95% CI 1.1–1.5) were associated with multi-site pain in past 12 months. Higher job satisfaction (IRR = 0.7, 95% CI 0.6–0.8) had protective effect on multi-site pain.
Haukka et al. 2012 Finland	Prospective study 2-year of follow-up	385 female kitchen workers	Perceived physical workload and perceived psychosocial workload	Multi-site musculoskeletal pain in past three months	High physical workload at baseline was an independent predictor of MSP at the 2-year follow-up (OR = 3.8, 95% CI = 1.7–8.5). Adverse psychosocial factors at work also predicted MSP after 2-year with OR = 4.0, 95% CI = 2.0–8.0 (high vs. low).
Solidaki et al. 2012 Greece	Prospective study One year follow-up	518 subjects of three occupational groups	Hours worked per week, strenuous physical activities, Job satisfaction, job demands, job control, job support, job security	Multi-site musculoskeletal pain in past one year	¤0 or more hours of work per week was associated with the new onset of multi-site pain (OR = 5.0, 95% CI 1.1–24.0). Four to seven strenuous physical activities predicted persistence of multi-site pain (OR = 3.2, 95% CI 1.4–7.4).

2.4 Work ability concept

The concept of work ability was developed in the early 1980s in Finland and was later adopted in various European and Asian countries. The concept is built on the balance between a person's resources and work demands (Ilmarinen, 2005). Work ability has turned out to be a useful concept in analysing work life, particularly in responding to the challenge to prolong the job careers of aging workers. Work ability has been measured in different ways. The work ability index (WAI) is a commonly used instrument in clinical occupational health care and research to assess work ability during health examinations and workplace surveys (Ilmarinen, 2007). The index is determined on the basis of the answers to a series of questions which take into consideration the demands of the work, the worker's health status and resources. Single item questions asking respondents to rate their current work ability on a 5- or 10-point scale are also commonly used nowadays (Lindberg et al. 2006, Ahlstrom et al. 2010).

The concepts of work ability have developed during the last decade in a more holistic and versatile direction. The level of work ability was related to the age of retirement in an earlier study (Feldt et al. 2009) and it shows that the better the work ability index the later the retirement. According to the health-based definition, work ability has been paired with integrated models and is created and promoted by many factors. In an 11-year follow-up study among food industry workers, Salonen et al. (2003) found that poor work ability was significantly associated with early exit from work. Nevertheless, Nygård and Arola (2004) showed that perceived work ability among workers in the food industry can be maintained or promoted by workplace health promotion intervention programmes. These include general health promotion, supervised physical training, or work organizational changes, including training for changes in working culture and methods and participatory planning of workplace health promotion.

In the literature from systematic reviews poor work ability has been associated with higher age, low socioeconomic status, lack of leisure physical activity, obesity etc. (van den Berg et al. 2009). Perceived work ability in midlife was also associated with mortality and disability in old age among blue-collar and white-collar employees (von Bonsdorff et al. 2011).

2.4.1 *Risk factors for poor work ability*

2.4.1.1 Multi-site pain

Several studies on multi-site pain and work ability have measured work ability in terms of sick leave or disability pension (Natvig et al. 2002; Ijzelenberg et al. 2004; Kamaleri et al. 2008a; Morken et al. 2003; Nyman et al. 2007). These studies have found that pain at multiple locations or widespread pain are strongly associated with long-term disability (Natvig et al. 2002), declining psychosocial health, sleep quality, educational level (Kamaleri et al. 2008b) and functional ability (Kamaleri et al. 2007). Long-term work disability was also predicted by low back pain in individuals with widespread pain (OR = 3.52, 95% CI 1.09–11.37) (Natvig et al. 2002). In a 14-year follow-up study from Norway, Kamaleri et al. (2009) demonstrated that the number of pain sites at baseline was a strong predictor of disability pension at follow-up. There are few studies (both cross-sectional and longitudinal) looking at the association of multi-site pain and poor work ability. In a larger population based cross-sectional study in Finland (Miranda et al. 2010), a graded association of multi-site pain was found with poor self-rated work ability (OR = 2.3, 95% CI 1.6–3.3).

2.4.1.2 Physical factors at work

Work-related factors have been shown in many studies to be associated with worker's work ability (Alavania et al,.2007; Sjögren-Rönkä et al. 2002). A systematic review of work related factors and work ability shows that high physical demands such as increased muscular work, poor work postures, and poor ergonomic conditions were positively associated with a lower work ability index (WAI) (van den Berg et al. 2009). Repetitive movements (OR = 1.56, 95% CI 1.41–1.72), static work postures (OR = 1.91, 95% CI 1.73–2.10), awkward back postures (OR = 2.05, 95% CI 1.86–2.27) and manual materials handling (OR = 1.21, 95% CI 1.01–1.34) were associated with the occurrence of poor or moderate work ability in a cross-sectional study among Dutch construction workers (Alavania et al. 2007). By contrast Lindberg et al. (2006) found no association between physical exposures such as physically strenuous work, heavy lifting, bent work postures and poor work ability among Swedish working population. High physical work demands such as heavy muscular work, poor work postures and environmental conditions were also associated with impaired work ability among home care workers (Pohjonen, 2001) and municipal workers in a prospective cohort study (Tuomi et al. 1997; Tuomi et al. 2004).

2.4.1.3 Psychosocial factors at work

There are some indications that preventing the development of poor work ability depends on organizational and psychosocial factors (Lindberg et al. 2006). In the review by van den Berg et al. (2009), high psychosocial work demands were associated with poor work ability. A positive association between high mental work demands and poor WAI was reported in some studies (Pranjic et al. 2006; Sjögren-Rönka et al. 2002; Tuomi et al. 2004). Among Dutch construction workers, Alavinia et al. (2007) found that lack of support at work (OR = 1.73, 95% CI 1.01–1.21), high work demands (OR = 1.11, 95% CI 1.01–1.21) and low job control (OR = 1.35, 95% CI 1.24–1.46) were weakly associated with poor work ability.

2.4.1.4 Health related factors

A study among aging industrial workers indicated that unhealthy lifestyles themselves are an important factor with respect to decreased work ability (Tuomi et al. 1997). Regular physical exercise at a moderate level has a positive effect on perceived work ability (Nurminen et al. 2002). Earlier studies have found that overweight (Fischer et al. 2006; Pohjonen et al. 2001; Tuomi et al. 2001), lack of leisure-time physical activity (Tuomi et al. 2001; Kaleta et al. 2006), smoking (Tuomi et al. 1991) and diet with low fibre intake (Kaleta et al. 2006) were associated with poor WAI. Alavinia et al. (2007) reported that overweight (OR = 1.37, 95% CI 1.22–1.55), and mild to moderate lung obstruction (OR = 1.41, 95% CI 1.07–1.86) were associated with poor work ability among Dutch construction workers. Gamperiene et al. (2008) also reported that partial satisfaction and dissatisfaction with physical health remained significant in predicting severely impaired work ability (RR = 5.1, 95% CI 2.2–11.9 and RR = 9.5, 95% CI 3.9–23.2).

2.4.1.5 Individual factors

Age has been acknowledged as an important factor with respect to impaired work ability (Pohjonen et al. 2001; Tuomi et al. 1991). Miranda et al. (2010) found a strong effect of age (especially older age group) on work ability among the general working population of Finland. Among the Dutch construction workers, the mean work ability index dropped by approximately 10% over a 40-year age span. Decreased WAI with older age has also been reported in some other studies (Goedhard et al. 1998; Monteiro et al. 2006). By contrast Fischer et al. (2006) reported a higher risk for poor WAI among younger workers. There was also an increased probability of both excellent and poor work ability for the oldest age group (≥ 55 years), but a decreased probability of poor work ability for the youngest age group (20–44) years (Lindberg et al. 2006). An adverse effect of aging for moderately and severely impaired work ability was also found in a study among Norwegian women (Gamperiene et al. 2008). Gamperiene also found that women over the age of 50 years had a stronger association with moderately impaired work ability than women aged 18–29 years. Only the age group 40–49 years was associated with severely impaired work ability in their study.

Gender was not associated with WAI in some earlier studies (Monterio et al. 2006; Martinez et al. 2006; Miranda et al. 2010). However, among Swedish working population men had a lower probability of poor work ability compared to women (Lindberg et al. 2006). In both genders lower work ability was more prevalent among blue-collar employees over 40 years than among white-collar employees over 40 years among employees of the City of Helsinki (Aittomäki et al, 2003).

Table 2: Association of multi-site pain and work ability

Reference, Country	Study design	Subjects Industry/sector	Exposure variables	Outcome and assessment	Main findings
Miranda et al. 2010 Finland	Cross-sectional	N=4087 General working population	Number of anatomical sites with pain Multi-site pain (Pain during preceding month)	Self-rated ability to work (4 features; physical demands, mental demands, work ability deteriorated and not able to continue working) and plans to retire early	Multi-site pain associated with poor work ability in dose response manner. Association of pain at 4 sites with poor physical work ability (OR = 1.9, 95% CI 1.4–2.6), work ability deteriorated (OR = 2.3, 95% CI 1.6–3.3), not able to continue working (OR = 2.0, 95% CI 1.3–3.1) and thought about retiring early (OR = 1.5, 95% CI 1.1–2.0)
Kamaleri et al. 2009 Norway	14 years of follow-up	N=2722 General working population	Pain in 10 different regions during last 12 months and last 7 days	Work disability in the follow-up year	Strong dose-response relationship of multi-site pain with work disability, e.g. pain in 9–10 regions of the body at baseline predicted work disability after 14 years (OR = 11.69, 95% CI 3.60–37.96)
Øverland et al. 2011 Norway	Cross-sectional	N=18565	Pain at different body locations for at least three consecutive months in the past year	Work disability. The medico-legal disability pension diagnosis was used.	Widespread pain with impact on work had risk (HR = 9.45, 95% CI 7.77–11.47) of disability pension. Also, widespread pain with sickness absence due to pain had risk (HR = 12.15, 95% CI 9.96–14.81) of disability pension.

2.5 Sickness absence

Sickness absence is an important public health problem as it contributes to lost productivity (Gründemann et al. 1997) and the well-being of the working population (Marmot et al. 1995; Bourbonnais et al. 1992). Consequently, sickness absence has emerged as an important indicator of a country's economic performance. Health 2000, a population based survey of the Finnish employed workforce aged 25–64 found that 45% of employees had taken sickness absences during the preceding six months (Kauppinen et al. 2004). In Finland sickness absence has increased by 20% in the past ten years, and by almost 50% for long-term absence (OECD, 2008). According to the Finnish statistics 15.7 million absence days were covered by National Health Insurance in 2011, counting six working days a week with a total cost of 844.8 million Euros for sickness absence allowances including partial sickness allowances (Finnish Centre for Pensions 2011; The Social Insurance Institution 2011). A comparative study among European Union (EU) Member States showed that sickness absence percentages in southern European countries were lower than in central and northern European countries (Gimeno et al. 2004). Reducing the number of employees from sickness absence at work is one of the top political priorities in the EU (Henderson et al. 2005).

Sickness absence can be measured in terms of spells, persons, or time based measurements (Hensing, 2004). Sickness absence spells are also known as absence episodes, which are common events throughout the world. The causes of sickness absence are multi-factorial and complex (Dekkers-Sanchez et al. 2008; Labriola et al. 2008), but musculoskeletal pain is the dominant source (Bergaman et al. 2007; Punnett et al. 2004) especially for long-term absence. Work environmental exposures (Krause et al. 2004; Allebeck et al. 2004) have also been sown to be common causes of sickness absence from the workplace. In many studies on sickness absence, the outcome is short-term sickness absence or no distinction is made between short and long-term absence. Long-term sickness absence is costly for individuals and the economy.

2.5.1 Risk factors for sickness absence

2.5.1.1 Multi-site pain

Several crucial factors contribute to long-term sickness absence among employees with musculoskeletal pain. The region of body pain (Ariens et al. 2002) and pain intensity may play a vital role for sickness absence (Lötters and Burdorf, 2006). Saastamoinen et al. (2009) also found that the association of pain with sickness absence is largely independent of workload factors or socio-economic position. Sickness absence was reported by 39.6%, 95% CI 37.5–41.8 of the general population due to widespread pain in Norway (Øverland et al. 2012). Morken et al. (2003) found among aluminum industry workers the widespread pain (RR = 4.5, 95% CI 3.4–5.8) and low back pain (RR = 2.7, 95% CI 2.1–3.3) were the strongest predictors for both short- and long-term sickness absence due to MSD. Widespread pain markedly increased the risk of long-term sickness absence in an earlier study among a representative sample of 5603 Danish employees with the hazard ratio for pain in hand/wrist plus low back plus neck/shoulder 2.63, 95% CI 1.99–3.46 after controlling for diagnosed disease (Andersen et al. 2011). Kääriä et al. (2012) also found that sciatica and neck pain was a stronger predictor of medically certified sickness absence than pain in one location.

2.5.1.2 Physical factors at work

Physical work environment exposures related to uncomfortable work postures, monotonous movements and high physical demands have been found to be associated with sickness absence in many studies (Hoogendoorn et al. 2002; Palsson et al. 1998; Charizani et al. 2005). Among Danish employees aged 18–64 years, work involving arm lifting and twisted hands OR = 1.3, 95% CI 1.07–1.59 and extreme bending/twisting of neck/back OR = 1.45, 95% CI 1.17–1.78 was associated with sickness absence. Another follow-up study from Denmark also reported similar findings; uncomfortable working positions (HR = 1.40, 95% CI 1.18–1.65) and physical workload (HR = 1.15, 95% CI 1.03–1.45) were associated with increased risk of long-term sickness absence. Trinkoff et al. (2001) also found awkward head and arm postures to predict sickness absence in a study among 3,727 registered nurses. Another prospective cohort study based on questionnaire and register data showed that twisting the back OR = 1.32, 95% CI 1.08–1.61 and physical activity in work OR = 1.41, 95% CI 1.18–1.67 were associated with long-term sickness absence (Labriola et al. 2006). Heavy physical workload together with hazardous exposures showed the strongest associations with long-term sickness absence among Helsinki city employees in Finland (Laaksonen et al. 2010).

2.5.1.3 Psychosocial factors at work

In recent years psychosocial working conditions have attracted most attention as work-related risk factors for sickness absence. Research has shown that various features of psychosocial working conditions (decision-making authority, adjustment latitude, job control, job complexity, supervisor's support) are related to sickness absence (Melchior et al. 2003; Duijts et al. 2006). High psychosocial job demands, low job control, high job strain and passive work were associated with more work-related sickness absence among permanent and non-permanent employees in EU member States (Gimeno et al. 2004). Low job control was associated with increased sickness absence in women (HR = 1.06, 95% CI 1.01–1.11) and job dissatisfaction was associated with increased risk of sickness absence in men (HR = 1.17, 95% CI 1.05–1.30) among Helsinki City employees (Laaksonen et al. 2010). Negative changes in the psychosocial work environment were found to be associated with increased risk of sickness absence after 7 years among healthy employees (Vahtera et al. 2000). The results from the Whitehall II Study also show that adverse changes in the psychosocial work environment predicted the incidence of long-term (> 7 days) sickness absence (Head et al. 2006).

2.5.1.4 Health related factors

Current smoking (OR = 1.6, 95% CI 1.32–1.96), former smoking (OR = 1.32, 95% CI 1.03–1.68), obesity (OR = 1.57, 95% CI 1.09–2.25), general poor health status (OR = 1.69, 95% CI 1.29–2.19) were associated with greater sickness absence among Danish employees (Labriola et al. 2006). In a 3-year follow-up study of the industrial population in Sweden, stopping smoking during the preceding year predicted higher risk of sickness absence (OR = 2.78, 95% CI 1.21–6.38) than among current smokers (Bergström et al. 2007). Bergström et al. (2007) also showed that physical activity in leisure time > 1 hour/day reduced the risk of sickness absence (OR = 0.39, 95% CI 0.20–0.76). Another study among industrial workers in Norway also showed that smokers had higher risk of short-term sickness absence (RR = 1.4, 95% CI 1.2–1.7) but not for long-term sickness absence (Morken et al. 2003). In the same study body mass index (BMI) > 25 was associated with long-term sickness absence (RR = 1.3, 95% CI 1.0–1.7) but not short-term absence. Moderate physical activity was also associated with less short-term sickness absence (Morken et al. 2003). Smoking and BMI were also associated with intermediate (4–14 days) sickness absence and long-term (15+ days) sickness absence among the employees of the city Helsinki in Finland (Laaksonen et al. 2010).

2.5.1.5 Individual factors

Gimeno et al. (2004) found that among permanent and non-permanent employees in EU Member States men had slightly more sickness absence than women. Some other earlier studies have also shown important gender differences in sickness absence but also opposite results reporting that women are more often absent sick (Gjesdal et al. 2009; Lötters and Burdoff, 2006; Allebeck et al. 2004; Laaksonen et al. 2007). Other studies found no gender difference (Morken et al. 2003; Holtermann et al. 2010) or only a minor effect on sickness absence (Burdoff et al. 1998) due to MSD among industrial workers.

Age did not predict sickness absence due to MSD among industrial workers in Norway (Morken et al. 2003). Other studies have also found age to be of minor importance in predicting sickness absence (Labriola et al. 2006; Laaksonen et al. 2010) sickness absence due to MSD (Burdorf et al. 1998) and also long-term sickness absence (Holtermann et al. 2010). However, among laundry workers Ijzelenberg et al. (2004) found a decreased risk of sickness absence in the older age group that could not be explained by work-related factors. Some earlier studies have also found that age > 50 years (OR = 2.4, CI 1.7–3.5) was a significant predictor of sickness absence (EshØj et al. 2001).

Among the industrial population, blue-collar employees were found to be more prone to higher risk of sickness absence than white-collar employees (Morken et al. 2003; Wickstrom et al. 1998; Kleiven et al. 1998). Blue-collar workers were also found to be associated with the risk of sickness absence in follow-up of 18-months and 3-years among working population (Bergström et al. 2007). Roelene et al. (2010) found that unskilled employees were at increased risk of recurrent sickness absence due to MSD. By contrast, Andersen et al. (2010) found that especially neck or shoulder pain was a risk factor for white-collar employees in Denmark.

Table 3: Association of multi-site pain and sickness absence

Reference, Country	Study design	Subjects Industry/sector	Exposure variables	Outcome and assessment	Main findings
Morken et al. 2003 Norway	2-year follow-up	N=3320 Aluminum industry workers	Widespread pain (Pain during past 12months) Individual factors and other psychosocial factors	Short-term (1–12 days) sickness absence and long-term (>12 days) sickness absence in follow-up year	Widespread pain predicted both short- (RR = 2.8, 95% CI 2.3–3.4) and long-term (RR = 4.5, 95% CI 3.4–5.8) sickness absence compared to no pain.
Andersen et al. 2011 Denmark	Prospective cohort study with 2-year follow-up	N=5603 Danish employees	Widespread pain (pain in 0 to 9 body regions in last 3 months.	Long-term sickness absence (at least 3 consecutive weeks)	Widespread pain predicted long-term sickness absence (HR = 2.63, 95% CI 1.99–3.46) even after adjusted for diagnosed disease.
Nyman et al. 2007 Sweden	Population based prospective cohort study with 5-year follow-up	N=2329 Swedish employees	Pain in different body regions during past six months	Short (1–14 days) and long-term (at least 14 consecutive days) sickness absence	Pain in two body regions (LBD and NSD) was strongly associated with long-term sickness absence (OR = 2.48, 95% CI 1.32–4.66).

3. THEORETICAL FRAMEWORK OF THE STUDY

Various risk factors of musculoskeletal pain exist in a healthy population. When musculoskeletal pain emerges, it may run its normal course, but in some people pain lasts longer and may become chronic (Lakke et al. 2009). These influential factors are the prognostic factors.

Several theoretical models have been proposed to describe the development and prolongation of musculoskeletal pain (Waddell, 2006; Pincus et al. 2006; Karsh, 2006). Most of the theoretical models describe the multifactorial aetiology of musculoskeletal pain. Understanding these models is necessary to better target interventions that might prevent or reduce musculoskeletal pain at the workplace. The theories also guide the selection of variables to be controlled for in the study.

