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LIFESTYLE AND HEALTH-RELATED FACTORS IN RELATION TO MUSCULOSKELETAL AND MENTAL DISABILITY
- A LIFE COURSE APPROACH

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ACADEMIC DISSERTATION

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I dedicate this thesis to my son and the memory of my late father.

CONTENTS

LIST OF ORGINAL PUBLICATIONS

The thesis is based on the following articles, referred to in text by Roman numerals I to IV. The original articles have been reprinted with the permission of the copyright holders.

I Frilander H, Miranda H, Mutanen P, Martelin T, Pihlajamäki H, Viikari-Juntura E. Trends in musculoskeletal disorders and related health care utilization among conscripts in Finland, 1967-2006. Mil Med. 2012;177(9):1069-74.

II Frilander H, Solovieva S, Mutanen P, Pihlajamäki H, Heliövaara M, Viikari-Juntura E. Role of overweight and obesity in low back disorders among men: a longitudinal study with a life course approach. BMJ Open. 2015;5(8). e007805.

III Frilander H, Viikari-Juntura E, Heliövaara M, Mutanen P, Mattila VM, Solovieva S. Obesity in early adulthood predicts knee pain and walking difficulties among men: a life course study. Eur J Pain. 2016;20(8):1278-1287.

IV Frilander H, Lallukka T, Viikari-Juntura E, Heliövaara M, Solovieva S. Health problems during compulsory military service predict disability retirement: a register-based study on secular trends during 40 years of follow-up. PloS One. 2016;11(8). e0159786.

ABBREVIATIONS

95% CI	95 percent confidence interval
BMI	body mass index
DP	disability pension
DR	disability retirement
FCP	Finnish Centre for Pensions
HR	hazard ratio
H2000	Health 2000 Study
KTL	Kansanterveyslaitos, National Public Health Institute, nowadays National Institute for Health and Welfare
LBP	low back pain
MSD	musculoskeletal disorder(s)
MSDs@Mil	Musculoskeletal Disorders in Military Service Study (TULEVA, Finnish abbreviation)
OECD	Organisation for Economic Cooperation and Development
OR	odds ratio
PR	prevalence ratio
SII	The Social Insurance Institution of Finland
THL	Terveyden ja Hyvinvoinnin laitos, National Institute for Health and Welfare (formerly KTL)
WC	waist circumference
WHO	World Health Organization
WHR	Waist to hip ratio
WHtR	Waist to height ratio

ABSTRACT

Background and aims

Low back and knee pain are common and often cause discomfort and disability as well as burdening the health care services. Previous studies have highlighted the significance of adults' lifestyle factors as factors determining musculoskeletal health and disability retirement (DR). Chronic musculoskeletal disorders tend to develop over long time periods, suggesting an importance of early-life exposures in disease onset. However, there is insufficient understanding of early indicators of knee and low back problems as well as those predicting DR. Furthermore, it is not known whether there is an optimal time window for prevention of these disorders.

The main aim of this thesis was to fill the gaps in knowledge on the role of early health-related and lifestyle factors in musculoskeletal health and permanent work disability by applying a life course approach and examining the impact of obesity and other lifestyle factors on back and knee problems over time. Furthermore, time trends in seeking medical advice during military service were explored. Finally, it was tested whether seeking medical advice could be a potential indicator for later DR.

Material and methods

The study base comprised a nationally representative random sample of 2843 men aged 18-50 years, living in mainland Finland and alive on 1 July 2000. The military records of these men were searched from the register of the Finnish Defence Forces, with 2639 (93%) being identified. The military records were linked with data from the Health 2000 Study and retirement data from the national registers of the Social Insurance Institution (SII) and the Finnish Centre for Pensions (FCP). Study I assessed temporal trends in seeking healthcare during military service over a 40 year period. Studies II-IV applied a longitudinal design, with pre-military health examinations and healthcare visits during military service as baseline information and the Health 2000 Study (Studies II, III) and national registers (Study IV) providing information for the follow-up.