This dissertation is based on the modified version of the theoretical model originally proposed by Sauter and Swanson (1996). Sauter and Swanson's (1996) ecological model was originally designed for office and visual display unit (VDU) work, and incorporates biomechanical, psychosocial and cognitive factors. This model shows that musculoskeletal pain can be traced ultimately to the nature of work technology, which includes both the nature of tools and work systems. The work technology has a direct path to physical demands as defined by the physical coupling between the worker and the tool and also a direct path to work organization. The pathway from work organization to physical demands suggests that the physical demands of work are influenced by organizational demands; e.g. increased specialization leads to increased repetition. This model also shows a direct path between the work organization and psychosocial exposures, which, in turn, influences musculoskeletal outcomes in two ways. Psychosocial exposure is hypothesized to produce muscle tension, and possibly other autonomic effects, which compound physical exposures induced by physical demands. The model also suggests that the relationship between physical exposures and the development of musculoskeletal symptoms is mediated by a complex of cognitive processes involving the detection and labeling of somatic symptoms. In the model (Figure 1), the effects of physical, psychosocial and individual factors are described in terms of a continuum of events involving first the development of musculoskeletal symptoms, then symptom reporting effect on work ability and sickness absence.

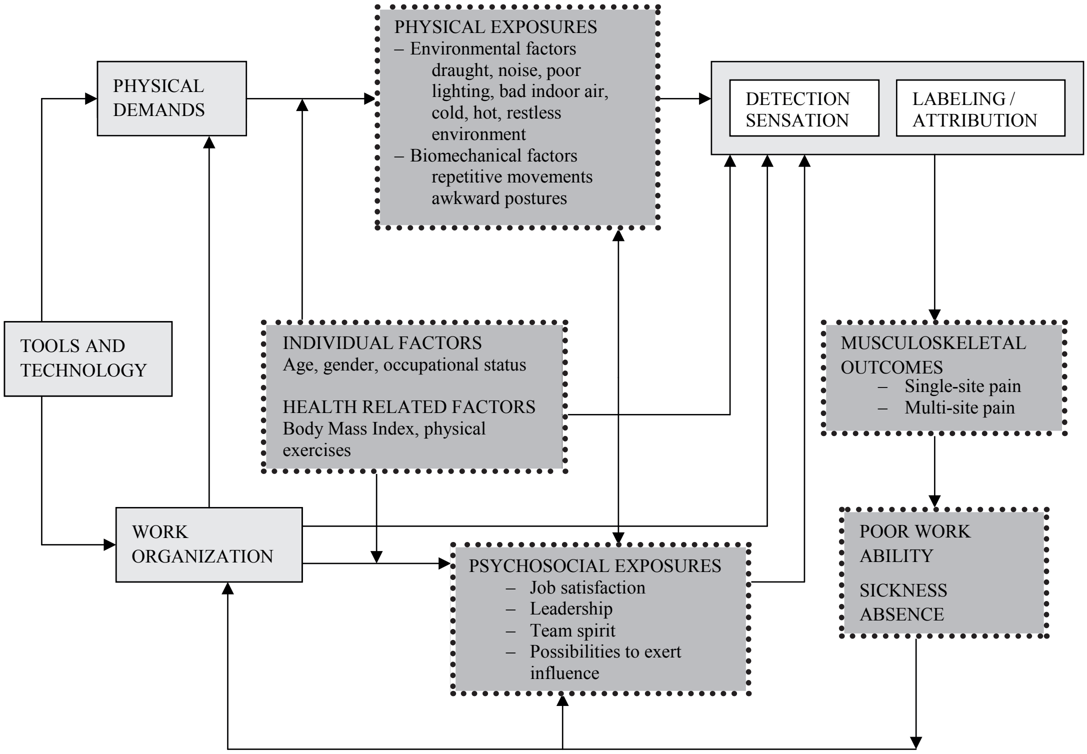

Figure 1: Theoretical framework of the study based on the conceptual model of work-related musculoskeletal disorders, adopted and modified from Sauter and Swanson (1996). Boxes with dashed lines show the measures used in the work at hand.

Study hypotheses based on the model

It was hypothesized that the baseline physical and psychosocial factors would predict multi-site pain at four-year follow-up when the effects of individual factors are controlled (Study I). Multi-site pain measured at baseline would predict poor work ability at follow-up separately and the combined effect with physical and psychosocial factors would be higher (Studies II–III). Finally, baseline multi-site pain would strongly predict long-term sickness absence due to MSD (Study IV).

4. AIMS OF THE STUDY

The main aim of this dissertation was to evaluate the occurrence of multi-site musculoskeletal pain, its determinants and consequences for work ability and sickness absences among employees in the Finnish food processing industry. The overall aim of the study was sub-divided into four sub-aims:

1. To investigate whether work-related physical and psychosocial factors at baseline predict and contribute to the persistence of multi-site pain at follow-up, whether these factors differ between men and women, and between younger and older workers (Study I).
2. To investigate whether the number of pain sites predicts poor work ability in a follow-up and whether the predictive effect differs by gender, age group or occupational status (Study II).
3. To examine the potential moderators of the association between multi-site musculoskeletal pain and poor work ability, and to examine whether and how physical and psychosocial exposures – separately and together with multi-site pain – predict poor work ability (Study III).
4. To analyse the impact of multi-site musculoskeletal pain on long-term sickness absence spells and days due to musculoskeletal diagnosis among blue- and white-collar employees (Study IV).

5. MATERIALS AND METHODS

5.1 General description of the study

The present study was based on a six-year follow-up of employees in a Finnish food processing Industry Company which began in 2003 and on the company's sickness absence registers (Virtanen et al. 2008). A questionnaire survey was conducted among all employees of the company in the first half of every second year starting from 2003. The questionnaires were distributed in the workplaces, filled in during the working hours, and the closed response envelopes were collected and sent to the researchers. The forms were not addressed to individual employees, thus no reminders could be sent. The respondents provided written consent for linking the survey data with data on age, gender and occupational status obtained from the personnel registers of the company. The study was financially supported by the Finnish Work Environment Fund. This study was approved by the ethics committee of Pirkanmaa Hospital District.

5.2 Subjects in Studies I–III

The subjects in Studies I, II and III were those who participated in the questionnaire survey conducted among all employees of the company in 2005 (N = 1,201, response rate 61%) and in 2009 (N = 1,398, response rate 72%). Of the respondents in 2005, 734 subjects (61 %) also participated in the survey in 2009.

5.3 Subjects in Study IV

The data for the Study IV was based on the companies' sickness absence register and questionnaires regarding musculoskeletal pain and work environmental factors. Information on age, gender and sickness absence diagnoses of all employees employed in the period 2005–2008 was obtained from the personnel register. In addition to the dates when the sickness absences started and stopped, the place at which the certificates were issued, as well as the diagnosis, according to the 10th revision of the International Classification of Diseases (ICD-10), was recorded to be used by occupational health care for statistics about the health of the personnel. The duration of job contract represents the "time at risk", from which the time absent from work for reasons other than sickness absences was subtracted.

5.4 Measurement of the variables

5.4.1 Multi-site musculoskeletal pain

Musculoskeletal pain was assessed by modified questions from the validated Nordic Musculoskeletal Questionnaire (Kuorinka et al. 1987) with a question on pain, ache or numbness in four anatomical areas (hands or upper extremities; neck or shoulders; low back and feet or lower extremities) during the preceding week on a scale from 0 (not at all) to 10 (very much). Each reply scale was dichotomised from the median (less than median: 0 = no, and more than median: 1 = yes). The cut-off values for pain in the upper extremities, neck and shoulder, low back and lower extremities were 4, 5, 2 and 2 respectively. All four dichotomised variables were summed and the sum variable was expressed in the number of areas with pain (from 0 = no pain to 4 = 4 pain sites). The dichotomous variable 'multi-site pain' was also created by further combining 2, 3 and 4 pain sites (0 and 1 pain site as 'no multi-site pain').

5.4.2 Work ability

Work ability was reported as an assessment of current work ability compared with a person's self-identified lifetime best (i.e. with the question "Assume that your work ability at its best has a value of 10 points. What score would you give your current work ability?"). This question is part of the seven-item Work Ability Index (Tuomi et al. 1998) and the currently used single item was strongly associated with the whole index (Ahlstrom et al. 2010). Work ability scores ranged from 0 (unable to work) to 10 (work ability at its best) and were categorized into four groups according to a cross-sectional population study (Gould et al. 2008), with the following cut-off points; excellent (score 10), good (score 9), moderate (score 8) and poor (scores 0–7) work ability. However, for the regression analysis, work ability was dichotomized as poor work ability (scores 0–7) and good work ability (scores 8–10).

5.4.3 Sickness absence

The sickness absence variable was measured as the rates per person-year for short (1–3 days) and long (4 or more days) spells, for sickness absence spells due to musculoskeletal diagnoses (4 or more days) and sickness absence days due to MSD. A physician's certificate was required for long-term sickness absence whereas short-term absences could be certified by a nurse or the worker him/herself in the case of white-collar workers.

5.4.4 Environmental factors

An index of environmental exposures at work was constructed from the questions concerning the occurrence of *draughts, noise, poor indoor climate, heat, cold, poor lighting* and *restless work environment* by summing the replies (scale from 1 = not at all to 5 = very much) into a score ranging from 7 to 35. The variable was then further categorized into 'low' (7–19) and 'high' (≥ 20) environmental exposure by the median value. The Cronbach's alpha of the index was 0.71.

5.4.5 Biomechanical factors

Biomechanical exposure was addressed with questions about the occurrence of *repetitive work* and *awkward work postures*, giving a choice on a 5-point (1 = not at all, 5 = very much) Likert scale. The variables were dichotomized by their median values to 'low' (1–2) and 'high' (≥ 3) exposure.

5.4.6 Psychosocial factors

Job satisfaction was assessed with a question 'how satisfied are you with your work?' on a scale 0 (totally dissatisfied) to 10 (highly satisfied) and classified to 3 equal categories from the tertiles for e.g. low (0–7), medium (8) and high (9–10).

Variables *incentive and participative leadership* (6 items, e.g.: "My manager pays attention to my suggestions and wishes), *team spirit* (6 items, e.g.: "My colleagues discuss improvements to work and/or the work environment) and *opportunities to exert influence at work* (5 items, e.g.: "The organization allows its employees an opportunity to set their own goals") were created by summing the response scores and divided by number of variables measured on a 5-point Likert scale from 1 (totally disagree/very probably not) to 5 (totally agree/very probably) (Ruohotie 1993). These three psychosocial factors were further categorized into three equal parts from their tertile values. The cut-off values for *incentive and participative leadership* were 3.16 and 3.83. Similarly, the cut-off values for *team spirit* were 3.16 and 3.66 also for the *opportunities to exert influence at work* were 3.00 and 3.60. The Cronbach's alphas of these measures from the reliability test varied between 0.68 and 0.85.

5.4.7 Covariates

Age, gender and occupational status (blue-collar and white-collar), body mass index (BMI) and the level of leisure-time physical activity were included in the analysis as covariates that may confound the relationships of work environmental factors and musculoskeletal pain with work ability. The level of physical activity during the past month was elicited on a scale from 0 (not at all) to 7 (vigorous physical activity for more than 3 hours a week).

The variables and their roles as outcomes, determinants or covariates and statistical analyses in the original studies are summarized in Table 4 below.

Table 4: Study subjects, outcomes, determinants and covariates and statistical analysis in the original studies

Study	Study design and subjects	Main outcomes	Determinants	Covariates	Statistical analysis
I	Four-year follow-up of 734 employees. Subjects with or without multi-site pain at baseline were analysed separately	Multi-site musculoskeletal pain at the follow-up with following categories: Multi-site pain: No Yes	Environmental exposures, Biomechanical exposures – repetitive movements – awkward postures Psychosocial factors – job satisfaction – team spirit – leadership – opportunities to exert influence at baseline year	Age, gender, occupational status, body mass index (BMI), physical exercise	Prevalence rates and odd ratios of the risk of multi-site musculoskeletal pain at follow-up due to baseline exposures. Logistic regression analysis was used.
II	Four-year follow-up of 734 employees. Subjects with or without poor work ability at baseline were analyzed separately	Poor work ability at the follow-up. Work ability was categorized as Work ability: Poor Good	Multi-site musculoskeletal pain at baseline No pain 1-site pain 2-site pain 3-site pain 4-site pain	Age, gender, occupational status, body mass index (BMI), physical exercise, environmental exposure, biomechanical exposures and psychosocial exposures at baseline	Risk of poor work ability after 4 years was predicted by odds ratios using binary logistic regression. Analyses were stratified by age and occupational status
III	Four-year follow-up of 734 employees. Only the subjects without poor work ability at baseline were analysed	Poor work ability at the follow-up. Work ability was categorized as Work ability: Poor Good	Multi-site pain (no, yes) was combined with work-related exposures to form a combined exposure with following category MSP/poor work-related exposures No/No Yes/No No/Yes Yes/Yes	Age, gender, occupational status, body mass index (BMI), physical exercise and work-related factors	Risk of poor work ability after 4 -years was predicted by odds ratios using binary logistic regression. Interaction of multi-site pain with work-related factors was tested.
IV	1,201 subjects who replied in the questionnaire survey 2005 were linked to the company's sickness absence register data from 2006–08.	Sickness absence: – Sickness absence spells due to MSD – Sickness absence days due to MSD	Multi-site musculoskeletal pain at the baseline No pain 1-site pain 2-site pain 3-site pain 4-site pain and Occupational status	Age, gender, environmental exposures and psychosocial exposures	Association of multi-site pain with sickness absence spells and days due to MSD was calculated as rate ratios by using GLM with negative binomial assumption. Analyses were also stratified by occupational status.

5.5 Statistical analysis

5.5.1 Descriptive statistics

A summary of the statistical analyses used in the original studies is presented in Table 4. In Studies II, III and IV means and frequency distributions were used to analyse the descriptive data. Pearson's chi-square test was used to study the difference in background characteristics, exposure and outcome between study subjects and those lost to follow-up in Study I.

5.5.2 Logistic regression analysis

Binomial logistic regression was the main modelling technique used to study the association between the work-related exposures and outcome variables in Studies I, II and III.

In Study I, logistic regression analysis was performed to examine whether baseline environmental exposure, biomechanical factors and psychosocial factors were associated with multi-site pain after four years of follow-up. The associations were presented as odds ratios and their 95% confidence intervals (95% CI). In addition to the whole cohort, analyses were conducted separately for those who had multi-site pain at baseline 'persistence of multi-site pain' and those with no multi-site pain at baseline 'onset of multi-site pain'. The models were built up in 3 steps: Model I: crude odds ratios, Model II: adjusted for age, gender and occupational status and lastly Model III: includes those covariates considered least likely to affect the association between the exposure and outcome variable such as the variables used to adjust for Model II and physical exercise and BMI.

In Study II, logistic regression analysis was conducted to examine whether baseline multi-site pain predicted the risk of poor work ability after four years of follow-up. Risks were presented as odds ratios and their 95% confidence intervals (95% CI). The results of the logistic regression analyses were calculated and presented for all employees and separately for those who did not have poor work ability in the baseline. The models were built up in 5 steps: Model I: crude odds ratios, Model II: adjusted for age, gender and occupational status, biomechanical factors and environmental exposures Model III: physical exercise and BMI, Model IV: job satisfaction, leadership, team spirit and opportunities to exert influence and Model V includes all the covariates from Model II, Model III and Model IV. These analyses were also performed stratified by gender, age-group and occupational status, (cut-off value median age, i.e., 42 years).

In Study III, the separate and combined effects of multi-site pain and various work-related exposures were calculated. New variables were created by combining the dichotomous variables into four category variables as follows: (i) neither multi-site pain nor adverse work exposure, (ii) multi-site pain but no adverse work exposure, (iii) no multi-site pain but adverse work exposure and (iv) multi-site pain and adverse work exposure. Logistic regression was performed to examine whether baseline multi-site pain or work factors separately or together predicted poor work ability at four-year follow-up. The regression analyses were restricted among those with 'non-poor work ability' at baseline. Odds ratios and their 95% confidence intervals (95% CI) were calculated. The models were built up in four steps: Model I: adjusted for age and gender, Model II: adjusted for the variables in Model I plus occupational status, Model III: adjusted for the variables in Model II plus physical or psychosocial variables at baseline and Model IV: adjusted for the variables in Model II plus leisure-time physical activity and body mass index. Age was included into the models as a continuous variable throughout the analyses. To assess if work exposures and multi-site pain modify each other's effects on work ability, p-values for their interactions were derived from the fully adjusted logistic regression models. The nature of those interactions was ascertained by stratification according to the level of psychosocial and physical factors.

The combined effect of workplace exposures on multi-site pain was also investigated by dichotomizing all seven exposures (low vs. medium/high) and summing the dichotomous variables. The sum index was categorized based on the distribution (number of exposures 0–2 = low, 3–5 = medium, 6–7 = high).

5.5.3 Generalized Linear Models (GLM)

In Study IV, individual person-years representing "days at risk for sickness absences" was calculated from the personal register. Generalized Linear Models (GLM) with negative binomial distribution assumption was used to determine associations between the occurrence of multi-site pain and sickness absences (long-term sickness absences spells and days due to musculoskeletal diagnosis). GLM analysis was performed among all employees and also stratified by occupational status. Long-term sickness absence spells and sickness absence days were used as dependent variable and a "person–years" variable was used as offset variable in the GLM analysis. Rate ratios (RR) and 95% confidence intervals (CI) were estimated as a measure of association. The models were built up in three steps in each regression analysis: Model I: crude rate ratios, Model II: adjusted for age, gender and occupational status, Model III:

adjusted for all the factors in Model II plus psychosocial factors (leadership, team spirit and opportunities to exert influence) and environmental exposures.

All the analyses were carried out with the statistical package SPSS version 15.0 (for Studies I, II and III) and 19.0 for Study IV.

6. RESULTS

6.1 Basic characteristics of the study population (Studies I–IV)

Of the employees who participated in the follow-up study, 65% were female and 71% were involved in blue-collar occupations. Mean age of the employees was 40.95 years, ranging from 20 to 66 years. Less than one-fifth were the youngest age group workers while, 28% were in the age group 31–40, 33% in the age group 41–50 and 21% were in the oldest (51+ years) age group. The frequency of employees with body mass index (BMI) is shown in Table 5, according to the distribution, one-fourth of the employees had BMI less than 23.0 Kg/m^2 and slightly under one-fourth had BMI higher than 29.0 Kg/m^2. Less than half of the employees reported taking moderate physical exercise, while 22% reportedly took very little or no physical exercise in the month just before the survey. Table 5 also shows the level of physical and psychosocial exposure for all employees.

There were 63% female and 75% blue-collar employees (total 1,201) participants in Study IV. The mean age of the employees was slightly lower (40.64 years) than that of the employees who continued in the questionnaire survey in 2009 (Table 5).

Table 5: Basic characteristics of the study population at baseline year 2005

	Studies I–III		Study IV	
	N=734	%	N =1201	%
Gender				
Female	480	65	759	63
Male	254	35	442	37
Age (years)				
20–30	132	18	259	22
31–40	206	28	349	29
41–50	244	33	303	27
51+	152	21	290	22
Occupational status				
Blue-collar workers	524	71	901	75
White-collar workers	210	29	300	25
BMI (kg/m^2)				
<23.0	180	25	308	26
23.0–25.9	230	31	347	29
26.0–28.9	153	21	241	20
>29.0	171	23	305	25
Physical exercise				
Not at all or only little	164	22	271	23
Moderate	324	45	524	44
Much	246	33	406	33
Physical working conditions (mean, SD)				
Environmental factors (7–35)	18.0 (5.5)	–	18.4 (5.5)	–
Biomechanical factors				–
Repetitive movements (1–5)	3.1 (1.3)	–	3.1 (1.3)	–
Awkward postures (1–5)	2.9 (1.3)	–	3.0 (1.2)	–
Psychosocial factors (mean, SD)				
Job satisfaction † (0–10)	7.4 (1.8)	–	7.3 (1.9)	–
Leadership (1–5)	3.5 (0.7)	–	3.4 (0.7)	–
Team Spirit (1–5)	3.5 (0.7)	–	3.4 (0.7)	–
Opportunities to exert influence (1–5)	3.4 (0.7)	–	3.4 (0.7)	–

† Used only in Studies I and II

6.2 Occurrence of multi-site pain (Study I)

The distribution and occurrence of multi-site pain among the employees at baseline and follow-up year are shown in Table 6. More than one fourth did not have any pain at baseline, 15% had pain at one site, 20% in two sites, 15% in three sites and 22% had pain at four sites at baseline. Multi-site pain (counting pain at two or more sites) was found among 57% of the employees at baseline, while at follow-up 51% reported pain at more than one site. About one-third of the respondents did not have multi-site pain. Among those with multi-site pain at baseline, the persistence of multi-site pain at follow-up was 69% (data not shown). Figure 2 shows a histogram of the differences in the total number of pain sites between 2005 and 2009. The difference in the total number of pain sites had increased during the follow-up year. Figure 3 shows the prevalence of multi-site pain in different age groups of employees at follow-up. Pain (either only one site or multi-site) increased continuously, peaked in middle age (41–50 years) and started to decrease in older age. Pain at four sites was very common among employees aged 41–50.

Table 6: Distribution and occurrence of outcome variables

	Baseline year 2005		Follow-up year 2009	
Outcome variables	**N**	**%**	**N**	**%**
Study-I (N=734)				
Multi-site pain				
– no pain [†]	213	28	237	32
– one site	108	15	127	17
– two sites	147	20	125	17
– three sites	107	15	94	13
– four sites	159	22	151	21
Studies II & III (N=734)				
Work ability				
Poor	106	15	161	22
Moderate	235	32	228	31
Good	274	37	238	33
Excellent	119	16	107	14
Study IV (N=1201)				
Long-term sickness absence (≥4 days)				
Spells per person year	–	–	1.32	
Spells due to MSD	–	–	0.60	
Sickness absence days				
Per person year	–	–	68.41	
Due to MSD per person year	–	–	25.43	

[†] Includes missing values

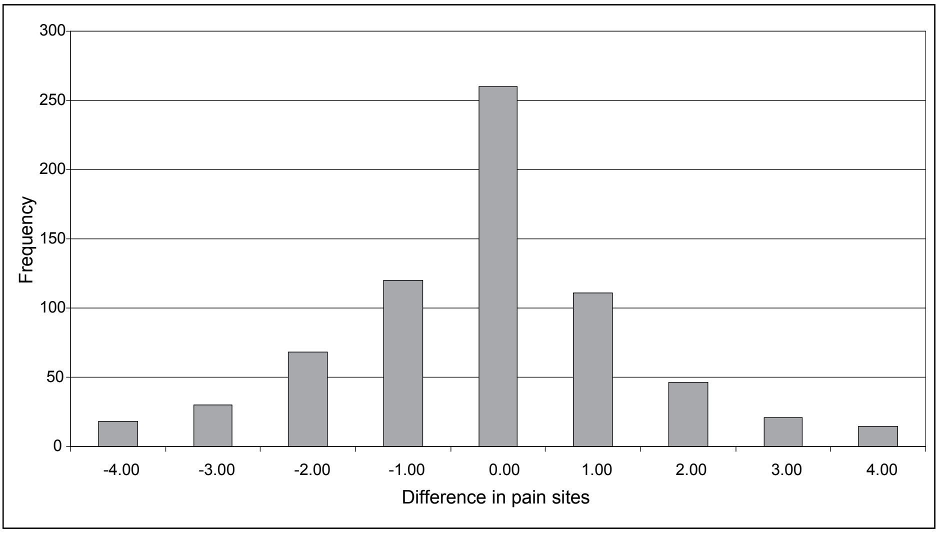

Figure 2: Distribution of the differences between number of pain sites in 2005 and 2009

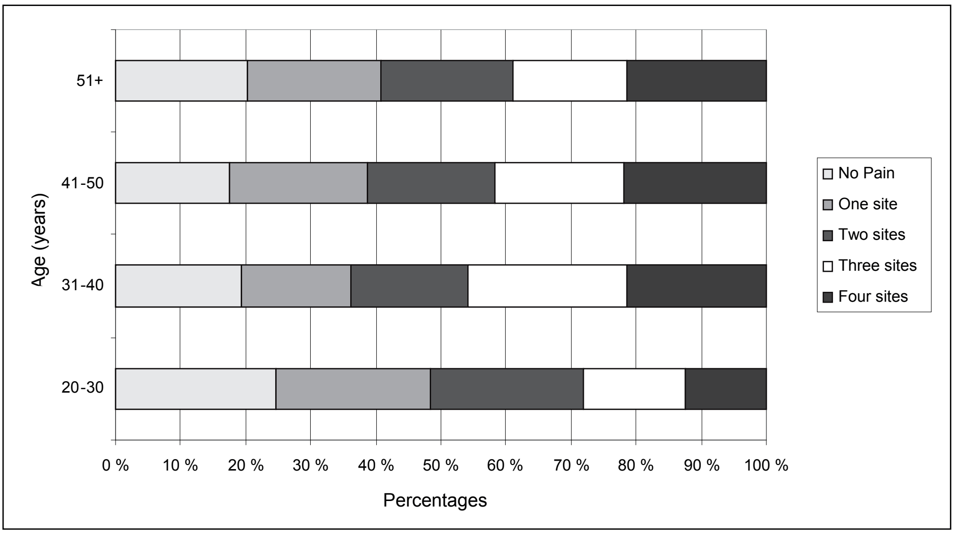

Figure 3: Multi-site pain in the follow-up year in different age groups

6.3 Work ability as an outcome (Studies II and III)

The distribution of poor, moderate, good and excellent work ability at baseline and at follow-up year are presented in Table 6. Among the 734 subjects, 106 subjects (15%) reported poor work ability at baseline, while 16% reported that their work ability was excellent. In the follow-up year, poor work ability increased by 7%, while excellent work ability was decreased by 2%. In the follow-up year poor work ability was more prevalent among older employees than their younger counterparts (25% vs. 20%) (data not shown). Work ability at follow-up among all employees in different age groups showed that poor work ability improved slightly until middle age (41–50 years) and rapidly declined in old age (Figure 4). Similarly, excellent work ability increased with decreasing age. Figure 5 shows the association of work ability at follow-up with the number of pain sites at baseline. Poor work ability became more common as the number of pain sites increased. Similarly excellent work ability was more prevalent among those with no pain at baseline.

6.4 Sickness absence as an outcome (Study IV)

In the period 2005–2008, altogether 5,449 short spells, 4,052 long spells due to any reason, 1,979 MSD spells (4 or more days) and 25,765 MSD days of sickness absence were recorded for 1, 201 participants. About 65% had at least one episode of long-term sickness absence and more than 40% had sickness absence spells (more than 4 days) at least once due to MSD. During the study period, sickness absence was recorded at 68.41 days per person-year, and 25.43 days per person-year due to MSD.

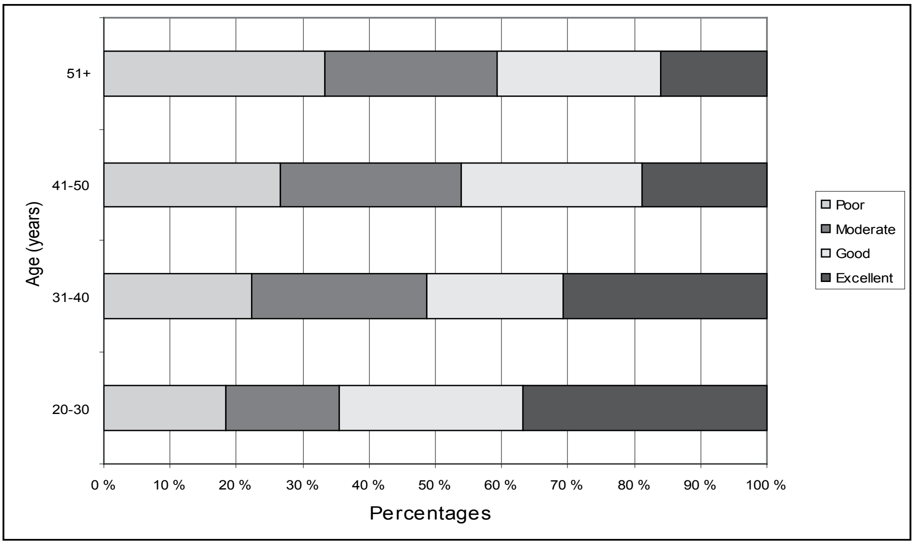

Figure 4: Work ability for amployees at follow-up in different age groups

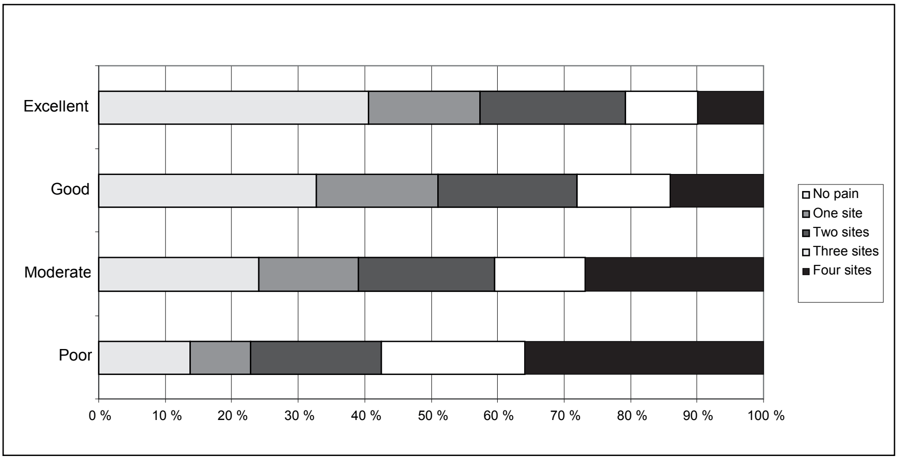

Figure 5: Multi-site pain at baseline and work ability after four years of follow-up

6.5 Determinants of multi-site pain (Study I)

Table 7: Odds ratios with 95% CI for multi-site pain at follow-up year related to baseline variables among all employees

	All	No. of	OR (95% CI)			
	N=734	cases†	Model I	Model II	Model III	Model IV
Physical working condition						
Environmental factor						
Low	248	100	1.0	1.0	1.0	1.0
Medium	259	123	1.4 (0.9–1.9)	1.3 (0.9–1.9)	1.4 (1.0–2.0)	1.1 (0.7–1.7)
High	213	141	3.0 (2.0–4.4)	2.8 (1.9–4.3)	3.2 (2.1–4.8)	1.7 (1.1–2.8)
Biomechanical factors						
Repetitive work						
Low	239	77	1.0	1.0	1.0	1.0
Medium	220	115	2.3 (1.5–3.3)	2.2 (1.5–3.3)	2.5 (1.7–3.7)	1.6 (1.0–2.5)
High	273	178	4.0 (2.7–5.8)	4.0 (2.6–6.0)	4.2 (2.9–6.2)	2.1 (1.4–3.4)
Awkward work postures						
Low	267	94	1.0	1.0	1.0	1.0
Medium	235	121	2.0 (1.4–2.9)	2.1 (1.4–3.2)	2.3 (1.6–3.3)	1.6 (1.0–2.6)
High	230	154	4.1 (2.8–6.0)	4.6 (3.0–7.2)	4.2 (2.8–6.2)	2.2 (1.3–3.7)
Psychosocial factors						
Job satisfaction						
High	182	75	1.0	1.0	1.0	1.0
Medium	267	123	1.2 (0.8–1.8)	1.2 (0.8–1.8)	1.3 (0.9–1.9)	1.0 (0.6–1.5)
Low	283	172	2.3 (1.6–3.4)	2.4 (1.6–3.6)	2.3 (1.5–3.4)	1.5 (0.9–2.3)
Leadership						
Good	253	109	1.0	1.0	1.0	1.0
Intermediate	214	120	1.0 (0.7–1.4)	0.9 (0.6–1.3)	1.1 (0.7–1.6)	0.9 (0.6–1.4)
Poor	240	140	1.3 (0.9–2.0)	1.3 (0.9–1.9)	1.3 (0.9–2.0)	1.1 (0.7–1.7)
Team spirit						
Good	275	122	1.0	1.0	1.0	1.0
Intermediate	174	101	0.9 (0.7–2.3)	0.8 (0.6–1.2)	1.0 (0.7–1.4)	1.1 (0.7–1.8)
Poor	258	147	1.6 (1.1–2.3)	1.3 (0.9–2.0)	1.6 (1.1–2.4)	1.1 (0.7–1.6)
Opportunities to exert influence						
Good	232	89	1.0	1.0	1.0	1.0
Intermediate	246	123	1.7 (1.2–2.5)	1.7 (1.1–2.5)	1.6 (1.1–2.4)	1.4 (0.9–2.2)
Poor	253	156	2.6 (1.8–3.8)	2.5 (1.6–3.8)	2.6 (1.8–3.8)	1.7 (1.1–2.7)

Model I: crude odds ratios
Model II: adjusted for age, gender and occupational status
Model III: Model II + physical exercise and body mass index
Model IV: Model III + baseline pain

† No. of subjects with multi-site pain at follow-up

Table 7 shows the unadjusted and adjusted risks for multi-site pain at follow-up related to baseline physical and psychosocial risk factors among all employees. Physical work exposures (environmental exposure, repetitive task and awkward work postures) at baseline were strongly associated with multi-site pain at follow-up with a dose-response relationship. The highest risk increases were related to the high exposure to repetitive work and awkward work postures, more than 4-fold (adjusted OR for repetitive work = 4.2, 95% CI 2.9–6.0, and for awkward work postures 4.2, 95% CI 2.8–6.0). Low job satisfaction, low team spirit and few opportunities to exert influence at work at baseline also strongly predicted multi-site pain. Few opportunities to exert influence especially increased the risk of multi-site pain at follow-up, with an adjusted odds ratio of 2.6 (95% CI 1.8–3.8). In general, adjustment for age, gender and occupational status affected the risks minimally, if at all. Further adjustment for BMI and physical exercise mainly strengthened the risks. When baseline pain was also controlled for, the risks diminished but remained elevated for physical exposures and opportunities to exert influence at work.

Biomechanical factors such as repetitive work and awkward work postures were consistently associated with both onset of MSP among those with no MSP at baseline and also the persistence of MSP throughout each adjustment. Environmental exposure was associated with only onset of MSP while opportunity to exert influence was associated with persistence of MSP after adjusting for several confounding factors.

Table 8: Risk of multi-site pain at follow-up related to the number of exposures at baseline (sum index of environmental, biomechanical and psychosocial exposures) among all employees

	All N=734	No. of cases†	OR (95% CI)			
			Model I	Model II	Model III	Model IV
No. of exposures						
0–2 (low)	123	37	1.0	1.0	1.0	1.0
3–5 (medium)	257	128	2.3 (1.5–3.6)	2.5 (1.5–4.0)	2.7 (1.6–4.4)	1.8 (1.1–3.0)
6–7 (high)	312	198	4.0 (2.6–6.3)	4.6 (2.7–7.7)	4.9 (2.9–8.3)	2.2 (1.2–4.0)

Model I: crude odds ratios
Model II: adjusted for age, gender and occupational status
Model III: Model II + physical exercise and body mass index
Model IV: Model III + baseline pain
† No. of subjects with multi-site pain at follow-up

Table 8 indicates a strong dose-response relationship between workplace exposures at baseline and multi-site pain at follow-up.

6.6 Predictors of poor work ability at follow-up (Studies II and III)

Adjusted risk estimates of poor work ability at follow-up in relation to baseline multi-site pain, psychosocial exposures and their combinations among all employees are shown in Table 9. In the fully adjusted Model III, an increased risk of future poor work ability was either due to the presence of multi-site pain or both exposures except for job satisfaction. In the adjusted models, multi-site pain increased the risk of future poor work ability with OR of 2.6 (95 % CI 1.4–5.2) when leadership was assessed to be good, with OR of 1.8 (95% CI 1.0–3.3) when opportunities to exert influence at work were good, and with OR of 3.1 (95% CI 1.7–5.7), when team spirit was good. Poor job satisfaction in the absence of multi-site pain also predicted poor work ability at follow-up even more strongly than multi-site pain alone (Model III: OR = 3.4, 95% CI 1.7–7.0). However, poor leadership, poor opportunities to exert influence and poor team spirit were not predictive of poor work ability separately from multi-site pain when all covariates were considered.

Table 9: Separate and combined effects of multi-site musculoskeletal pain (MSP) and psychosocial working conditions on poor work ability at follow-up among all employees. Logistic regression analysis, odds ratios (OR) with 95% confidence intervals

	All subjects (N =734)	No. of subjects with poor work ability (%)	OR (95%CI)		
			Model I	Model II	Model III
MSP / Poor Job Satisfaction					
No / No	236	21 (9)	1.0	1.0	1.0
Yes / No	215	49 (23)	3.0 (1.7–5.2)	2.7 (1.5–4.7)	2.9 (1.6–5.2)
No / Yes	85	22 (26)	3.6 (1.8–6.9)	3.2 (1.6–6.3)	3.4 (1.7–7.0)
Yes / Yes	198	69 (35)	5.5 (3.2–9.4)	4.6 (2.5–8.3)	5.0 (2.6–9.3)
MSP / Poor leadership					
No / No	163	16 (10)	1.0	1.0	1.0
Yes / No	179	45 (25)	3.1 (1.7–5.7)	2.5 (1.3–4.8)	2.6 (1.4–5.2)
No / Yes	155	26 (17)	1.9 (1.0–3.6)	1.5 (0.8–3.1)	1.6 (0.8–3.2)
Yes / Yes	237	74 (31)	4.2 (2.3–7.5)	3.1 (1.6–5.7)	3.2 (1.7–6.2)
MSP / Poor opportunities to exert influence					
No / No	180	23 (13)	1.0	1.0	1.0
Yes / No	200	50 (25)	2.3 (1.3–3.9)	2.0 (1.1–3.5)	1.8 (1.0–3.3)
No / Yes	141	20 (14)	1.1 (0.6–2.1)	1.1 (0.5–2.1)	0.9 (0.5–1.9)
Yes / Yes	213	68 (32)	3.2 (1.9–5.4)	2.5 (1.4–4.5)	2.5 (1.4–4.6)
MSP / Poor team spirit					
No / No	208	22 (11)	1.0	1.0	1.0
Yes / No	193	53 (28)	3.2 (1.9–5.5)	2.8 (1.6–5.1)	3.1 (1.7–5.7)
No / Yes	114	21 (18)	1.9 (1.0–3.6)	1.6 (0.8–3.2)	1.8 (0.9–3.8)
Yes / Yes	219	65 (30)	3.6 (2.1–6.1)	2.6 (1.4–4.8)	2.9 (1.5–5.5)

Model I: Crude odds ratios

Model II: age, gender, occupational status, biomechanical factors and environmental exposure at baseline

Model III: Model II + physical exercise and BMI

Table 10 shows the adjusted risk estimates of poor work ability at follow-up in relation to baseline multi-site pain, biomechanical and work environmental exposures, and to the combinations of multi-site pain with these exposures. Work environmental exposures (Model III, OR = 2.4, 95% CI 1.2–5.2) and awkward postures (OR = 5.8, 95% CI 2.4–14.5) as well as multi-site pain (OR = 3.6, 95% CI 1.9–6.6 and OR = 7.0, 95% CI 2.8–17.2 respectively) were separately predictive of poor work ability. The combined effect of multi-site pain with poor work environment or awkward postures was normal in size compared with the separate effects in the fully adjusted models. Exposure to repetitive movements did not influence work ability after adjusting for all covariates, while the combination of multi-site pain with repetitive movement influenced work ability (OR = 3.8, 95% CI 2.0–7.5).