Due to the different aims, the populations of the four studies included in the thesis had varying inclusion and exclusion criteria. Baseline data consisted of information from military records (measured weight and height, self-reported smoking and physical activity, health care visits, interruption of military service and its cause). The Health 2000 Study provided weight-related measures at follow up and during life course, information on low back and knee symptoms and disorders, as well as information on other lifestyle and health-related factors. Data on all DR events and their main and secondary diagnoses were obtained from the national registers of SII and FCP.

Results

During the four decades of the study period i.e. 1967-2006, there has been a marked increase in healthcare seeking due to any reason as well as due to musculoskeletal problems among Finnish conscripts. No specific reason for the steady increase in

healthcare seeking was detected. The majority of conscripts visited healthcare at least once due to MSDs during their compulsory military service, most frequently due to problems in the lower extremities and the lower back. There was a tripling in the proportion of men seeking medical advice about a mental problem or due to both mental and musculoskeletal problems at least once during their military service if the incidence in 1967-1976 was compared to 1987-1996.

The longitudinal analyses revealed that both baseline and life course BMI predicted one-month radiating low back pain (LBP), knee pain as well as functional limitations due to a knee problem at follow-up. Men who were borderline obese at baseline and became severely obese during the follow-up exhibited an increased risk of developing radiating LBP and experiencing functional knee limitations, while the risk of knee pain was increased already for those who had normal BMI at baseline and became overweight during follow-up. No clear associations were seen for non-specific LBP or clinically defined low back outcomes. Smoking and physical activity were not associated with either low back or knee outcomes.

Baseline borderline obesity doubled the risk of both traumatic and non-traumatic knee injuries during military service. The association of baseline borderline obesity with functional limitations due to knee problems in the follow-up was reduced when those visits due to knee problems after an accidental injury during military service were entered in the model, suggesting a mediating role of these accidental knee injuries in knee functioning.

In the cross-sectional analyses at follow-up, both general and abdominal obesity were associated in a similar manner with radiating LBP and unilateral knee pain. In contrast, neither general nor abdominal obesity was associated with non-specific LBP or clinically defined low back outcomes. Functional limitations of the knee were associated with general, but not with abdominal, obesity.

Men who did not complete military service had a clearly higher cumulative incidence of DR, particularly due to mental disorders, in comparison with their counterparts who completed military service. Visiting military health care due to both musculoskeletal and mental problems clearly increased the overall risk of DR, in particular DR due to mental disorders.

Conclusions
The results of this thesis suggest that in men, health behaviours in early adulthood as well as during life course, increase the likelihood of low back and knee problems, functional knee limitations and work disability later in life. Adolescence and young adulthood seem to be a critical period for the development of adult male musculoskeletal health. The findings point to a mediating role of traumatic knee injuries suffered during military service with the development of a knee disability in overweight men, thus providing further support for mechanical pathways in the aetiology of knee functioning.

It is important to prevent traumatic and over-exertion injuries in the lower extremities during military service. Health-related problems, particularly mental ones, in early adulthood are important predictors of DR. In particular, the comorbidity of musculoskeletal and mental problems in late adolescence seems to be detrimental for future work ability.

Encouraging young people from becoming overweight and avoiding further weight gain during the life course may prevent radiating LBP as well as knee pain and associated disability. Call-up examinations and follow-up of visits to military healthcare provide access to the entire age cohort of males. On these occasions, those individuals at risk for work disability can be identified and early preventive measures initiated. Risk indicators should be identified and preventive measures initiated also in school healthcare as well as in occupational health services in those young adults entering working life.