Table 10: Separate and combined effects of multi-site musculoskeletal pain (MSP) and physical working conditions on poor work ability at follow-up among all employees. Logistic regression analysis, odds ratios (OR) with 95% confidence intervals (CI)

	All subjects (n =734)	No. of subjects with poor work ability (%)	OR (95%CI)		
			Model I	Model II	Model III
MSP / Poor work environment					
No / No	222	21 (10)	1.0	1.0	1.0
Yes / No	175	45 (26)	3.3 (1.9–5.8)	3.3 (1.8–6.0)	3.6 (1.9–6.6)
No / Yes	99	22 (22)	2.7 (1.4–5.3)	2.1 (1.0–4.3)	2.4 (1.2–5.2)
Yes / Yes	238	73 (31)	4.2 (2.5–7.2)	3.2 (1.8–5.8)	3.5 (1.9–6.5)
MSP / Awkward postures					
No / No	167	9 (5)	1.0	1.0	1.0
Yes / No	102	25 (25)	5.7 (2.5–12.8)	6.0 (2.6–14.2)	7.0 (2.8–17.2)
No / Yes	154	34 (22)	5.0 (2.3–10.8)	4.8 (2.1–11.4)	5.8 (2.4–14.5)
Yes / Yes	311	93 (30)	7.5 (3.7–15.3)	7.0 (3.1–15.5)	7.8 (3.3–18.3)
MSP / Repetitive movements					
No / No	159	16 (10)	1.0	1.0	1.0
Yes / No	82	19 (23)	2.7 (1.3–5.6)	2.6 (1.2–5.6)	3.0 (1.4–6.7)
No / Yes	162	27 (17)	1.8 (0.9–3.5)	1.6 (0.8–3.4)	2.0 (0.9–4.4)
Yes / Yes	331	99 (30)	3.8 (2.2–6.7)	3.4 (1.8–6.3)	3.8 (2.0–7.5)

Model I: Crude odds ratios
Model II: age, gender, occupational status and psychosocial factors at baseline
Model III: Model II + physical exercise and BMI

6.7 Association of sickness absence with MSP (Study IV)

Table 11 shows the rate ratios for sickness spells due to MSD. The graded association of long spells due to MSD with multi-site pain was found in crude rate ratios (Model I). Employees with 4-site pain had 2.31-fold more probability of having long-term sickness spells due to MSD (RR = 2.31, 95% CI 1.85–2.87). However, when the model was adjusted for age, gender and occupational status then only three and four-site pain remained significantly associated with sickness absence spells due to MSD. The trend remained consistent when further adjustment was made for physical and psychosocial factors (Model III) and all factors together (Model IV).

Table 11: Rate ratio (RR) and 95% confidence intervals (CI) for sickness absence spells due to MSD with multi-site pain

	Sickness absence spells due to MSD, RR (95% CI)			
	Model I	Model II	Model III	Model IV
Multi-site pain				
– no pain	1.0	1.0	1.0	1.0
– one site	1.15 (0.89–1.48)	1.03 (0.79–1.35)	1.12 (0.86–1.46)	1.01 (0.77–1.34)
– two sites	1.47 (1.16–1.87)	1.25 (0.97–1.60)	1.27 (0.99–1.63)	1.17 (0.90–1.52)
– three sites	2.28 (1.79–2.89)	2.03 (1.58–2.61)	1.61 (1.24–2.09)	1.74 (1.32–2.28)
– four sites	2.31 (1.85–2.87)	1.74 (1.39–2.20)	1.60 (1.25–2.04)	1.47 (1.14–1.89)

Model I: crude odds ratio
Model II: adjusted for age, gender and occupational status
Model III: adjusted for physical and psychosocial factors
Model IV: adjusted for Model II + Model III

Table 12 shows the rate ratios for sickness absence days due to MSD. Employees with four-site pain had 2.41-fold risk of having sickness absences due to MSD than those with no pain (RR = 2.41, 95% CI 2.01–2.90). After adjusting for age, gender and occupational status in Model II, the association became weaker but still remained significant except for one-site pain. However, one-site pain was associated with sickness absence days due to MSD when further adjustment was made with physical and psychosocial factors at work (Model III). The association became still weaker when all the variables were adjusted together in the full model (Model IV).

Table 12: Rate ratio (RR) and 95% confidence intervals (CI) for sickness absence days due to MSD with multi-site pain

	Sickness absence days due to MSD, RR (95% CI)			
	Model I	Model II	Model III	Model IV
Multi-site pain				
– no pain	1.0	1.0	1.0	1.0
– one site	1.18 (0.96–1.44)	1.02 (0.83–1.26)	1.32 (1.07–1.63)	1.06 (0.85–1.31)
– two sites	2.07 (1.71–2.50)	1.41 (1.15–1.73)	1.96 (1.61–2.39)	1.32 (1.07–1.64)
– three sites	2.10 (1.72–2.57)	1.87 (1.51–2.30)	1.65 (1.34–2.03)	1.61 (1.26–2.01)
– four sites	2.41 (2.01–2.90)	1.82 (1.50–2.21)	1.87 (1.53–2.27)	1.60 (1.30–1.97)

Model I: crude odds ratio
Model II: adjusted for age, gender and occupational status
Model III: adjusted for physical and psychosocial factors
Model IV: adjusted for Model II + Model III

Associations of MSP with sickness absence spells and days due to MSD were found to be strong among both white-collar and blue-collar employees. However, a threshold in the rate ratios was found between two-site and three-site pain among white-collar employees, whereas among blue-collar employees the threshold was rather between one-site and two-site pain (data not shown).

7. DISCUSSION

7.1 Summary of findings

Multi-site musculoskeletal pain was very common in this study population (57% prevalence). Baseline physical and psychosocial factors at work predicted MSP four years later. MSP at baseline had a strong association with poor self-perceived work ability. MSP had a clear separate impact on poor work ability, which was stronger than the combined effects including working conditions. MSP also strongly predicted long-term sickness absence spells and days due to MSD among both white-collar and blue-collar employees.

7.2 Comparison with earlier studies

7.2.1 Occurrence of multi-site pain

This follow-up study corroborates the current evidence that musculoskeletal pain at multiple body sites is currently a common and persistent phenomenon among working people. More than two-thirds of the employees in this study reported multi-site pain either at the beginning or the end of the 4-year follow-up period, and 40% had multi-site pain at both time points. This finding that multi-site pain was common in this study population is consistent with the findings of earlier studies (Haukka et al. 2006; Solidaki et al. 2010). Among municipal kitchen workers in Finland, 73% of the workers reported pain at at least two sites during the preceding three months (Haukka et al. 2006). Multi-site pain during the preceding12 months was also reported to be as common as 66% among Greek employees (Solidaki et al. 2010). Among a representative sample of actively working Finnish adults, multi-site pain was reported by 34% of the sample (Miranda et al. 2010). Another population based study from the UK also found that multi-site pain was reported by 33% of the study sample (Carnes et al. 2007). Among the general working population of Norway, Kamaleri et al. (2008a) reported 52% prevalence of multi-site pain. In the present study, of those with multi-site pain at baseline, 69% also experienced persistent pain at follow-up. This shows that multi-site pain is likely to persist once established (Kamaleri et al. 2009; Papageorgiou et al. 2002). Multi-site pain also had a high persistence rate: 84% of the workers with multi-site pain at baseline reported it at two-year follow-up (Haukka et al. 2012). The average number of pain sites appears to be established by age 20 and little variation occurs thereafter (Croft, 2009; Kamaleri et al. 2009). About 15% of the employees in this study had new onset of multi-site pain at follow-up. Among the cohorts of newly employed workers in UK, the new onset rate of widespread pain was also 15% at 12 months and 12% at 24 months (Harkness et al. 2004). More than one-fourth of the employees did not have pain at baseline while at follow-up the number increased to almost one-third.

Among different age groups of employees, those aged 20–30, 31–40, 41–50 and 51+ years, the occurrence of MSP at follow-up was 46, 57, 57 and 55% respectively. Similarly among male employees the occurrence of MSP at follow-up was less than among females (48% vs. 58%). A difference in the occurrence of MSP among males and females was also reported in some earlier studies. Among the general population of Norway, Kamaleri et al. (2008a) reported that 62% of females and 45% of males had experienced MSP during the past week. Widespread pain was more often reported by women than men among the general population in another study (Øverland et al. 2011). Blue-collar employees reported MSP more often than white-collar employees (58% vs. 47%) (data not shown).

A study from Finland showed earlier that pain is a very common complaint among Finnish population. One third of the people aged 15–74 years reported experiencing chronic pain. In the same study one week prevalence of any pain was reported to be 79.5% (Turunen, 2007). In this dissertation one week prevalence of any pain was reported by 72% of the employees in the baseline year. The results are somewhat comparable although this study was among industrial employees in the age group 20–64 years.

7.2.2 Determinants of multi-site pain

The result of this study shows a dose-response relationship between exposures at work and multi-site pain. Biomechanical factors, such as repetitive work and awkward work postures as well as psychosocial factors, such as low job satisfaction and poor opportunities to exert influence at work, showed an equally strong graded association with multi-site pain at follow-up. Environmental exposures also increased the risk of multi-site pain. Several earlier studies have also found that work-related mechanical, psychosocial, environmental (Harkness et al. 2004), and psychosocial factors (Solidaki et al. 2010) predict multi-site pain among employees. There is evidence that exposure to repetitive motion patterns; forceful exertion and body postures (both dynamic and static) may cause musculoskeletal disorders at single or multiple anatomical sites (Punnett and Wegman 2004). Baseline awkward work posture was the strongest predictor (adjusted OR = 2.2, 95% CI 1.3–3.7) of MSP at follow-up among all employees in our study. Awkward posture remained the strongest predictor (adjusted OR = 4.2, 95% CI 1.9–9.3) of MSP at follow-up among the employee cohort who had no multi-site pain at baseline. Among female kitchen employees who perceived their physical workloads to be high at baseline had an increased risk (OR = 4.6, 95% CI 2.2–9.7) of multi-site pain at two-year follow-up (Haukka et al. 2012). High perceived physical workload also increased the risk of MSP with odds ratios increasing 2–4-fold with increasing number of pain sites among dentists (Alexopoulos et al. 2004). Solidaki et al. (2010) also found a strong and graded relationship of the combination of various physical exposures with number of pain sites among Greek employees. In their study, the physical exposure was composed of heavy lifting, working with hands above the shoulder level, repeated bending and straightening of the elbow, repeated wrist-hand movements, and kneeling, squatting or climbing stairs. We found strong graded associations with MSP in our study after four years when all the exposure variables at baseline were combined.

In our study psychosocial factors, especially low job satisfaction and poor opportunities to exert influence (corresponding to job control), predicted pain at multiple body sites in four years of follow-up. Our findings are consistent with some earlier studies. Low job control and low supervisor support were the strongest predictors of multi-site pain 3 months later among kitchen workers (Haukka et al. 2011). Among newly employed workers, low job satisfaction and low social support increased the risk of widespread pain 2 years later (Harkness et al. 2004). Intermediate (OR = 2.9, 95% CI 1.4–6.0) and high (OR = 2.2, 95% CI 1.0–4.5) levels of adverse psychosocial factors at work at baseline also increased the risk of MSP at follow-up (Haukka et al. 2012).

Among the lifestyle factors, high BMI, low leisure-time physical activity and smoking were also associated with MSP at baseline in Norwegian population (Kamaleri et al. 2009). Low and moderate leisure-time physical activity at baseline and obesity were connected with a persistently high prevalence of MSP among kitchen workers in Finland (Haukka et al. 2012). However, we did not find any significant impact of BMI and leisure-time physical activity on MSP in our study.

7.2.3 Consequences of MSP and working conditions for work ability

The results of this study showed that poor self-perceived work ability was considerably more common among employees over the four years of follow-up (about 50% increase in prevalence) and that the number of concurrent painful body sites is a strong predictor of future self-perceived poor work ability. Multi-site pain at baseline increased the risk of poor work ability even after controlling for baseline work ability and after exclusion of those with poor work ability at baseline. Moreover, the relatively minor confounding effect of the various covariates (including several work-related confounders), as well as the dose-response increase in the risks further strengthen the evidence that multiple-site pain is a strong predictor of poor work ability. The results of our studies are consistent with earlier findings. Multi-site pain predicted work disability and disability pension for any health reason 14 years later in a study by Kamaleri et al. (2009). The risk of reporting poor work ability due to MSP was also higher (age and gender adjusted prevalence ratio up to 8) among the general population of Finland (Miranda et al. 2010). Natvig et al. (2010) also reported that widespread pain was associated with disability. Widespread pain was a very strong predictor for later disability pension even after adjusting for several confounders (Øverland et al. 2011).

The separate and combined effect of multi-site pain and exposures to adverse physical and psychosocial working conditions shows that MSP has a marked influence on the development of work ability, and even though several psychosocial and physical factors are strongly related to poor work ability among workers without multiple pain symptoms, they contribute relatively little to the considerably elevated risk of poor work ability among workers with multi-site pain. The contribution was mainly derived from poor leadership and team spirit, high awkward work postures and repetitive work. For example, a 2.6-fold risk of poor work ability at follow-up among workers with multi-site pain increased up to 3.3-fold when they were also exposed to poor leadership. The results of our study also support findings showing that high physical workload and high environmental exposures increase the risk of poor work ability (van der Berg et al. 2009). Current work performance, health problems and associated consequences for functioning and sick leave, work-related physical and psychosocial factors were found to be the important predictive factors of lower work ability among Dutch construction workers (Alavinia et al. 2009). In another study on female workers, poor self-perceived physical health and unskilled work were the strongest factors associated with reduced work ability (Gamperiene et al. 2008). Another study from a Finnish food industry company showed that long-term exposure to cold working conditions may constitute a risk for work ability impairment (Sormunen et al. 2009).

7.2.4 Consequences of MSP for sickness absence

The results of this study showed that multi-site musculoskeletal pain predicts long term sickness absence spells and also strongly predicts sickness absence days due to musculoskeletal diagnosis (MSD).

A previous study from Norway among workers in the aluminium industry showed that widespread pain and low back pain were the strongest predictors for long-term sickness absences due to musculoskeletal disorders (Morken et al. 2003; Holtermann et al. 2010). In general, the prevalence of long-term sickness absence and sickness absence spells and days due to MSD was found to be high in our study. The importance of preventing pain (especially multi-site pain) to decrease sickness absence was emphasized in an earlier study (Schell et al. 2012). They found that workers with no history of sickness absence experienced less work-related pain, less stress, sleep disturbance, and worry about their own health etc.

Blue-collar workers had an increased risk compared to white-collar workers for short and long-term sickness absence due to widespread musculoskeletal pain in one earlier study among industrial workers (Morken et al. 2003). By contrast, Andersen et al. (2011) found a stronger association of multiple site pain with long-term sickness absence in white-collar workers than in their blue-collar counterparts. Interestingly, our study found a strong association of multi-site pain with sickness absence spells among both white-collar and blue-collar employees. However, the size of the effect of association of multi-site pain with sickness absence days was slightly higher among white-collar employees. A threshold in the association was obtained between two-site and three-site pain among white-collar employees, whereas in blue-collar employees the threshold was rather between one-site and two-site pain.

In our study, the effect of multi-site pain on short-term sickness absence seemed to be minor although the prevalence of short-term absence periods was high. Short-term sickness absence is assumed to be related to minor or incipient health problems, whereas long-term absence is typically thought to reflect unavoidable work disability related to serious impairment (Marmot et al. 1995; Vahtera et al. 2004).

7.3 Strengths and limitations of the study

One of the excellences of this study is its follow-up in a prospective design. Another advantage is that our study populations were from diverse occupational groups, entailing an advantage over other observational epidemiologic study designs in investigating causal relationships. In each respective study, exposure variables were assessed prior to the measurement of the outcomes. The response rates to the surveys were satisfactory. However, the possibility of selection bias due to differential participation at baseline or at follow-up affected our results. Selection out of the workforce is more likely to occur among workers with health problems, as well as those with the highest exposure levels, leaving the healthiest workers at the workplaces, for instance to be selected in cohort studies like ours. Such a bias diminishes the associations between workplace exposures and health outcomes.

In one of the papers we used official register data combined with questionnaire survey data to study the association of sickness absence and multi-site musculoskeletal pain and other work-related variables. The use of register data makes it possible not only to obtain accurate figures regarding length and frequency of sickness absence but also to eliminate any recall bias.

The aim of this epidemiologic study was to examine the effect of exposure, but sometimes the apparent effect of exposure is actually the effect of another characteristic which is associated with the exposure and with the outcome. Theses other characteristics are a confounder provided that it is not an intermediate step between the exposure and the outcome (Szklo and Nieto, 2000). In each respective study, regression analyses were adjusted for several potential confounders. However, one weakness of this study is that we did not measure personal factors such as negative affectivity or tendency for somatization that can affect participant reporting behaviour for both exposure and outcome. They may cause systematic overestimations and bias the association between exposure and outcome. Information on smoking was not elicited in this study.

We also adjusted the analyses for corresponding outcome variables at baseline but the results from the model may be underestimations. This is due to the fact that, for instance, prior (baseline) pain is known to be the strongest predictor of future pain, and the same baseline exposures investigated in this study most likely also caused the baseline pain. Baseline corresponding outcome variable could then be considered as an intermediate variable between exposures and outcome at follow-up, and adjustment for intermediate variables would leave little power to determine the additional effects of baseline exposures on outcome variable at follow-up.

The subjects were asked to report pain that had occurred during the past 7 days. This timeframe increases the likelihood that pain had truly occurred at multiple body sites concurrently and also decreases the likelihood of recall bias. The perception of musculoskeletal pain, physical factors and psychosocial were assessed by questionnaire; no objective measurements were carried out. However, a self-report method appears to be the best (and practically only) way of assessing pain in epidemiological studies because of its complex and subjective nature (Crombie et al. 1999; Natvig et al. 2001). Work ability in this study was measured by a single item question. In addition to being a quick and cost-effective method, it has been shown to be valid especially for clinical use and its results are easy to interpret (Ahlstrom et al. 2010).

In addition to age, gender and occupational status, BMI and physical exercise were also considered as confounders since some studies have indicated that lifestyle factors are associated with the number of pain sites (Kamaleri et al. 2008a). The quality of the psychosocial variables was carefully assessed. The internal consistency of the measures of 'leadership', 'team spirit' and 'opportunities to exert influence' proved to be good.

7.4 Study findings in relation to the theoretical framework of the study

Musculoskeletal pain is not due to one single mechanism. Work exposure may act in different ways depending upon individual and other work-related factors. Several theories and models of work related musculoskeletal pain share many similarities (Karsh, 2006; Huang et al. 2002), however the main emphasis of each of the models is that physical or psychosocial work exposures lead to responses which are moderated by individual factors. One common limitation of all theories is that the magnitude and duration of an exposure that leads to certain responses or the length of the latency period between exposure and response is not well defined. Some of the theories have highlighted the role of psychological mechanisms in the development of musculoskeletal pain (Carayon et al. 1999), the working style (Feuerstein, 1996), and some have highlighted the influence of demands outside the workplace (Melin and Lundberg, 1997).

This study was based on a modified version of the ecological model by Sauter and Swanson (1996), which integrates three constituents: physical, psychosocial and individual factors. The model shows a pathway from physical factors to tissue damage to somatic interpretation. The model also suggests that the relationship between biomechanical factors (i.e. internal physiological events) and the development of musculoskeletal symptoms is mediated by a complex cognitive process which involves the detection and attribution of symptoms.

Musculoskeletal pain and physical and psychosocial factors seem to be reciprocally linked together in this current study. Individual differences may occur e.g. in pain sensitivity or in the manner of experiencing the physical and psychosocial working environment. Many factors come into play to modify the individual perception, such as coping mechanism, motivations, past history of pain, life experiences etc. The present results suggest that pain modifies the effect of working conditions (both physical and psychosocial) on work ability and sickness absence. The model modified from Sauter and Swanson (1996) also shows these reciprocal links between musculoskeletal disorders, work organization and psychosocial strain mediated by the cognitive process.