TIIVISTELMÄ

Tausta ja tavoitteet

Alaselkä- ja polvikipu ovat yleisiä oireita ja aiheuttavat usein haittaa, terveyspalvelujen käyttöä ja työkyvyttömyyttä. Aikaisemmat tutkimukset ovat korostaneet aikuisten elämäntapatekijöiden merkitystä tuki- ja liikuntaelinterveydelle (TULE) ja työkyvyttömyyseläkeriskille. Krooniset TULE-vaivat näyttävät kehittyvän pidemmän ajan kuluessa, mikä saattaa viitata elämän varhaisten vaiheiden elinympäristö- ja elintapatekijöiden merkitykseen sairauksien synnyssä. Kuitenkin ymmärrys polvi- ja selkäongelmien sekä työkyvyttömyyseläkkeiden varhaisista indikaattoreista on puutteellinen. Emme myöskään tiedä, missä elämän vaiheessa ehkäisytoimenpiteet olisivat tehokkaimpia.

Tämän väitöskirjatyön pääasiallisena tavoitteena oli selvittää varhaisten terveyteen ja elämäntapoihin liittyvien tekijöiden merkitystä liikuntaelinten terveydelle ja työkyvyttömyydelle käyttäen elämänkaareen pohjautuvaa lähestymistapaa. Tavoitteen saavuttamiseksi selvitettiin lihavuuden ja muiden elämäntapatekijöiden yhteyksiä myöhempiin polvi- ja selkävaivoihin. Väitöskirjatyössä tutkittiin myös varusmiespalvelun aikaisen terveyspalvelujen käytön muutoksia ajassa. Lisäksi selvitettiin terveyspalvelujen käytön merkitystä myöhemmän työkyvyttömyyseläkkeen ennustajana.

Aineisto ja menetelmät

Tutkimuksen lähdeväestö koostui kansallisesti edustavasta Terveys 2000 -tutkimuksen satunnaisotoksesta, johon kuului 2843 Manner-Suomessa asuvaa 1.7.2000 elossa olevaa 18-50 vuotiasta miestä. Asevelvollisuustiedot löytyivät Puolustusvoimien arkistosta 93 %:lle. Nämä tiedot yhdistettiin Terveys 2000 -tutkimuksen tietoon sekä Kansaneläkelaitoksen (KELA) ja Eläketurvakeskuksen (ETK) eläkerekisteritietoihin. Ensimmäisessä osatutkimuksessa arvioitiin varusmies-palvelun aikaisen terveyspalvelujen käytön muutoksia 40 vuoden aikana käyttäen Puolustusvoimien Asevelvollisuusrekisterin sairaskertomustietoja. Tutkimukset II-IV sovelsivat pitkittäistä tutkimusotetta käyttäen asevelvollisten terveystarkastuksia lähtötilanteena ja Terveys 2000 -tutkimusta (tutkimukset II, III) ja kansallisia rekistereitä (IV) seurantana. Lähtötilanteessa asevelvollisilta oli mitattu pituus ja paino ja kysytty tupakoinnista ja liikunnan harrastamisesta. Puolustusvoimien rekistereistä selvitettiin vastaanottokäynnit ja niiden syy sekä mahdollinen palveluksen keskeyttäminen ja sen syy. Terveys 2000 -tutkimuksessa mitattiin pituus, paino ja vyötärön ympärys ja kysyttiin painon kehityksestä seurannan aikana. Lisäksi kerättiin tietoa selkä- ja polvioireista sekä liikuntaelinten toimintakyvystä. Kelan ja ETKn kansallisista eläkerekistereistä saatiin tieto kaikista työkyvyttömyyseläke-tapahtumista diagnooseineen.

Tulokset

Tutkimuksen neljän vuosikymmenen aikana, vuosina 1967-2006, suomalaisten varusmiesten terveyspalvelujen käyttö, sekä yleensä että tuki-ja liikuntaelinongelmien vuoksi, on lisääntynyt huomattavasti. Mitään yksittäistä syytä tälle tasaiselle nousulle ei todettu. Enemmistö varusmiehistä hakeutui vastaanotolle TULE-ongelmien vuoksi

vähintään kerran varusmiespalvelun aikana, useimmiten alaraaja- tai selkäongelmien vuoksi. Mielenterveys- tai sekä mielenterveys- että tuki-ja liikuntaelinongelmien vuoksi vähintään kerran vastaanotolle hakeutuneiden osuus kolminkertaistui ajanjaksojen 1967-1976 ja 1987-1996 välillä.