The perception of pain may also modify perceived physical working conditions. Leisure-time physical exercise may also influence pain perception.

8. CONCLUSIONS AND FUTURE IMPLICATIONS

1) This study provides new evidence of the frequent occurrence and persistence of musculoskeletal pain at multiple body sites in an industrial population. A dose-response relationship between physical and psychosocial working conditions and multi-site pain was found: biomechanical factors, such as repetitive work and awkward work postures, as well as psychosocial factors, such as poor opportunities to exert influence at work, showed a graded association with multi-site pain.
2) Poor-self perceived work ability was considerably common among industrial workers. Multi-site musculoskeletal pain increases the risk of future poor self-perceived work ability, especially among younger workers. MSP at baseline increased the risk of poor work ability even after controlling for baseline work ability and after exclusion of those with poor work ability at baseline.
3) This study also found that the decline in work ability connected with multi-site pain was not modified by physical or psychosocial working conditions. Among workers without multi-site pain symptoms working conditions are associated with an increased risk of future poor work ability.
4) This study also indicates that multi-site pain strongly predicts long-term sickness absence spells and days among both white-collar and blue-collar employees. However, the threshold of pain sites was different among white-collar and blue-collar employees with lower threshold among blue-collar employees compared to their white-collar counterparts.

The prevention of musculoskeletal pain is very challenging as it is multifactorial in aetiology, frequent in occurrence, recurrent and subjective in nature. Low birth rates with increasing longevity in all developed countries mean that a shrinking proportion of the population in the paid workforce now has to support an expanding proportion of those not working (the dependency ratio is growing). Effective interventions to prevent musculoskeletal pain in multiple body regions at work are needed to tackle the work disability and increasing rates of sickness absence, spells and days. The results implies that either once multi-site pain has set in, the effects of work-related physical and psychosocial factors on work ability or sickness absence are no longer important, or that the experience of multi-site pain and the perception of the physical and psychosocial work environment are substantially intertwined. The results of this study also support the view that simply counting the concurrent pain sites can be used to screen for workers with high risk of work disability in e.g., occupational health care practice. In general, widespread pain requires special attention and effective preventive measures in order to improve the work ability, reduce the cost due to sickness absence and prolong the work careers of working-age people.

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ORIGINAL PUBLICATIONS

I Neupane S, Miranda H, Virtanen P, Siukola A, Nygård C-H.
Do physical or psychosocial factors at work predict multi-site musculoskeletal pain? A 4-year follow-up study in an industrial population.
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II Neupane S, Miranda H, Virtanen P, Siukola A, Nygård C-H.
Multi-site pain and work ability among an industrial population.
Occup Med 2011; 61:563-569.

III Neupane S, Virtanen P, Leino-Arjas P, Miranda H, Siukola A, Nygård C-H.
Multi-site pain and working conditions as predictors of work ability in a 4-year follow-up among food industry employees.
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IV Neupane S, Virtanen P, Leino-Arjas P, Miranda H, Siukola A, Nygård C-H.
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ORIGINAL ARTICLE

Do physical or psychosocial factors at work predict multi-site musculoskeletal pain? A 4-year follow-up study in an industrial population

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Abstract

Purpose Musculoskeletal pain at multiple sites is common among working-age people and greatly increases work disability risk. Little is known of the work-related physical and psychosocial factors contributing to multi-site pain.

Methods Survey responses from 734 employees (518 blue- and 216 white-collar; 65 % female) of a food processing company were collected twice, in 2005 and 2009. Information on musculoskeletal pain during the preceding week, and on environmental, biomechanical and psychosocial work exposures were obtained through a structured questionnaire. The association of multi-site pain with work exposures was estimated with logistic regression by gender and age group.

Results At baseline, 54 % of informants reported pain in more than one area, and 50 % at 4-year follow-up. Forty percent of all employees had multi-site pain both at baseline and at follow-up. Among those with multi-site pain at baseline, 69 % had multi-site pain at follow-up. Both repetitive work and awkward work postures at baseline were associated with multi-site pain at follow-up. Psychosocial factors (low job satisfaction, low team spirit, and little opportunity to exert influence at work) also strongly predicted multi-site pain at follow-up, especially among younger workers and men.

Conclusion This prospective study provides new evidence of the high occurrence and persistence of musculoskeletal pain at multiple body sites in an industrial population with a strong association between biomechanical and psychosocial exposures at work and multi-site pain. Prevention of multi-site pain with many-sided modification of work exposures is likely to reduce work disability.

Keywords Disability · Food industry · Multiple sites pain · Work environment · Physical factors

Introduction

Most earlier studies on musculoskeletal pain have concentrated exclusively on single-site pain and considered risk factors as distinct and specific to each pain area or disorder (Grotle and Croft 2010). Recently, multi-site pain has gained more attention in epidemiological research, especially after the findings that multi-site musculoskeletal pain is extremely common in the working population (Haukka et al. 2006; Carnes et al. 2007; Miranda et al. 2009; Kamaleri et al. 2008a). Several studies have also reported that the consequences of multi-site pain are more severe than those of single-site pain (Haukka et al. 2006; Carnes et al. 2007; Miranda et al. 2009). Multi-site pain has a substantial impact on physical fitness, general health and wellbeing, activities of daily living (Carnes et al. 2007; Kamaleri et al. 2008a), self-reported work ability and plans for early retirement (Miranda et al. 2009) as well as long-term sickness absence (Nyman et al. 2007).

Although multi-site pain occurs as frequently as single-site pain (Haukka et al. 2011; Solidaki et al. 2010), little is

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known about the determinants of multi-site pain. The number of prospective studies investigating the role of work-related exposures on multi-site pain is especially limited. In a 2-year follow-up study among newly employed subjects in 12 diverse occupational settings, the risk of a new onset of chronic widespread pain was associated with work-related psychosocial factors, such as low job satisfaction, low social support, and monotonous work, as well as with several mechanical and posture exposures. The strongest independent predictors of symptom onset, however, were psychosocial factors (Harkness et al. 2004). In another study with a 2-year follow-up, Haukka et al. found several psychosocial factors to predict multi-site pain among female municipal kitchen workers. The role of physical exposures was not investigated in this study (Haukka et al. 2011).

Since workers with multi-site pain are at high risk of work disability (Miranda et al. 2009), more information is needed for preventive purposes on the workplace risk factors that predict future multi-site pain. The prevalence of multi-site pain is known to differ by gender (women have higher prevalence) (Leveille et al. 2005; Rollman and Lautenbacher 2001). Accordingly, the risk factors may also differ by gender, or moreover by age. These differences should be taken into account in order to better target preventive measures.

The aim of this prospective study in an industrial population was to investigate whether work-related physical and psychosocial factors at baseline predict multi-site pain at follow-up, whether these factors differ between men and women, or younger and older workers, and which factors contribute in particular to the continuation of multi-site pain over the 4 years.

Materials and methods

Study population

A research project following up the employees of one of the largest food industry companies in Finland was established in 2003 (Virtanen et al. 2008). This study is based on questionnaire surveys conducted among all employees of the company in spring 2005 and spring 2009. The questionnaires were distributed at the workplaces to every employee. It was possible to reply anonymously or to sign the consent for individual follow-up of the surveys and for linking to them to the personnel registers of the company including information on age, gender occupational status, workplace and duration and interruptions of the job contract. The replies were placed in sealed envelopes which were collected and forwarded to the researchers. As the question forms were not addressed to individual employees, no reminders could be sent. The study was approved by the ethical committee of Pirkanmaa Hospital District.

Outcome variable

The main outcome variable, that is, musculoskeletal pain was assessed by modified questions from the validated Nordic Musculoskeletal Questionnaire (Kuorinka et al. 1987) with a question on pain or numbness in four anatomical areas (hands or upper extremities; neck or shoulders; low back, and feet or lower extremities) during the preceding week with the reply scale from 0 (not at all) to 10 (very much). Each reply scale was dichotomized from the median (less than median: 0 = no and more than median: 1 = yes). The cutoff values for pain in the upper extremities, neck and shoulder, low back and lower extremities were 4, 5, 2 and 2, respectively. All four dichotomized variables were summed and the sum variable was expressed in the number of areas with pain (from 0 = no pain to 4 = 4 pain sites). The dichotomous variable "multi-site pain" was then created by further combining 2, 3, and 4 pain sites (0 and 1 pain site as a reference category "no multi-site pain").

Determinants

Environmental exposures

Environmental exposure was constructed from the questions adopted from the survey of statistics of Finland (Lehto and Sutela 2009) concerning draught, noise, poor indoor climate, heat, cold, poor lighting and restlessness of work environment (noisy and restless workplace) by summing the replies (scaled from 1 = not at all to 5 = very much) into a sum score variable ranging from 7 to 35. The variable was then further categorized into 3 from their tertile values and named "low," (7–16) "moderate," (17–21) and "high" (22–35) environmental exposure.

Biomechanical factors

Biomechanical factors were addressed with questions about repetitive work and awkward work postures, giving the choice on a 5-point Likert scale and categorized into three equal parts from their tertile values for both variables as low (1–2), moderate (3) and high (4–5).

Psychosocial factors

Job satisfaction was assessed with a question "how satisfied are you with your work?" on a reply scale 0 (totally dissatisfied) to 10 (highly satisfied) and classified to 3 equal categories from tertiles, for example, low (0–7), medium (8), and high (9–10). Variables "incentive and participative leadership" (6 items, for example, "My manager pays attention to my suggestions and wishes)," "team spirit" (6 items, for example, "My colleagues discuss improvements to work and/or the work environment)," and "opportunities to exert influence at work" (5 items, e.g.,: "The organization allows its employees an opportunity to set their own goals") were created by summing the response scores and divided by number of variables measured on the 5-point Likert scale from 1 (totally disagree/very probably not) to 5 (totally agree/very probably) (Ruohotie 1993). Those three psychosocial factors were further categorized into 3 equal parts from their tertile values. The cutoff values for "incentive and participative leadership" were 3.16 and 3.83. Similarly, the cutoff values for "team spirit" were 3.16 and 3.66 also for the "opportunities to exert influence at work" were 3.00 and 3.60. The Cronbach's alphas of these measures from the reliability test varied between 0.68 and 0.85.

Confounders

The potential confounders were occupational status (blue- or white-collar), physical exercise and body mass index (BMI, kg/m^2). BMI was calculated using workers' self-reported weight and height. The level of physical exercise during the last month was elicited on a scale from 0 (not at all) to 7 (strenuous physical activity for more than 3 h a week).

Statistical analysis

The Chi-square test was used to study the difference in background characteristics, exposure, and outcome between study subjects and those lost to follow-up. Logistic regression analysis was performed to examine whether baseline environmental exposure, biomechanical factors and psychosocial factors were associated with multi-site pain after 4 years of follow-up. Binary outcomes in cohort studies could be analyzed by applying a logistic regression model to the data to obtain odds ratios for comparing groups with different sets of characteristics (Barros and Hirakanta 2003). The associations are presented as odd ratios and their 95 % confidence intervals (95 % CI). In addition to the whole cohort, analyses were conducted separately for those who had multi-site pain at baseline "persistence of multi-site pain" and those with no multi-site pain at baseline "onset of multi-site pain". The models were built up in 3 steps: Model I: crude odds ratios, Model II: adjusted for age, gender and occupational status and lastly Model III: includes those covariates considered as least likely to affect the association between the exposure and outcome variable such as variables used to adjust for Model II and physical exercise and BMI. These analyses were also performed stratified by gender and age group (cutoff value median age, i.e., 42 years). All analyses were performed using SPSS (version 15.0) software.

Results

The response rate at baseline (including those who consented to the use of their individual responses) was 60 % (1,201/1,985); corresponding figures at follow-up were 72 % (1,398/1,939). A total of 734 employees participated and consented in both surveys. Of the 518 blue-collar workers, the majority were food processing and maintenance workers which entails muscular work with a lot of lifting and carrying in different postures, while of the 216 white-collar employees, the majority worked in management. The median age of the respondents was 42 years ranging from 20 to 62 years at baseline, and two out of three were women. Those lost to follow-up, that is, who replied and consented to the individualized use of baseline questionnaire but did not reply or consent at follow-up ($N = 467$), were younger and more often women (60 %), than were those who responded to both questionnaires. They were also slightly more often exposed to awkward work postures and had more often multi-site pain at baseline (Table 1).

Multi-site pain was common in this cohort of industrial workers: almost 54 % of the employees had pain in more than one body area (55 % of the women and 53 % of the men) at baseline and 50 % at follow-up. The baseline prevalence in the age groups of 20–30, 31–40, 41–50, and 50+ years were 51, 58, 57, and 53 %, respectively. Blue-collar employees had a higher prevalence of multi-site pain than white-collar employees (62 vs. 47 %). About one-third of respondents did not have multi-site pain over the four follow-up years, 15 % had multi-site pain only at follow-up, and about 40 % of the all employees had multi-site pain at both baseline and at follow-up (Table 2). Among those with multi-site pain at baseline, the persistence of multi-site pain at follow-up was 69 %.

The analyses among all employees showed that work exposures (environmental exposure, repetitive task, and awkward work postures) at baseline were strongly associated with multi-site pain at follow-up with a dose-response relationship even after adjusting for age, gender, occupational status, physical exercise, BMI, and baseline pain (data not shown). Low job satisfaction, low team spirit, and poor opportunities to exert influence at work at baseline also predicted multi-site pain, but in the final model only poor opportunities to exert influence remained significant.

Table 1 Characteristics of the subjects lost to follow-up and the study subjects

	Lost to follow-up		Study subjects		*P* value
	N = 467	%	*N* = 734	%	
Gender					0.028
Female	279	60	480	65	
Male	188	40	254	35	
Age (years)					<0.001
20–30	127	27	132	18	
31–40	143	31	206	28	
41–50	79	17	244	33	
51+	118	25	152	21	
Occupational status					<0.001
Blue-collar	377	81	524	71	
White-collar	90	19	210	29	
Environmental exposure					0.816
Low	151	32	249	34	
Medium	172	37	259	35	
High	144	31	226	31	
Biomechanical factors					
Repetitive work					0.188
Low	144	31	239	32	
Medium	124	27	220	30	
High	199	42	275	38	
Awkward posture					0.014
Low	137	29	268	37	
Medium	150	32	235	31	
High	180	39	231	32	
Psychosocial factors					
Job satisfaction					0.287
High	99	21	184	25	
Medium	261	56	396	54	
Low	107	23	154	21	
Leadership					0.069
Good	153	33	281	38	
Intermediate	166	35	260	35	
Poor	148	32	193	26	
Team spirit					0.886
Good	148	32	242	33	
Intermediate	177	38	270	37	
Poor	142	30	222	30	
Opportunities to exert influence					0.313
Good	157	34	235	32	
Intermediate	137	29	246	33	
Poor	173	37	253	35	
Multi-site pain					0.026
No	185	40	334	46	
Yes	282	60	400	54	

In the gender-stratified analyses, the difference between the women and men was small when multi-site pain at follow-up was related to environmental exposures and biomechanical factors. However, with respect to psychosocial factors, mainly low job satisfaction and poor opportunities to exert influence at work, a gender

Table 2 Multi-site musculoskeletal pain at baseline and follow-up

Multi-site pain at baseline, [n(%)]	Multi-site pain at follow-up, [n(%)]	
	No	Yes
No	213 (29)	108 (15)
Yes	122 (16)	291 (40)
		Total $n = 734$ (100 %)

difference was seen: multi-site pain at follow-up (with Model III adjustments) was associated more strongly with low job satisfaction and poor opportunities to exert influence at work in men [(odds ratios 3.6 (95 % CI: 1.7–7.7) and 4.0 (1.8–8.8), respectively)] than in women [(odds ratios 1.9 (1.1–3.2) and 1.8 (1.3–3.1), respectively)]. Similarly, the younger workers had stronger associations related to all work environmental factors. The association of multi-site pain with low job satisfaction and poor opportunities to exert influence at work for younger employees: 2.7 (1.5–4.8) and 2.8 (1.6–5.1), compared with that for older workers was 1.8 (1.0–3.4) and 1.8 (0.9–3.4), respectively.

Environmental exposure and biomechanical factors under study were associated with onset of multi-site pain among those with no multi-site pain at baseline year (Table 3). Of the psychosocial factors, poor opportunities to exert influence at work also increased the odds, but only in the crude model.

Repetitive work and awkward work postures were related to the highest probability of persistent multi-site pain (Table 4). The odds ratios were higher, even after adjustments, for low job satisfaction and poor opportunities to exert influence at work compared with poor team spirit and poor leadership.

Discussion

This study corroborates existing evidence that musculoskeletal pain at multiple body sites concurrently is a common and persistent phenomenon among working people. More than two-thirds of the workers in a food processing company reported multi-site pain either at the beginning or the end of the 4-year follow-up period, and 40 % had multi-site pain at both time-points. Of those with multi-site pain at baseline, 69 % also experienced persistent pain at follow-up. An important finding is the dose–response relationship between exposures at work and multi-site pain: biomechanical factors, such as repetitive work and awkward work postures, as well as psychosocial factors, such as poor opportunities to exert influence at work, showed a graded association with future multi-site pain. Environmental exposures also increased the risk of multi-site pain.

Our study is in line with earlier studies in occupational populations showing that multi-site pain is at least as prevalent as, if not more prevalent than single-site pain (Haukka et al. 2011; Yeung et al. 2002; Gold et al. 2009; Alexopoulos et al. 2004; Ijzelenberg and Burdorf 2005; Solidaki et al. 2010; Papageorgiou et al. 2002; Andersson 2004; Hill et al. 2004; Kamaleri et al. 2009). For example, among kitchen workers, prevalence as high as 73 % have been reported for musculoskeletal pain occurring in at least two body sites (Haukka et al. 2006). Pain in two or more body sites was also more prevalent (64 %) than single-site pain (19 %) among Chinese manual workers (Yeung et al. 2002). Our results also strongly support the finding from earlier studies that multi-site pain is likely to persist once established (Papageorgiou et al. 2002; Kamaleri et al. 2009).

Moreover, multi-site pain being more common among women in our study is also consistent with other studies (Picavet and Schouten 2003; Walker-Bone et al. 2004; Kamaleri et al. 2008b). No linear age-related increase was detected, which is also in accordance with another study in actively working populations (Miranda et al. 2009). Multi-site pain was most prevalent among workers aged 30–50, becoming less prevalent after 50 years of age. The decrease in the oldest age-group may indicate the healthy worker effect; multi-site pain has been linked to work disability and selection to lighter jobs or entirely out of workforce is most likely to occur strongly among the oldest workers.

The association of future multi-site pain increased with the increasing level of biomechanical and psychosocial factors. The effect of the biomechanical exposures especially was considerable. Biomechanical exposures have been linked to multi-site pain in some earlier studies, most studies being cross-sectional, however. High perceived physical workload among dentists increased the risk of co-occurring musculoskeletal pain with odds ratios increasing 2–4-folds with increasing number of pain sites (Alexopoulos et al. 2004). In another cross-sectional study among Greek workers, a combination of various physical exposures had a strong and graded relationship with the number of pain sites (Solidaki et al. 2010). In a 2-year follow-up study among newly employed workers, lifting and poor work postures predicted the onset of widespread pain (Harkness et al. 2004). Moreover, in a general population sample, manual material handling and repetitive work and awkward postures increased the risk of chronic widespread pain 3 years later (McBeth et al. 2001). Repetitive work movements also increased the risk of future episodes of forearm pain co-occurring with other regional pain by 3–4-fold (Macfarlane et al. 2000).