Pitkittäisanalyysit osoittivat, että sekä kutsunta-aikainen että elämänaikainen painoindeksi ennustivat myöhempää säteilevää selkäkipua, polvikipua ja polven toimintarajoitteita. Nuorena lievästi ja myöhemmin vaikeasti lihavilla oli lisääntynyt säteilevän alaselkäkivun ja polven toimintarajoitteiden riski. Polvikivun riskiä lisäsi jo ylipainon kehittyminen lähtötilanteessa normaalipainoisille. Ylipaino tai lihavuus eivät olleet yhteydessä epäspesifiseen selkäkipuun tai lääkärin toteamiin selkäsairauksiin. Myöskään tupakointi tai liikunnan harrastaminen eivät olleet yhteydessä selkä- tai polviongelmiin.

Lihavuus kaksinkertaisti sekä tapaturmaisten että ei-tapaturmaisten polvivammojen riskin varusmiespalvelun aikana. Lihavuus oli yhteydessä myös polven myöhempään toimintarajoitteeseen. Tämä yhteys heikkeni, kun malliin lisättiin terveyspalvelun käyttö tapaturmaisen polviongelman vuoksi, viitaten siihen, että tapaturmat välittivät lihavuuden ja polven toimintarajoitteiden yhteyttä. Poikkileikkausasetelmassa sekä seurantahetken yleinen (painoindeksi) että keskivartalolihavuus olivat yhteydessä säteilevään alaselkäkipuun ja toispuoliseen polvikipuun. Toisaalta yleinen tai keskivartalolihavuus eivät olleet yhteydessä epäspesifiseen selkäkipuun eivätkä lääkärin toteamiin selkäsairauksiin. Polven toimintarajoitteet olivat yhteydessä yleiseen lihavuuteen mutta eivät keskivartalo-lihavuuteen.

Varusmiespalvelun keskeyttäneillä oli selkeästi lisääntynyt työkyvyttömyyseläkkeiden riski, erityisesti mielenterveysongelmista johtuen. Myös hoitoon hakeutuminen varuspalvelun aikana sekä liikuntaelinten että mielenterveysongelmien vuoksi lisäsi selvästi työkyvyttömyyseläkkeen riskiä yleisesti – ja etenkin mielenterveyssyistä.

Johtopäätökset
Väitöskirjan tulokset viittaavat siihen, että terveyskäyttäytyminen varhaisessa aikuiselämässä ja elämän aikana lisää myöhempien alaselkä- ja polvikipujen, polven toimintarajoitteiden ja työkyvyttömyyseläkkeen todennäköisyyttä. Nuoruus ja varhainen aikuisikä näyttävät kriittisiltä ajanjaksoilta miesten aikuisiän liikuntaelinten terveyden kehittymiselle. Tulokset viittaavat siihen, että varusmiespalvelun aikaiset tapaturmaiset polvivammat toimisivat välittäjinä ylipainoisten miesten polven toimintarajoitteiden synnyssä korostaen mekaanisten tekijöiden merkitystä.

Alaraajojen tapaturmien ja rasitusvammojen ehkäisyn tulisi jatkossakin olla painopistealue varusmiespalvelun aikana. Terveyteen liittyvät ongelmat, etenkin mielenterveysongelmat, varhaisessa aikuiselämässä ovat työkyvyttömyyseläkkeen tärkeitä ennustavia tekijöitä. Erityisesti samanaikaiset tuki-ja liikuntaelinten ja mielenterveyden ongelmat myöhäisnuoruudessa näyttävät ennustavan työkyvyttömyyttä.

Ylipainon ehkäisy nuoruudessa ja lisäpainon kertymisen välttäminen aikuiselämän aikana saattavat ehkäistä säteilevää alaselkäkipua, polvikipua ja siihen liittyvää toimintakyvyn vajavuutta. Kutsuntatarkastusten ja varusmiespalvelun aikaisten terveydenhuoltokäyntien avulla on mahdollista seurata kokonaisia nuorten miesten ikäluokkia, jolloin työkyvyttömyyttä uhkaavat tekijät voidaan tunnistaa ja ryhtyä ehkäiseviin

toimiin. Riskitekijät tulisi tunnistaa ja niihin pyrkiä vaikuttamaan myös kouluterveydenhuollossa ja työterveyshuollossa niiden nuoren aikuisten kohdalla, jotka ovat siirtymässä työelämään.