Table 3 Odds ratios with 95 % confidence intervals (CI) for multi-site pain at 4-year follow-up according to environmental exposure, biomechanical factors, and psychosocial factors in an employee cohort with no multi-site pain at baseline

Baseline exposures	All $N = 321$	No. of cases[a]	Multi-site pain at follow-up		
			Model I OR (95 % CI)	Model II OR (95 % CI)	Model III OR (95 % CI)
Environmental exposure					
Low	141	35	1.0	1.0	1.0
Medium	109	32	1.3 (0.7–2.2)	1.1 (0.6–2.0)	1.2 (0.6–2.2)
High	55	28	3.1 (1.6–6.0)	2.7 (1.3–5.5)	3.0 (1.4–6.2)
Biomechanical factors					
Repetitive work					
Low	148	33	1.0	1.0	1.0
Medium	87	33	2.1 (1.2–3.8)	2.1 (1.2–3.9)	2.3 (1.2–4.2)
High	72	29	2.4 (1.3–4.3)	2.2 (1.1–4.3)	2.3 (1.2–4.5)
Awkward work postures					
Low	161	35	1.0	1.0	1.0
Medium	95	35	2.1 (1.2–3.7)	2.1 (1.1–3.9)	2.6 (1.4–5.1)
High	51	25	3.5 (1.8–6.7)	3.6 (1.7–7.6)	4.2 (1.9–9.3)
Psychosocial factors					
Job satisfaction					
High	112	35	1.0	1.0	1.0
Medium	114	33	0.9 (0.5–1.6)	0.9 (0.5–1.6)	0.9 (0.5–1.7)
Low	80	27	1.1 (0.6–2.1)	1.1 (0.6–2.1)	1.2 (0.6–2.3)
Leadership					
Good	119	35	1.0	1.0	1.0
Intermediate	101	29	1.0 (0.5–1.7)	0.9 (0.5–1.7)	0.9 (0.5–1.7)
Poor	88	31	1.3 (0.7–2.4)	1.1 (0.6–2.1)	1.1 (0.6–2.0)
Team spirit					
Good	138	42	1.0	1.0	1.0
Intermediate	77	23	1.0 (0.5–1.8)	0.8 (0.4–1.6)	0.9 (0.5–1.7)
Poor	93	30	1.1 (0.6–1.9)	0.9 (0.5–1.6)	0.9 (0.5–1.6)
Opportunities to exert influence					
Good	126	31	1.0	1.0	1.0
Intermediate	100	30	1.3 (0.7–2.4)	1.2 (0.6–2.3)	1.2 (0.6–2.4)
Poor	81	33	2.1 (1.2–3.8)	1.8 (0.9–3.6)	1.9 (0.9–3.7)

Model I: crude odds ratios

Model II: adjusted for age, gender and occupational status

Model III: Model II + physical exercise and body mass index

[a] No. of subjects with multi-site pain at follow-up

In our study, low job satisfaction and particularly poor opportunities to exert influence (corresponding to job control) predicted pain at multiple body sites 4 years later. Our results support the findings from other studies according to which psychosocial factors contribute to the development of multi-site pain. However, the number of prospective studies on psychosocial factors and multi-site pain is limited. Among kitchen workers, low job control and low supervisor support were the strongest predictors of multi-site pain 3 months later. Moreover, adverse changes in psychosocial factors, especially in job control over a 2-year follow-up period were associated with a higher risk of having persistent multi-site pain (Haukka et al. 2011). Among newly employed workers, low job satisfaction and low social support increased the risk of widespread pain 2 years later (Harkness et al. 2004).

Factors other than those associated with biomechanical and psychosocial workload may also play a role in the

Table 4 Odds ratios with 95 % confidence intervals (CI) for multi-site pain at 4-year follow-up according to environmental exposure, biomechanical factors, and psychosocial exposures in an employee cohort with multi-site pain at baseline

Baseline exposures	All $N = 413$	No. of cases[a]	Multi-site pain at follow-up		
			Model I OR (95 % CI)	Model II OR (95 % CI)	Model III OR (95 % CI)
Environmental exposures					
Low	101	65	1.0	1.0	1.0
Medium	147	91	0.9 (0.5–1.6)	0.9 (0.6–1.6)	0.9 (0.5–1.6)
High	158	113	1.5 (0.8–2.6)	1.5 (0.8–2.6)	1.4 (0.8–2.6)
Biomechanical factors					
Repetitive work					
Low	82	44	1.0	1.0	1.0
Medium	132	82	1.4 (0.8–2.6)	1.4 (0.8–2.5)	1.6 (0.8–2.8)
High	199	149	2.6 (1.5–4.6)	2.6 (1.5–4.8)	2.7 (1.5–4.8)
Awkward work postures					
Low	101	59	1.0	1.0	1.0
Medium	136	86	1.2 (0.7–2.2)	1.3 (0.7–2.4)	1.3 (0.7–2.3)
High	175	129	2.1 (1.2–3.6)	2.3 (1.2–4.2)	1.9 (1.1–3.4)
Psychosocial factors					
Job satisfaction					
High	75	40	1.0	1.0	1.0
Medium	123	90	1.0 (0.6–1.9)	1.1 (0.6–1.9)	1.0 (0.5–1.9)
Low	172	145	1.9 (1.0–3.5)	2.0 (1.1–3.8)	1.8 (1.0–3.4)
Leadership					
Good	127	74	1.0	1.0	1.0
Intermediate	121	91	1.2 (0.7–2.1)	1.2 (0.7–2.1)	1.2 (0.7–2.1)
Poor	153	109	1.2 (0.7–2.1)	1.2 (0.7–2.1)	1.3 (0.7–2.2)
Team spirit					
Good	133	80	1.0	1.0	1.0
Intermediate	105	78	1.3 (0.7–2.3)	1.3 (0.7–2.3)	1.4 (0.8–2.5)
Poor	163	117	1.2 (0.7–2.0)	1.2 (0.7–1.9)	1.3 (0.8–2.2)
Opportunities to exert influence					
Good	102	58	1.0	1.0	1.0
Intermediate	140	93	1.6 (0.9–2.8)	1.7 (1.0–3.1)	1.5 (0.9–2.7)
Poor	169	123	2.0 (1.2–3.4)	2.1 (1.2–3.6)	1.9 (1.1–3.3)

Model I: crude odds ratios

Model II: adjusted for age, gender and occupational status

Model III: Model II + physical exercise and body mass index

[a] No. of subjects with multi-site pain at follow-up

development and persistence of musculoskeletal disorders. To the best of our knowledge, this is the first study to report that environmental exposures at work other than biomechanical factors also contribute to musculoskeletal pain at multiple body sites. Of the environmental exposures measured in our study (draught, noise, poor indoor climate, heat, cold, poor lighting, and restless work environment), the strongest individual association with multi-site was found for restless work environment. We included restless work environment to our study, as belongs as an item in the established questionnaire on environmental exposures adopted for use in this study (Lehto and Sutela 2009); in other words, it refers to exposure to "physically" restless environment caused by other people talking and moving around the site of the work.

Restless work environment as well as psychosocial loading at work is likely to increase mental stress among workers, and exposure to stress can exaggerate subsequent pain experience and lower pain thresholds via many mechanisms (Geerse et al. 2006; Imbe et al. 2006). Stress may for example, increase muscle tension. Cumulative stress has also been linked to a number of physiological changes in the brain and body that reflect dysregulated hormonal and autonomic activity (Lupien et al. 2009; McEwen and Kalia 2010). It has been reported that chronic stress can activate the immune system in such a way that pain transmission is facilitated at the neuronal level (Sauro and Becker 2009).

Earlier studies have concluded that musculoskeletal pain in general and widespread pain is more common among women, especially older women (Leveille et al. 2005). In addition to biological differences (e.g., hormonal factors), gender segregation at work may at least partially explain the gender differences in musculoskeletal morbidity. In a large Finnish study among general working population, in women, as opposed to men, the highest exposure to most physical workload factors was found in their later work life. Regarding psychosocial exposures, no major gender difference was detected (Kausto et al. 2010). Interestingly, in our study, the multi-site pain was more strongly related to psychosocial factors among the men. We also found somewhat higher odds for multi-site pain among younger (≤42 years) workers related to biomechanical factors, and among older workers related to environmental exposures. It is possible that older workers have developed strategies for coping with the physical and psychosocial demands of the job while younger workers may lack this experience (IJmker et al. 2007).

The food industry was chosen to represent an occupational area in which high levels of exposures to physical and psychosocial load as well as enough variation in the exposures can be found. Food processing is a universal industry, employing a considerable proportion of the workforce, for example, in Finland, 34,000 workers (1–2 % of the workforce). Typically, work-related accidental injury and sickness absence rates are remarkably high in food processing. Musculoskeletal disorders are the major reason for sick leaves in industrial occupations (Stenbeck and Persson 2006). To the best of our knowledge, this is the first study to report work-related risk factors for musculoskeletal pain at multiple body sites among food industry workers.

The study had the advantage of a longitudinal design, allowing us to examine baseline predictors of multi-site pain at 4 years for those with and those without multi-site pain at baseline. Response rates for both surveys were satisfactory. However, we cannot rule out the possibility that selection due to differential participation at baseline or at follow-up affected our results. Selection out of the workforce is more likely to occur among the workers with most health problems, as well as the highest exposure levels, leaving the healthiest workers at the workplaces and being selected in cohort studies as ours. In our study, workers who were exposed to poor overall work environments and had multi-site in the baseline were lost to follow-up. Such biases deflate the associations between workplace exposures and health outcomes.

The subjects were asked to report pain that had occurred during the past 7 days. This timeframe increases the likelihood that pain had truly occurred at multiple body sites concurrently and also decreases the likelihood of recall bias. The perception of musculoskeletal pain, physical factors and psychosocial were assessed by questionnaire, that is, no objective measurements were carried out. However, a self-report method appears to be the best (and practically only) way of assessing pain in epidemiological studies because of its complex and subjective nature (Crombie et al. 1999; Natvig et al. 2001). In addition to age, gender, and occupational status, BMI and physical exercise were also considered as confounders, since some studies have indicated that lifestyle factors are associated with the number of pain sites (Kamaleri et al. 2008a). One weakness of this study is that we did not measure personal factors such as negative affectivity or tendency for somatization, which may affect participant reporting behavior for both exposure and outcome. They may cause systematic overestimations and bias the association between exposure and outcome. Information on smoking was likewise not collected in this study. In a large population study, smoking had no effect on multi-site pain (Miranda et al. 2009), so the effect of unmeasured confounding by smoking is likely to be minor.

Conclusions

This prospective study provides new evidence on the high occurrence and persistence of musculoskeletal pain at multiple body sites in an industrial population. It also reports a significant association between biomechanical and psychosocial exposures at work and multi-site pain. Prevention of multi-site pain is crucial since workers with multi-site pain are at high risk of work disability. Workplace interventions to effectively reduce both physical and psychosocial exposures at work are needed to tackle the increasing rates of work disability due to common musculoskeletal disorders such as multi-site pain.

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Conflict of interest None declared.

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Multi-site pain and work ability among an industrial population

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Background Multi-site pain is a common phenomenon among working-age people and it strongly increases work disability risk. Little is known about the impact of musculoskeletal pain on work ability.

Aims To investigate whether the number of musculoskeletal pain sites predicts future poor work ability.

Methods The study was conducted in 2005 and 2009 in a food processing company. A total of 734 workers participated in the study. The information on self-perceived work ability and musculoskeletal pain during the preceding week was obtained through a structured questionnaire distributed to employees. The risk of poor work ability at follow-up related to the number of pain sites at baseline was estimated with logistic regression.

Results The proportion of poor work ability increased in 4 years from 15 to 22%, parallel to the increase in the number of pain sites. Among those with 'non-poor' work ability at baseline, one-tenth reported their work ability to be poor after 4 years. The number of pain sites predicted poor work ability after 4 years of follow-up with a dose–response manner. Those with widespread pain had almost a 3-fold risk of developing poor work ability at follow-up. The associations were stronger for younger and white-collar workers.

Conclusions The results of the present study indicate that multi-site musculoskeletal pain at baseline strongly predicts poor work ability after 4 years among industrial workers. Counting the number of concurrent pain sites may be a simple method of identifying workers with high risk of work disability in occupational health practice.

Key words Follow-up study; food industry; multiple-site pain; musculoskeletal pain; work ability.

Introduction

Musculoskeletal pain is a common work-related health problem among the working population. Many epidemiological studies concentrating on the occurrence of musculoskeletal pain have focused on a specific anatomical site. However, musculoskeletal symptoms often occur in several anatomical locations [1–4] and pain at one site is associated with an increased occurrence of pain at another site [1]. Musculoskeletal pain at a specific anatomical site is also associated with increased risk of impaired work ability and increased sickness absenteeism [2,5].

Work ability is a useful concept in analysing work life, in particular in responding to the challenge of prolonging the job tenures of aging workers. The concept is built on the balance between a person's resources and work demands [6]. High physical work demands such as heavy muscular work, poor work postures and environmental conditions impair work ability [7–11]. The few earlier studies concerning the relationship of multiple-site pain with work ability have mostly measured work ability in terms of self-reported sickness absence and work disability pension [12–15].

Musculoskeletal pain has direct and immediate effects on work disability [16]. A recent study among a representative sample of actively working Finnish adults [17] found that pain at multiple sites imparts considerable risk for reduced self-perceived work ability. This study had, however, a cross-sectional design and could not establish causality between multi-site pain and reduced work ability. Therefore, longitudinal studies are needed to verify that the total number of pain sites truly is an important prognostic factor of poor work ability. This knowledge has substantial public health importance since counting pain sites can then act as a simple method in clinical work for screening workers at high risk of work disability.

The aim of this study was to investigate in an industrial population whether the number of pain sites predicts future poor work ability after 4 years and whether the predictive effect differs by gender, age group or occupational status.

Methods

A follow-up study in a Finnish food industry company of about 2000 employees was started in 2003 [18]. Questionnaire surveys were conducted among all employees of the company in spring 2005 ($N = 1201$) and spring 2009 ($N = 1398$). The questionnaires were distributed in the workplaces, filled in during the working hours, and the closed reply envelopes were collected and sent to the researchers. The forms were not addressed to individual employees; thus, no reminders could be sent. The respondents provided written consent for linking the survey data with data on age, gender and occupational status obtained from the personnel registers of the company. This study was approved by the ethical committee of Pirkanmaa Hospital District.

The questions in the survey covered working environment, work ability and musculoskeletal problems. The outcome variable or work ability was assessed as a subjective assessment of current work ability compared with a person's self-identified lifetime best (i.e. with the question 'Assume that your work ability at its best has a value of 10 points. What score would you give your current work ability?'). This question is part of the seven-item Work Ability Index (WAI) and contains most of the individual differences of the index [8]. The WAI was developed at the Finnish Institute of Occupational Health in the 1980s and has been validated against clinical data [19]. The WAI is an instrument used in both clinical occupational health care and in research in several countries (translated in 26 languages) nowadays. The index is determined on the basis of the answers to a series of questions regarding demands of work, workers' health status and resources [20]. Scores range from 0 (unable to work) to 10 (work ability at its best) and are categorized into excellent (score 10), good (score 9), moderate (score 8) and poor (scores 0–7) work ability [21]. In this study, work ability is dichotomized into good (8–10) and poor (0–7).

The main determinant, multi-site musculoskeletal pain, was assessed by modified questions from the validated Nordic Musculoskeletal questionnaire [22] with a question on pain or numbness in four anatomical areas (hands or upper extremities, neck or shoulders, low back and feet or lower extremities) during the preceding week with the reply scale from 0 (not at all) to 10 (very much). Each reply scale was dichotomized from the median (less than median: 0 = no and more than median: 1 = yes). All four dichotomized variables were summed and the sum variable was expressed in the number of areas with pain (from 0 = no pain to 4 = 4 pain sites).

Age, gender and occupational status (blue-collar and white-collar), environmental exposure, biomechanical and psychosocial factors and body mass index (BMI) and the level of physical activity were included in the analysis as covariates that may confound the relationship of musculoskeletal pain with work ability. BMI was calculated by using self-reported weight and height of the workers. The level of physical activity during the last month was asked on a scale from 0 (not at all) to 7 (high physical activity for more than 3 h a week). Environmental exposure was constructed from the questions concerning draught, noise, poor indoor climate, heat, cold, poor lighting and restless work environment [23] by summing the replies (scaled from 1 = not at all to 5 = very much) into a sum score variable ranging from 7 to 35. Biomechanical factors were addressed with questions about repetitive work and awkward work postures [23], giving the choice on a 5-point Likert scale. Other potential confounders were psychosocial factors at the workplace, for example job satisfaction was assessed with a question 'how satisfied are you with your work?' with a reply scale 0 (absolutely unsatisfied) to 10 (very satisfied) [23]. Variables 'incentive and participative leadership' (six items, e.g. 'My manager pays attention to my suggestion and wishes'), 'team spirit' (six items, e.g. 'My colleagues discuss improvements to work and/or the work environment') and 'possibilities to exert influence at work' (five items, e.g. 'The organization allows its employees an opportunity to set their own goals') were created by summing of the response scores measured on the 5-point Likert scale from 1 (totally disagree/very probably not) to 5 (totally agree/very probably) [24].

Logistic regression analysis was performed to examine whether baseline multi-site pain predicted the risk of poor work ability after 4 years of follow-up. Risks are presented as odds ratios (ORs) and their 95% confidence intervals (95% CIs). The results of logistic regression analysis were calculated and presented for all employees and separately for those who did not have poor work ability in the baseline. The models were built up in five steps: Model I: crude ORs; Model II: adjusted for age, gender and occupational status, biomechanical factors and environmental exposures; Model III: adjusted for physical exercise and BMI; Model IV: adjusted for job satisfaction, leadership, team spirit and possibilities to exert influence and Model V included all the covariates from Model II, Model III and Model IV. These analyses were also performed stratified by gender, age group and occupational status (cut-off value median age, i.e. 42 years). All analyses were performed using SPSS (version 15.0) software.

Results

A total of 734 employees participated in both surveys with response rates of 60% at baseline and 72% at follow-up.

Of these, 518 were blue-collar employees, the majority worked in food processing and maintenance, whereas 216 were white-collar employees, mainly working in management. The mean age of the employees was 41 years (SD = 9.9) ranging from 20 to 62 years at baseline and two-thirds were women. Those lost to follow-up (i.e. who replied to the baseline questionnaire but did not reply at follow-up) were younger and more often men, compared to those who replied to both questionnaires. They had more often multi-site pain and poor work ability at baseline.

Among the 734 subjects, poor work ability was reported by 106 subjects (15%) at baseline and 161 subjects (22%) at follow-up. Women and men differed only a little regarding their work ability; 15% of women and 13% of men reported poor work ability at baseline, while 20% of women and 25% of men reported poor work ability at follow-up. The distributions of poor, moderate, good and excellent work ability are presented in Table 1.

Table 2 presents the graded association between number of pain sites at baseline and poor work ability at follow-up (*P* value for trend <0.01). After mutual adjustment for various covariates, the risks remained elevated being 3-fold for three to four pain sites (Model II–IV). After additional adjustment for work ability at baseline together with all other covariates in the model, the ORs for three and four pain sites remained significantly increased by more than 2-fold for three to four pain sites (OR for four-site pain 2.1; 95% CI 1.0–4.3).

The association between the number of pain sites and work ability did not differ by gender. Moreover, the risk of poor work ability due to three to four-site pain was 4- to 5-fold for both male and female employees. In the occupational status-stratified analyses (Table 3), most notable findings were the high risk of poor work ability in white-collar employees with four-site pain and the low, albeit non-significant, risk of white-collar employees with one-site pain. Two- and three-site pain incurred similar risks (point estimates 1.9 and 3.3 for the blue-collar and 2.1 and 3.3 for the white-collar employees in Model IV) with statistical significance in the case of three-site pain in blue-collar employees. However, when work ability at baseline was introduced into the model together with other covariates, pain lost the significant association for white-collar workers (Model V; Table 3). Consequently, in the age-stratified analyses (Table 4), the risks of poor work ability at follow-up differed considerably among younger and older workers: the younger workers were at greater risk due to multi-site pain compared to the older workers. Older workers lost the significant association with multi-site pain when baseline work ability was introduced into the model (Model V).

Table 5 presents the association between number of pain sites at baseline and poor work ability at follow-up for those who did not have poor work ability at baseline. Again, a strong dose–response association was found (*P* value for trend < 0.01), with unadjusted ORs for three-site pain of 2.7 (95% CI: 1.3–5.4) and for four-site pain of 3.1 (95% CI: 1.6–5.8).

Table 1. Basic characteristics of the study subjects at baseline

Variables	All employees	
Age (mean, SD)	41 (10.0)	
Gender (*N*, %)		
Female	479	65
Male	255	35
Occupational status (*N*, %)		
Blue collar	518	71
White collar	216	29
Physical working conditions (mean, SD)		
Environment[a] (7–35)	18 (5.5)	
Biomechanics[b] (2–10)	6 (2.5)	
Pain sites (*N*, %)		
None	194	27
One	108	15
Two	147	21
Three	107	15
Four	159	22
Work ability (*N*, %)		
Poor	106	15
Moderate	235	32
Good	274	37
Excellent	116	16
BMI (*N*, %)		
<23	180	26
23.0–25.9	221	32
26.0–28.9	150	22
>29.0	138	20
Physical exercise (*N*, %)		
Not at all or only little	160	22
Moderate	324	45
Much	246	33
Psychosocial factors (mean, SD)		
Job satisfaction (0–10)	7.4 (1.8)	
Leadership (1–5)	3.5 (0.7)	
Team spirit (1–5)	3.5 (0.7)	
Possibilities to exert influence (1–5)	3.4 (0.7)	

[a]Environmental exposure includes draught, noise, bad indoor climate, heat, cold, poor lighting and restless environment.

[b]Biomechanical factors include repetitive work and awkward postures.

Discussion

The results of this prospective study showed that poor self-perceived work ability became considerably more common among industrial worker over the 4 years of follow-up (about 50% increase in the prevalence) and that the number of concurrent painful body sites was a strong predictor of future self-perceived poor work ability. multi-site pain at baseline increased the risk of poor work ability even after controlling for baseline work ability and after exclusion of those with poor work ability at baseline. Moreover, the relatively minor confounding effect of the various covariates (including several work-related confounders), as well as the dose–response increase in

Table 2. The risk of poor work ability at follow-up by the number of musculoskeletal pain sites at baseline among all employees

Pain sites	All subjects (n = 734)	No. of subjects with poor work ability (%)	The risk of poor work ability at follow-up				
			Model I, OR (95% CI)	Model II, OR (95% CI)	Model III, OR (95% CI)	Model IV, OR (95% CI)	Model V, OR (95% CI)
None	194	21 (11)	1.0	1.0	1.0	1.0	1.0
One	108	14 (13)	1.2 (0.6–2.5)	1.1 (0.5–2.4)	1.1 (0.5–2.4)	1.3 (0.6–2.7)	0.9 (0.4–2.1)
Two	147	30 (20)	2.1 (1.2–3.9)	1.8 (1.0–3.4)	2.1 (1.1–3.9)	2.2 (1.1–4.1)	1.5 (0.7–3.1)
Three	107	33 (31)	3.7 (2.0–6.8)	3.2 (1.7–6.0)	3.5 (1.9–6.4)	3.5 (1.8–6.7)	2.5 (1.2–5.3)
Four	159	55 (35)	4.4 (2.5–7.6)	3.3 (1.8–6.0)	3.9 (2.2–7.0)	4.2 (2.3–7.6)	2.1 (1.0–4.3)

Model I: crude ORs; Model II: age, gender, occupational status, biomechanical factors and environmental exposure at baseline; Model III: BMI and physical exercise; Model IV: job satisfaction, leadership, team spirit and possibilities to exert influence and Model V: Model II +Model III + Model IV + baseline work ability.

Table 3. The risk of poor work ability at follow-up by the number of musculoskeletal pain sites at baseline among blue- and white-collar employees

	All subjects (n = 734)	No. of subjects with poor work ability (%)	The risk of poor work ability at follow-up				
			Model I, OR (95% CI)	Model II, OR (95% CI)	Model III, OR (95% CI)	Model IV, OR (95% CI)	Model V, OR (95% CI)
Blue collar (n = 518)							
Pain sites							
None	122	16 (13)	1.0	1.0	1.0	1.0	1.0
One	67	13 (19)	1.6 (0.7–3.6)	1.5 (0.7–3.4)	1.5 (0.7–3.4)	1.6 (0.7–3.8)	1.2 (0.5–3.2)
Two	101	22 (22)	1.8 (0.9–3.7)	1.7 (0.8–3.4)	1.9 (0.9–3.9)	2.0 (0.9–4.2)	1.4 (0.6–3.3)
Three	78	27 (35)	3.5 (1.7–7.1)	3.3 (1.6–6.9)	3.4 (1.7–7.0)	3.4 (1.6–7.3)	2.6 (1.1–6.1)
Four	133	45 (34)	3.4 (1.8–6.4)	3.0 (1.5–5.9)	3.1 (1.6–5.9)	3.6 (1.8–7.2)	2.3 (1.0–5.1)
White collar (n = 216)							
Pain sites							
None	72	5 (7)	1.0	1.0	1.0	1.0	1.0
One	41	1 (2)	0.3 (0.1–3.0)	0.3 (0.1–2.8)	0.4 (0.1–3.4)	0.3 (0.1–2.9)	0.2 (0.0–3.2)
Two	46	8 (17)	2.8 (0.9–9.2)	2.3 (0.6–7.9)	2.7 (0.8–9.1)	2.4 (0.7–8.2)	2.2 (0.4–10.6)
Three	29	6 (21)	3.5 (1.0–12.5)	3.0 (0.8–12.0)	3.2 (0.8–11.9)	3.6 (0.9–13.5)	3.6 (0.6–20.8)
Four	26	10 (39)	8.4 (2.5–27.9)	6.3 (1.5–26.0)	7.2 (2.1–24.8)	6.8 (1.9–24.3)	1.9 (0.3–1.1)

Model I: crude ORs; Model II: age, gender, biomechanical factors and environmental exposure at baseline; Model III: BMI and physical exercise; Model IV: job satisfaction, leadership, team spirit and possibilities to exert influence and Model V: Model II + Model III + Model IV + baseline work ability.

the risks further strengthen the evidence that multiple-site pain was a strong predictor of poor work ability. To our knowledge, this study is the first to prospectively establish this association.

The findings of this study support the results from an earlier cross-sectional study among a sample of the general population in Finland in which multi-site pain was strongly associated with reduced self-perceived work ability. Work ability was assessed with respect to the physical and mental demands of work [17]. In our study, the outcome variable was based on a single-item question on work ability compared with the lifetime best with the scale from 0 to 10. This simple question has been shown to strongly predict the status and progress of work ability and has therefore been suggested to be used as a useful indicator of work ability. It can also be used as a less time-consuming alternative for the WAI [25].

This study showed that although work ability decreased with age and poor work ability was more common among blue-collar workers, the relationship between multi-site pain and poor work ability was stronger among younger and white-collar workers. This is likely to be caused by a selection bias called the healthy worker effect, which may cause underestimations in the detected associations. Those workers with pain at various body areas may have left the workforce entirely or sought lighter jobs, whereas those workers, especially the older manual workers, who remain in the workforce, are healthier and more resistant to the effect of widespread pain symptoms. The presence of a healthy worker

Table 4. The risk of poor work ability at follow-up by the number of musculoskeletal pain sites at baseline among younger (<42 years) and older (≥42 years) employees

	All subjects (n = 734)	No. of subjects with poor work ability (%)	The risk of poor work ability at follow-up				
			Model I, OR (95% CI)	Model II, OR (95% CI)	Model III, OR (95% CI)	Model IV, OR (95% CI)	Model V, OR (95% CI)
Younger (n = 393)							
Pain sites							
None	115	9 (8)	1.0	1.0	1.0	1.0	1.0
One	54	8 (15)	2.0 (0.7–5.6)	2.1 (0.8–5.8)	2.2 (0.8–6.1)	1.9 (0.6–5.6)	1.7 (0.5–5.2)
Two	77	14 (18)	2.6 (1.1–6.4)	2.6 (1.0–6.6)	2.6 (1.1–6.5)	2.7 (1.0–6.8)	2.1 (0.8–5.9)
Three	60	18 (30)	5.0 (2.1–12.1)	4.8 (1.9–12.2)	4.4 (1.8–10.8)	4.9 (1.9–12.6)	3.2 (1.1–9.4)
Four	87	25 (29)	4.8 (2.1–10.8)	4.2 (1.7–10.3)	4.3 (1.9–10.0)	4.9 (2.0–11.9)	2.9 (1.0–8.0)
Older (n = 322)							
Pain sites							
None	79	12 (15)	1.0	1.0	1.0	1.0	1.0
One	54	6 (11)	0.7 (0.2–2.0)	0.6 (0.2–1.9)	0.6 (0.2–1.7)	0.8 (0.3–2.3)	0.4 (0.1–1.6)
Two	70	16 (23)	1.7 (0.7–3.8)	1.3 (0.6–3.2)	1.6 (0.7–3.7)	1.6 (0.7–3.9)	1.0 (0.4–2.7)
Three	47	15 (32)	2.6 (1.1–6.2)	2.3 (0.9–5.6)	2.7 (1.1–6.4)	2.6 (1.0–6.6)	2.0 (0.7–5.8)
Four	72	30 (42)	4.0 (1.8–8.6)	2.9 (1.2–6.7)	3.6 (1.6–8.0)	3.4 (1.5–8.0)	1.3 (0.4–3.6)

Model I: crude ORs; Model II: Occupational status, biomechanical factors and environmental exposure at baseline; Model III: BMI and physical exercise; Model IV: Job satisfaction, leadership, team spirit and possibilities to exert influence and Model V: Model II + Model III + Model IV + baseline work ability.

Table 5. The risk of poor work ability at follow-up by the number of musculoskeletal pain sites at baseline among those who had 'non-poor' work ability at baseline

Pain sites	All subjects (n = 628)	No. of subjects with poor work ability (%)	The risk of poor work ability at follow-up				
			Model I, OR (95% CI)	Model II, OR (95% CI)	Model III, OR (95% CI)	Model IV, OR (95% CI)	Model V, OR (95% CI)
None	186	18 (10)	1.0	1.0	1.0	1.0	1.0
One	101	10 (10)	1.0 (0.5–2.3)	1.1 (0.5–2.4)	1.0 (0.5–2.3)	1.1 (0.5–2.5)	0.9 (0.4–2.3)
Two	125	20 (16)	1.8 (0.9–3.5)	1.7 (0.8–3.4)	1.8 (0.9–3.6)	2.0 (1.0–4.1)	1.7 (0.8–3.7)
Three	85	19 (22)	2.7 (1.3–5.4)	2.6 (1.2–5.6)	2.5 (1.2–5.1)	2.6 (1.2–5.7)	1.9 (0.8–4.4)
Four	117	29 (25)	3.1 (1.6–5.8)	2.7 (1.3–5.3)	2.7 (1.4–5.3)	3.4 (1.7–6.8)	1.7 (0.8–3.7)

Model I: crude ORs; Model II: age, gender, occupational status, biomechanical factors and environmental exposure at baseline; Model III: BMI and physical exercise; Model IV: job satisfaction, leadership, team spirit and possibilities to exert influence and Model V: Model II + Model III + Model IV + baseline work ability.

effect is also supported by our loss-to-follow-up analyses: non-response at follow-up was related to the greater likelihood of having multi-site pain and poor work ability at baseline.

Women tend to report more musculoskeletal pain and have a higher risk of sickness absence and work disability pensions, especially due to musculoskeletal disorders [26]. However, with respect to self-perceived work ability, some earlier studies among the general population have indicated that males and females perceive their work ability to be approximately the same [21,27]. We also did not find any major gender differences in the perceived poor work ability related to multi-site pain. This is in line with the other Finnish study in which the effect of multi-site pain on perceived work ability did not differ between the women and the men [17].

This study has strengths, of which the most important is the prospective follow-up design. In addition to predicting poor work ability at follow-up, the change in work ability from non-poor to poor was assessed and similar dose–response risk increases were detected. The response rates for both surveys were satisfactory. However, it considerably improved at follow-up to 72%. Musculoskeletal pain reporting concerned the previous 7 days. This time frame increases the likelihood of pain truly occurring at multiple body sites concurrently. It also reduces the effects of recall bias. A variety of work-related factors, including environmental exposures such as cold work environment, was considered as confounders. However, the effects of unmeasured confounding, for example due to chronic illnesses, cannot be ruled out. The role of age, gender and occupational status as effect modifiers was investigated with stratified analyses. The risks varied by age and occupational status, and hence, they should be considered in future studies as well. All information was elicited by questionnaire, i.e. no objective measurements were carried out. However, a self-report method appears to be the best (and practically only) way of assessing pain in epidemiological studies [28, 29]. Moreover, the single-item question on self-perceived work ability is a quick and cost-effective method especially for clinical use and its results are easy to interpret [25].

This study represents food industry employees in which high levels of exposures to physical and psychosocial load can be found. Including white-collar workers in the cohort increased the variation and contrast in the exposures. Although sickness absence and work disability rates are remarkably high in the food industry and musculoskeletal disorders are the major reason for sick leaves and work disability, the occurrence of musculoskeletal disorders and its relation with work ability have rarely been assessed in an epidemiological study. The food processing industry is a significant employer in Finland with about 34 000 workers (1–2% of the workforce).

In conclusion, single-site and multi-site pain have a very different prognosis with respect to work ability. Multi-site musculoskeletal pain increases the risk of future poor self-perceived work ability, especially among younger workers. The study results support the view that simply counting the concurrent pain sites can be used to screen for workers with high risk of work disability in occupational health practice. In general, widespread pain requires special attention and effective preventive measures in order to improve the work ability and prolong the work careers of working-age people.

Key points

- Among working people, multi-site musculoskeletal pain is a common phenomenon.
- Multi-site musculoskeletal pain increases the risk of future poor self-perceived work ability, especially among younger workers.
- Multi-site pain requires special attention and effective preventive measures in order to improve the work ability and prolong the work careers of working-age people.

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Conflicts of interests

None declared.

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ORIGINAL ARTICLE

Multi-site pain and working conditions as predictors of work ability in a 4-year follow-up among food industry employees

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Abstract

Background: We investigated the separate and joint effects of multi-site musculoskeletal pain and physical and psychosocial exposures at work on future work ability.
Methods: A survey was conducted among employees of a Finnish food industry company in 2005 ($n = 1201$) and a follow-up survey in 2009 ($n = 734$). Information on self-assessed work ability (current work ability on a scale from 0 to 10; 7 = poor work ability), multi-site musculoskeletal pain (pain in at least two anatomical areas of four), leisure-time physical activity, body mass index and physical and psychosocial exposures was obtained by questionnaire. The separate and joint effects of multi-site pain and work exposures on work ability at follow-up, among subjects with good work ability at baseline, were assessed by logistic regression, and *p*-values for the interaction derived.
Results: Compared with subjects with neither multi-site pain nor adverse work exposure, multi-site pain at baseline increased the risk of poor work ability at follow-up, allowing for age, gender, occupational class, body mass index and leisure-time physical activity. The separate effects of the work exposures on work ability were somewhat smaller than those of multi-site pain. Multi-site pain had an interactive effect with work environment and awkward postures, such that no association of multi-site pain with poor work ability was seen when work environment was poor or awkward postures present.
Conclusions: The decline in work ability connected with multi-site pain was not increased by exposure to adverse physical or psychosocial factors at work.

1. Introduction

Recent epidemiological studies have shown that multi-site musculoskeletal pain is very common among the general (Haukka et al., 2006; Carnes et al., 2007; Kamaleri et al., 2008) and the working population (Miranda et al., 2010; Neupane et al., 2011). Studies with a cross-sectional design have reported a substantial correlation with multi-site pain (MSP) on physical fitness, general health and functioning (Haukka et al., 2006; Saastamoinen et al., 2006; Carnes et al., 2007; Natvig et al., 2010), as well as on self-reported work ability and plans of early retirement (Miranda et al., 2010). We have previously found that the number of pain sites among actively working people predicted poor work ability 4 years later in a dose–response-like manner (Neupane et al., 2011).

Work ability is a multidimensional concept (Ilmarinen, 2006). It reflects the balance between the work demands and individual resources of a worker. In

What's already known about this topic?

- Multi-site pain is a common phenomenon in the working population.
- Multi-site pain predicts poor future self-perceived work ability.
- Decrease in work ability is associated with poor working conditions.

What does this study add?

- Multi-site pain is associated with a decline in work ability, which is stronger than that of work-related exposures.
- The effect of multi-site pain on work ability was not potentiated by the concurrent occurrence of physical or psychosocial exposures.

the literature from systematic review, poor work ability has been associated with high age, low socio-economic status, high physical and mental demands at work, poor work autonomy, overweight, lack of leisure-time physical activity and poor physical capacity (van den Berg et al., 2009). Among Dutch construction workers, decreased work ability was associated with awkward postures [odds ratio (OR) = 2.05; 95% confidence interval (CI) = 1.86–2.27] and manual handling tasks (OR = 1.21; 95% CI = 1.01–1.34), high job demands (OR = 1.11; 95% CI = 1.01–1.21) and low job control (OR = 1.35; 95% CI = 1.24–1.46; Alavinia et al., 2007). Prospective studies investigating the role of work-related exposures on work ability are few. In an 11-year follow-up of municipal employees, declined work ability was associated with decreased possibilities for development and influence at work, increased role ambiguity, increased muscular work, decreased satisfaction with work tools and workrooms, poor physical climate and decreased leisure-time physical exercise (Tuomi et al., 1997). Consistently, excellent work ability among managers over a 10-year period was connected with high job control, good organizational climate and high organizational commitment at baseline (Feldt et al., 2009).

Our earlier study among food industry workers showed that multi-site musculoskeletal pain predicts poor self-perceived work ability, especially among younger workers (Neupane et al., 2011). That study left, however, unanswered questions about possible interactions between MSP and working conditions. It seems plausible that pain would affect work ability differently depending on the amount of physical workload or adverse psychosocial working conditions. The aim of this prospective study was to examine these conditions as potential moderators of the association between multi-site musculoskeletal pain and decline in the work ability. The second aim was to examine whether and how physical and psychosocial exposures – separately and jointly with MSP – predict poor work ability.

2. Methods

2.1 Study design and data collection

This study is a part of a 6-year follow-up survey in one of the leading food industry companies in Finland employing more than 2000 employees (Virtanen et al., 2008). A questionnaire survey was conducted among all employees of the company in 2005 (n = 1201, response rate 61%) and in 2009 (n = 1398, response rate 72%). Of the respondents in 2005, 734 subjects (61 %) participated also in the survey in 2009. The questionnaires were distributed to the workplaces, after which the closed reply envelopes were collected and sent to the researchers. There were no reminder rounds. The respondents provided written consent for linking the surveys data with register data obtained from the personnel registers of the company including information on age, gender and occupational status. This study was approved by the ethics committee of Pirkanmaa Hospital District.

2.2 Work ability

Work ability was reported as an assessment of current work ability compared with a person's self-identified lifetime best (i.e., with the question 'Assume that your work ability at its best has a value of 10 points. What score would you give your current work ability?'). This question is part of the 7-item Work Ability Index (Tuomi et al., 1998) and the currently used single item has been highly associated to the whole index (Ahlstrom et al., 2010). Work ability scores ranges from 0 (unable to work) to 10 (work ability at its best) and were categorized into four groups according to a cross-sectional population study (Gould et al., 2008), with following cut-off points: excellent (score 10), good (score 9), moderate (score 8) and poor (scores 0–7) work ability. However, for the regression analysis, work ability was dichotomized as poor work ability (scores 0–7) and good work ability (scores 8–10).

2.4 Multi-site musculoskeletal pain

Musculoskeletal pain was assessed by modified questions from the validated Nordic Musculoskeletal Questionnaire (Kuorinka et al., 1987) with a question on pain or numbness in four anatomical areas (hands or upper extremities; neck or shoulders; low back; and feet or lower extremities) during the preceding week with the reply scale from 0 (not at all) to 10 (very much). Each reply scale was dichotomized from the median (less than median: 0 = no and more than median: 1 = yes). The cut-off values for upper extremities, neck and shoulder, low back and lower extremities pain were 4, 5, 2 and 2, respectively. The four dichotomized variables were summed to inform about the number of body sites with pain (0 = no pain to 4 = 4 pain sites). The dichotomous variable 'multi-site pain' was then created by further combining 2, 3 and 4 pain sites (0 and 1 pain site as 'no multi-site pain').