1   INTRODUCTION

Musculoskeletal diseases (MSDs) as well as mental disorders are prevalent health problems; they cause discomfort, and disability and consume health care resources (March et al. 2014, Wittchen et al. 2011, Woolf et al. 2010). In addition to personal suffering, they pose a major burden to societies all around the world (European Commission 2007, Murray et al. 2012, Vos et al. 2012). Mental and behavioural problems together with musculoskeletal conditions are responsible for nearly 45% of years lived with disability (YLD) in the world (Hoy et al. 2015). Major depressive disorder and low back pain (LBP) have been estimated as the two top-ranking causes of YLDs in the Global Burden of Disease Studies in 1990 and 2010 (Vos et al. 2012). In addition to the economic and social consequences, an individual's premature departure from paid employment can be detrimental to his/her health (Waddel and Burton 2006).

MSDs and mental diseases are the two most prominent causes of DR in the Western countries (OECD 2010). The incidence of DR due to mental disorders increased in Finland and in other parts of Europe during the 1990s (Järvisalo et al. 2005a, OECD 2010, Salminen et al. 1997). Since the mean age when people with mental disorders move to DR is relatively low, this translates into long durations of disability pensions (DPs), and thus these types of pensioners make up the largest group of disability retirees. Indeed, mental disorders accounted for 30-40% of all disability benefits among OECD member states (OECD 2015).

Various factors experienced during early life and then later throughout the life course may affect the risk of later symptoms, disease and disability (WHO and International Longevity Centre - UK 2000). Musculoskeletal and mental symptoms are prevalent already in young people; these have shown increasing secular trends (Collishaw 2015, Hakala et al. 2002). However, more information is needed to clarify the long-term consequences of symptoms and health behaviour in early adult life and during life course.

Military defence in Finland is based on the civic duty of military service, thus the Finnish Defence Forces have relied on universal male conscription since 1922. Obligatory conscription call-ups are organised annually in the autumn and they apply to all males with Finnish citizenship who turn 18 during that year. During the call-up, the young men found to be fit for service are conscripted for military service during the next few years. The participation rate in Finnish military service is far higher than in other countries (Siilasmaa et al. 2010); therefore conscripts comprise an excellent population for epidemiological studies. The call-up for obligatory military service includes a health examination and this offers an outstanding opportunity to reach out to an entire age cohort of males for the very last time after they have left school. Young men attending military service are relatively healthy and represent well the young male population. About 80% of male age cohorts complete their military service, although there is a declining trend (Parkkola 1999, Siilasmaa et al. 2010).

Mid-life determinants of musculoskeletal and mental problems have been widely studied. However, effective prevention would benefit if there was knowledge of modifiable risk factors present earlier in an individual's life. To fill this knowledge gap, this thesis has undertaken life course studies, taking advantage of the Finnish nationwide registers, with data linkage from different stages of life.

2 REVIEW OF THE LITERATURE

2.1 LIFE COURSE APPROACH

The life course approach was first used in the 1960s to forecast future adult health on the basis of early life socio-economic and developmental factors (Wadsworth et al. 2003). Later it became evident that exposure during the life course and its interaction with experience and conditions during childhood influence health, morbidity and general functioning. Thus, it is important to assess risk behaviours, to identify protective factors and to evaluate environmental exposure from several periods of life when analysing complex processes of disease epidemiology (Yu 2006). Chronic diseases, not only cancers but also several MSDs, develop very gradually, which means that there are long time intervals between exposure, disease initiation and clinical diagnosis. This suggests that exposures occurring early in life play a role in initiating disease processes before there are any evident pathological signs of the disease (Lynch and Smith 2005). Moreover, many risk factors for chronic disease (e.g. body weight-related measures) have their own natural history, stressing the importance of time in monitoring the development of chronic disease (Kuh and Ben-Schlomo 2004). The life course approach examines an individual's life history e.g. it can evaluate how early life events (e.g. weight gain/traumas) influence later life events (e.g. knee pain). A life course perspective to chronic disease epidemiology demands an interdisciplinary framework and places the emphasis on early intervention.

Life course epidemiology has been defined as 'the study of long term effects on later health or disease risk of physical or social exposures during gestation, childhood, adolescence, young adulthood and later life' (Kuh and Ben-Schlomo 2004). It seeks to elucidate the underlying biological, behavioural and psychosocial processes that operate across the life span and even over generations, to influence the development of disease risk. In particular, one aim is to study how early life factors combine with later life factors and the approach seeks to identify risk and protective processes throughout the life course (Kuh et al. 2003).

Two main models (critical period and accumulation of risk models) have been developed (Ben-Shlomo and Kuh 2002, WHO and International Longevity Centre - UK 2000) (Table 1).

Critical period models refer to crucial times in development, when a risk factor can influence health in later life. These can be divided into two subgroups: 1a) A model, where an exposure acting during a specific period has lasting or lifelong effects, for example, poor growth in utero can lead to the individual developing cardiovascular disease. 1b) The second subgroup is an extension of the first subgroup with several interrelated exposures acting during critical time periods, possibly involving effect modifiers.

Accumulation of risk models focus on the importance of exposure over time and the sequence of exposure. 2a) A model with uncorrelated risk factors, the effects of which will accumulate over time. 2b) Other types of accumulation of risk models are those with correlated risk factors (clustering, chains or pathways of risk). In real life,

risk factors are often clustered. An example of this type of clustering would be a person with a sedentary life style, who becomes obese and develops knee OA later in life.

The life-course approach to studying the aetiology of chronic disease is thus not simply a collection of longitudinal data or the use of a particular study design or analytical method. Rather, it is an academic framework that creates hypotheses and tests the possibilities of theoretical models to identify pathways linking exposure across life course to later life health outcomes (Kuh et al. 2003).

As many factors associated with MSDs in adult life are present already in children and adolescents, it is clear that epidemiological studies exploiting a life course perspective are needed if one wishes to understand the development of MSDs and their related disabilities (Dunn et al. 2013).

Table 1.   *Life course risk models*

Critical period models (*Main focus on the timing of exposure*)
a) Unrelated exposures without effect modifiers
b) Interrelated exposures, of which one can act as an effect modifier
Accumulation of risk models (*Main focus on the dose of exposures over time*)
a) Independent and uncorrelated risk factors
b) Correlated risk factors (clustering, chains or pathways of risk)

Adapted from Kuh and Ben-Schlomo 2004 and WHO and International Longevity Centre - UK 2000.

2.2   DEFINITION AND ASSESSMENT OF OBESITY

The word overweight implies that a person has too much body fat. The most commonly used measure to describe weight status in both epidemiological studies and health promotion is the body mass index (BMI). An individual's BMI is the ratio of height in meters and the square of the weight in kilograms (BMI = kg/m^2). It is an easy obtainable proxy for thinness and fatness. In adults, the World Health Organization (WHO) defines underweight as BMI < 18.5 kg/m^2, normal weight as 18.5-24.9, and overweight as 25.0–29.9 kg/m^2 and obesity as ≥30 kg/m^2 (WHO 1995). In children, other cut-off points are used (Cole et al. 2000, Kuczmarski et al. 2000, Monasta et al. 2011). The cut-off points of BMI recommended by WHO are based on increased risks of non-communicable diseases (WHO 2000).