2.5 Psychosocial factors

Variables '*incentive and participative leadership*' (six items, e.g., 'My supervisor pays attention to my suggestions and wishes), '*team spirit*' (six items, e.g., 'My colleagues discuss improvements to work and/or the work environment') and '*possibilities to exert influence at work*' (five items, e.g., 'The organization allows its employees an opportunity to set their own goals') were created by summing up the response scores and dividing them by the number of variables measured on the 5-point Likert scale from 1 (totally disagree/very probably not) to 5 (totally agree/very probably; Ruohotie, 1993). The three psychosocial factors were further dichotomized by their median values. The cut-off values for *incentive and participative leadership, team spirit* and *possibilities to exert influence at work* were 3.50, 3.33 and 3.20, respectively. The Cronbach's alphas of these measures were 0.68, 0.81 and 0.85, respectively.

2.6 Work environment

An index of environmental exposures at work was constructed from the questions concerning the occurrence of draught, noise, poor indoor climate, heat, cold, poor lighting and restless work environment by summing the replies (scale from 1 = not at all to 5 = very much) into a score ranging from 7 to 35. The variable was then further categorized into 'low' (7–19) and 'high' (≥20) environmental exposure by the median value. The Cronbach's alpha of the index was 0.71

2.7 Biomechanical exposures

Biomechanical exposure was addressed with questions about the occurrence of *repetitive work* and *awkward work postures*, giving the choice on a 5-point (1 = not at all, 5 = very much) Likert scale. The variables were dichotomized by their median values as 'low' (1–2) and 'high' (≥3) exposure.

2.8 Covariates

Age, gender and occupational status (blue collar and white collar), body mass index (BMI) and the level of leisure-time physical activity were included in the analysis as covariates that may confound the relationships of work environmental factors and musculoskeletal pain with work ability. The level of physical activity during the past month was asked by a scale from 0 (not at all) to 7 (high physical activity for more than 3 h a week).

2.9 Statistical analysis

To study the separate and joint effects of MSP and various work-related exposures, new variables were created combining the dichotomous variables into four category variables as follows: (1) neither MSP nor adverse work exposure, (2) MSP but no adverse work exposure, (3) no MSP but adverse work exposure and (4) MSP and adverse work exposure. Logistic regression was performed to examine whether baseline MSP or work factors separately or jointly predicted poor work ability at the 4-year follow-up. The regression analyses were restricted among those with 'non-poor work ability' at baseline. Odds ratios and their 95% CI were calculated. The models were built up in four steps: model I: adjusted for age and gender; model II: adjusted for the variables in model I plus occupational status; model III: adjusted for the variables in model II plus physical or psychosocial variables at baseline; and model IV: adjusted for the variables in model II plus leisure-time physical activity and body mass index. Age was forced into the models as a continuous variable throughout the analyses.

To assess if work exposures and MSP modify each others effects on work ability, *p*-values for their interactions were derived from the fully adjusted logistic regression models. The nature of those interactions was ascertained by stratification according to the level of psychosocial and physical factors.

All analyses were performed using SPSS (version 15.0, SPSS Inc., Chicago, IL, USA) software.

3. Results

The age of the 734 subjects who participated in the 4-year follow-up survey ranged between 20 and 62

Table 1 Characteristics of background variables.

	All employees at baseline		Employees with 'non-poor' work ability at baseline	
	n = 734	%	*n* = 628	%
Gender				
Female	479	65	407	65
Male	255	35	221	35
Age (years)				
20–30	132	18	121	20
31–40	205	28	170	27
41–50	244	33	209	33
51+	153	21	128	20
Occupational status				
Blue collar	518	71	433	69
White collar	216	29	195	31
Leisure-time physical activity				
Not at all or only little	160	22	128	20
Moderate	324	44	267	43
Much	250	34	233	37
Body mass index (kg/m^2)				
<23	180	25	162	26
23.0–25.9	230	31	204	33
26.0–28.9	153	21	128	20
>29.0	171	23	134	21

years (mean 41, standard deviation 9.9) at baseline. There were 518 blue-collar employees (Table 1), the majority of whom were food processing and maintenance workers, and 216 white-collar employees, the majority working in administrative duties. Compared to those who replied to both questionnaires, the non-respondents in the follow-up survey were younger; mostly, men were more often exposed to poor physical and psychosocial factors and had mostly poor work ability.

The prevalence of poor work ability was 14% ($n = 106$) at baseline and 22% at follow-up ($n = 161$). A total of 16% estimated their work ability as excellent at baseline and 14% at follow-up (data not shown). Women and men did not differ regarding their work ability, but there were differences by age group, poor work ability becoming more prevalent with age. Also, blue-collar workers reported more often poor work ability.

Adjusted risk estimates of poor work ability at follow-up in relation to baseline MSP, psychosocial exposures and their combinations, among the employees with 'non-poor work ability' at baseline are shown in Table 2. In model III, when adjusted also for baseline psychosocial factors, an increased risk of future poor work ability was either due to the presence of MSP or both exposures. In the adjusted models (model IV), MSP increased the risk of future poor work ability with the OR of 2.4 (95 % CI = 1.1–4.9), when leadership was assessed to be good, and with the OR of 2.7 (95% CI = 1.4–5.1), when possibilities to exert influence at work were good. The former OR slightly increased and the latter decreased when the psychosocial work factors were assessed as poor. There

Table 2 Separate and joint effects of multi-site musculoskeletal pain (MSP) and exposure to poor leadership, poor team spirit and poor possibility to exert influence on poor work ability at follow-up, among employees with 'non-poor' work ability at baseline. Logistic regression analysis, odds ratios (OR) with 95% confidence intervals.

			OR (95%CI)			
	n = 628	No. of subjects with poor work ability (%)	Model I	Model II	Model III	Model IV
MSP/poor leadership						
No/no	157	13 (8)	1	1	1	1
Yes/no	141	19 (14)	2.6 (1.3–5.3)	2.5 (1.2–5.0)	2.7 (1.3–5.5)	2.4 (1.1–4.9)
No/yes	144	27 (19)	1.8 (0.8–3.7)	1.6 (0.7–3.3)	1.8 (0.7–4.4)	1.6 (0.8–3.5)
Yes/yes	186	42 (23)	3.3 (1.7–6.5)	2.9 (1.5–5.7)	3.3 (1.4–7.5)	2.8 (1.4–5.6)
MSP/poor possibilities to exert influence						
No/no	208	22 (11)	1	1	1	1
Yes/no	193	53 (28)	2.9 (1.6–5.5)	2.8 (1.5–5.3)	2.9 (1.5–5.5)	2.7 (1.4–5.1)
No/yes	114	21 (18)	2.1 (1.0–4.4)	1.6 (0.7–3.3)	1.1 (0.4–2.9)	1.7 (0.8–3.5)
Yes/yes	219	65 (30)	3.0 (1.6–5.6)	2.3 (1.2–4.3)	1.6 (0.6–4.0)	2.2 (1.1–4.3)
MSP/poor team spirit						
No/no	180	23 (13)	1	1	1	1
Yes/no	200	50 (25)	1.7 (1.0–3.1)	1.6 (0.9–2.9)	1.6 (0.9–2.9)	1.5 (0.8–2.8)
No/yes	141	20 (14)	0.7 (0.3–1.5)	0.6 (0.3–1.3)	0.6 (0.2–1.5)	0.6 (0.3–1.3)
Yes/yes	213	68 (32)	2.0 (1.1–3.7)	1.7 (0.9–3.1)	1.7 (0.7–3.8)	1.7 (0.9–3.1)

Model I: age and gender; model II: model I+ occupational status; model III: model II+ poor leadership, poor possibilities to influence and poor team spirit at baseline; model IV: model II+ leisure-time physical activity and BMI.

Table 3 Separate and joint effects of multi-site musculoskeletal pain (MSP) and exposure to poor work environment, awkward postures and repetitive movements on poor work ability at follow-up, among employees with 'non-poor' work ability at baseline. Logistic regression analysis, odds ratios (OR) with 95% confidence intervals (CI).

			OR (95% CI)			
	n = 628	No. of subjects with poor work ability (%)	Model I	Model II	Model III	Model IV
MSP/poor work environment						
No/no	222	21 (10)	1	1	1	1
Yes/no	175	45 (26)	3.2 (1.7–6.1)	3.2 (1.7–6.1)	2.8 (1.4–5.4)	3.1 (1.6–5.9)
No/yes	99	22 (22)	2.7 (1.3–5.7)	2.1 (1.0–4.5)	2.1 (0.8–5.7)	2.3 (1.0–4.9)
Yes/yes	238	73 (31)	3.2 (1.7–6.0)	2.6 (1.3–4.9)	2.3 (0.9–5.7)	2.5 (1.3–4.8)
MSP/awkward postures						
No/no	167	9 (5)	1	1	1	1
Yes/no	102	25 (25)	4.3 (1.7–10.5)	4.4 (1.8–10.9)	4.3 (1.7–10.6)	4.6 (1.8–11.3)
No/yes	154	34 (22)	4.5 (1.9–10.4)	3.5 (1.5–8.3)	2.9 (1.2–7.2)	3.7 (1.6–9.0)
Yes/yes	311	93 (30)	5.8 (2.7–12.7)	4.6 (2.0–10.3)	3.5 (1.4–8.4)	4.4 (1.9–10.0)
MSP/repetitive movements						
No/no	159	16 (10)	1	1	1	1
Yes/no	82	19 (23)	2.1 (0.9–5.1)	2.1 (0.9–5.0)	1.9 (0.8–4.7)	2.1 (0.8–5.1)
No/yes	162	27 (17)	2.1 (1.0–4.6)	1.7 (0.8–3.7)	1.3 (0.6–2.9)	1.8 (0.8–4.0)
Yes/yes	331	99 (30)	3.7 (1.9–7.3)	3.0 (1.5–6.0)	2.1 (1.0–4.6)	2.9 (1.5–5.9)

Model I: age and gender; model II: model I+ occupational status; model III: model II+ environmental exposures, awkward postures and repetitive movements at baseline; model IV: model II+ leisure-time physical activity and BMI.

was an influence of MSP on poor work ability under good team spirit when adjusted for age and gender, but the effect attenuated with further adjustments. Poor leadership, poor possibilities to exert influence and poor team spirit were not predictive of poor work ability, separately from MSP, when all covariates were considered.

The joint effect of MSP and poor leadership on work ability was only slightly stronger than that of MSP separately (model III, OR = 2.8 and OR = 2.4, respectively). In contrast to this, the joint effect of MSP and poor possibilities to exert influence was slightly lower than the separate effect of MSP (OR = 2.2 and OR = 2.7). The effect of the combination of MSP and poor team spirit on work ability failed to reach statistical significance in models II, III and IV.

Table 3 shows the adjusted risk estimates of poor work ability at follow-up in relation to baseline MSP, biomechanical and work environmental exposures, and to the combinations of MSP with these exposures. Work environmental exposures (model IV, OR = 2.3; 95% CI = 1.0–4.9) and awkward postures (OR = 3.7; 95% CI = 1.6–9.0) as well as MSP (OR = 3.1; 95% CI = 1.6–5.9 and OR = 4.6; 95% CI = 1.8–11.3, respectively) were separately predictive of poor work ability. The joint effect of MSP with poor work environment or awkward postures was intermediate in size compared with the separate effects in the fully adjusted models. Neither MSP nor exposure to repetitive movements influenced work ability when adjusted for all covariates, while their combination did (OR = 2.9; 95% CI = 1.5–5.9).

The interaction terms of MSP and the psychosocial factors on work ability turned out as statistically non-significant. Of the physical factors, the interaction was significant for work environment * MSP ($p = 0.030$) and for awkward postures * MSP ($p = 0.012$). The nature of these interactions is displayed in Table 4, which demonstrates that MSP increased the risk of poor work ability when working conditions were good (ORs varied between 2.0 and 4.7), but not when working conditions were poor (ORs between 1.1 and 1.7).

4. Discussion

To our knowledge, this study is the first to report separate and combined effects of MSP and physical and psychosocial work exposures on work ability in a prospective design. The results show that MSP had a clear separate influence on the decrease of work ability that was stronger than the effect of the work exposures. Poor work environment (OR = 3.1; 95% CI = 1.6–5.9) and awkward postures (OR = 4.6; 95% CI = 1.8–11.3) had a negative separate influence on future work ability. We also found an interaction between MSP and work environment on one hand, and MSP and awkward postures, on the other. This

Table 4 Associations of multi-site pain (MSP) with poor work ability at follow-up, among the employees with good work ability at baseline, stratified by psychosocial and physical work factors. Logistic regression analyses adjusted for age, gender, occupational status, physical activity and BMI. Odds ratios (OR) with 95% confidence intervals (CI).

No. of subjects (*n* = 628)	Good	Poor
Psychosocial working conditions		
Leadership		
No MSP	1	1
MSP	2.2 (1.0–4.5)	1.7 (0.9–3.2)
Team spirit		
No MSP	1	1
MSP	2.9 (1.4–6.0)	1.5 (0.8–2.9)
Possibilities to exert influence		
No MSP	1	1
MSP	2.7 (1.4–5.2)	1.3 (0.7–2.6)
Physical working conditions		
Environmental exposure		
No MSP	1	1
MSP	3.0 (1.6–5.9)	1.1 (0.6–2.2)
Repetitive movements		
No MSP	1	1
MSP	2.0 (0.8–5.1)	1.6 (0.9–2.9)
Awkward posture		
No MSP	1	1
MSP	4.7 (1.9–11.9)	1.2 (0.7–2.1)

interaction was such that MSP increased the risk of poor work ability when working conditions were good but not when working conditions were poor.

We found that only one psychosocial factor at work (possibility to exert influence) among workers free of MSP increased the risk of poor work ability when adjusted for age and gender (OR = 2.1; 95% CI = 1.0–4.4). The effect became smaller with subsequent adjustments. In analyses stratified by psychosocial exposures, MSP had an effect on future work ability only in the absence of poor psychosocial exposures – a similar finding to that with physical exposures.

Our results are in line with previous studies reporting on the importance of pain in several body sites on perceived work ability (Miranda et al., 2010; Neupane et al., 2011) and decreased work ability leading to sickness absence (Morken et al., 2003; Nyman et al., 2007) or work disability pension (Kamaleri et al., 2009). The results also corroborate findings showing that high physical workload and high work environmental exposures increase the risk of poor work ability (Gamperiene et al., 2008; Alavinia et al., 2009; van den Berg et al., 2009). Work-related physical risk factors such as working in awkward postures were strongly associated with poor work ability among Dutch construction workers (Alavinia et al., 2009). In another study of female workers, poor self-reported physical health and unskilled work were the strongest factors associated with reduced work ability (Gamperiene et al., 2008). Of the environmental exposures measured in our study (draught, noise, poor indoor climate, heat, cold, poor lighting and restless work environment), the strongest individual association with poor work ability was found for restless work environment. Statistical significance of the interactions indicates that physical conditions are an important moderator of the MSP-related decline in work ability. Lower risk in more adverse conditions seems paradoxical. It may be due to stronger MSP-related healthy worker effect. In particular, this finding is pending replication studies with data about the MSP-related replacements and rearrangements of the jobs within the company as well as about the routes of exit from the company.

Poor leadership and team spirit (or work climate) are concepts that have gained increasing attention in occupational research. They both have been shown to affect workers' health and predict disability (Sonnentag and Zijlstra, 2006; Sinokki et al., 2010). The evidence suggests that psychosocial factors can contribute to the development of work-related musculoskeletal pain (Macfarlane et al., 2009) and MSP (Haukka et al., 2011), and a recent study showed that mental stress mediates the effect of pain on disability (Hall et al., 2011). It is possible that there exists a cumulative process where adverse psychosocial factors and MSP influence each others. Our results suggest that once MSP has appeared, its interaction with work-related psychosocial conditions is non-significant, in other words, the conditions are not anymore an important moderator with respect to the decline of work ability. Moreover, earlier research seems not to report our finding that poor psychosocial working conditions do not influence work ability in the absence of MSP.

In addition to replicating the findings of our earlier study (Neupane et al., 2011) with the cohort with 'non-poor' work ability at baseline, this study provided insight to the importance of the physical and psychosocial conditions and contexts for the consequences of pain among working population, in particular among workers of food processing industry. This work sector was chosen to represent an occupational area with high levels of exposures to physical and psychosocial loading. The food processing industry employs in Finland 34,000 workers (1–2% of the workforce). Typically, work-related accidental injuries and sickness absence rates are high in food processing. Musculoskeletal disorders are the major reason for sick leaves in industrial occupations. Also, we may argue that corresponding study in any work sector with heavy manual work would yield similar findings.

The prospective design is among the strengths in our study. Response rates for both surveys were satisfactory. However, we cannot rule out the possibility of a selection due to differential participation at baseline or at follow-up affected our results. Selection out of the workforce is more likely to occur among the workers with health problems, as well as with the highest exposure levels, leaving the healthiest workers at the workplaces, for instance to be selected in cohort studies such as ours. Such a bias deflates the associations between workplace exposures and health outcomes.

The validated Nordic Musculoskeletal Questionnaire (Kuorinka et al., 1987) was used in the study. It measures musculoskeletal pain that has occurred during the past 7 days. This time frame increases the likelihood that pain had truly occurred at multiple body sites concurrently and which also decreases the likelihood of a recall bias. The information regarding musculoskeletal pain, physical factors and psychosocial factors were measured by questionnaire, i.e., no objective measurements were carried out. However, a self-report method appears to be a good (and practically only) way of assessing pain in epidemiological studies because of the complex and subjective nature of the pain (Crombie et al., 1999; Natvig et al., 2001). Physical and psychosocial factors were measured by using single-item question, which have already been used in scientific research since 1977 in Finnish Statistics (Virtanen et al., 2008; Lehto and Sutela, 2009). In addition to age, gender and occupational status, also BMI and physical exercise were considered as possible confounders, since some studies have indicated that lifestyle factors are associated with the number of pain sites and work ability (Miranda et al., 2010). However, we did not find that those factors had much influence on our results.

Work ability was measured by a single-item question. In addition to being a quick and cost-effective method, it has been shown to be valid especially for clinical use and its results are easy to interpret (Ahlstrom et al., 2010). Work ability could be considered as an intermediate variable between exposures and future work ability, and a follow-up of those with non-poor work ability at baseline would decrease the power to determine additional effects of baseline exposures on future poor work ability.

Personal factors such as negative affectivity or tendency for somatization can affect participant reporting behaviour for both exposure and outcome, which may be a weakness of this study. They may cause systematic overestimations and bias the association between exposure and outcome. This calls for the development of objective measurement options of both physical exposures and psychosocial factors at work, applicable in epidemiological studies.

This prospective study indicates a clear effect of MSP on the decline in work ability, separate from and stronger than those of work-related exposures. It also shows that the effect of MSP on work ability was not potentiated by the concurrent occurrence of physical or psychosocial exposures at work. However, a limited number of work exposure variables available is a limitation of our study. The results also imply that among workers without widespread pain symptoms, poor work environment and high biomechanical exposures are associated with an increased risk of future poor work ability, while some central psychosocial factors at work may be less significant. On the other hand, the decreasing effect of MSP on work ability was only seen among employees without adverse physical or psychosocial working conditions. The latter suggests that once MSP has appeared, work-related influences on work ability decrease in importance. Therefore, occupational health care services should pay attention to screen and alleviate adverse physical and psychosocial working conditions as well as MSP in order to help workers to sustain work ability for the future. We hope that these findings can guide prevention efforts among food industry workers and similar occupational groups and may have importance public health implications for this labour force.

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Author contributions

C.H.N., P.V. and A.S. involved in the data collection. S.N. analysed the data and wrote up the manuscript. P.V., P.L.A., H.M., A.S. and C.H.N. revised the manuscript. All authors read and approved the final manuscript.

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