Nonetheless, the application of BMI as a measure of obesity has several limitations, in particular, criticisms have been raised against its inability to reliably distinguish fat from lean body mass (Rothman 2008, Snijder et al. 2006, Wellens et al. 1996). The higher proportion of muscle mass in men compared to women is not reflected in the BMI values or cut-off points, thus contributing to gender differences in BMI's ability to detect adiposity. BMI does not distinguish between different distributions of excess fat mass, which might have different impacts on health. Indeed, especially the importance of abdominal adiposity on cardiovascular health was recognised as early as 1947 (Vague 1947). Furthermore, a meta-analysis of studies assessing the performance of BMI to detect body adiposity concluded that owing to its low sensitivity, the use of

the current BMI cut-off values fails to detect excess adiposity in many individuals (Okorodudu et al. 2010).

In order to address the above mentioned problems, other means of assessing obesity have been developed. Measuring waist circumference (WC) is a simple method to assess the extra fat mass around the abdomen. WC may be a better measure of obesity than BMI (Snijder et al. 2006), but relatively few studies have assessed the association of measures of abdominal obesity with MSDs.

Waist-to-hip ratio is a valid measure for predicting weight- related disease, but it has been less widely applied because it involves two measurements and measuring hip circumference may be more difficult than measuring waist circumference alone (WHO 2011). The waist-to-height ratio has been shown to be a good predictor of obesity-related cardiovascular risk (Schneider et al. 2010), although it has been rarely used in studies evaluating the association of obesity with health-related outcomes.

Measurement of skinfold thickness is another anthropometric measure of adiposity used in fieldwork. Bioelectric impedance analysis is the most advanced method routinely exploited in both routine clinical and epidemiological research; in this technique a small, imperceptible, safe electric current passes through the body, measuring the resistance. (Hu 2008). The current faces more resistance passing through fat than it does passing through lean body mass or water. Equations are available to estimate body fat percentage and lean mass.

2.3 OVERWEIGHT AND OBESITY TRENDS

Worldwide obesity has increased by more than 50% since 1980 such that in 2014 almost four out of every ten adults were overweight (WHO 2015). In the OECD countries, over half of the adult population are overweight or obese (OECD 2014). In Finland, 62% of men and 50% of women older than 20 years are overweight or obese (Ng et al. 2014). In global terms, overweight and obesity have been estimated to be responsible for 4% of disability-adjusted life-years (Lim et al. 2012). The global obesity epidemic now affects most populations already in childhood and impacts on children's wellbeing and health, e.g. reporting of musculoskeletal pain already in childhood (Smith et al. 2014). Being obese in childhood is predictive of adult obesity and adiposity (Freedman et al. 2005) and thus it potentially influences adult health and general functioning. Also in Finland there has been a noticeable increase in the prevalence of overweight and obesity among adolescents occurring during the last two decades of the 20th century (Kautiainen et al. 2009, Kautiainen et al. 2002). Obesity has an impact on musculoskeletal health and functioning already in youth (Paulis et al. 2014, Smith et al. 2014, Tsiros et al. 2011). Continuing exposure to excess weight during adulthood has been associated with certain disabling musculoskeletal conditions, e.g. LBP, knee and hip osteoarthritis (Ells et al. 2006, Kulkarni et al. 2016, Shiri et al. 2010a).

2.4   LOW BACK PAIN

LBP is defined as pain in the lumbar or gluteal region with or without radicular pain to the lower extremities. The vast majority of individuals with pain affecting the lower back have no specific diagnosis and are categorised as having non-specific LBP (Airaksinen et al. 2006), i.e. the cause of non-specific LBP is usually unknown. When back pain radiates to the lower extremity, the condition is called radiating LBP (lumbar radicular pain, sciatic pain). The pain is caused by compression or irritation of one of the lumbosacral roots (Heliövaara et al. 1987) When radicular pain is accompanied by clinical findings of nerve root compression, the condition is called sciatica (Konstantinou and Dunn 2008, Valat et al. 2010). LBP is a very common symptom (Heistaro et al. 2007), but physician-diagnosed non-specific chronic low back syndrome and sciatica are less prevalent (Heliövaara et al. 1991, Kaila-Kangas et al. 2009). The estimated prevalence of LBP depends on the recall period as well as on the duration of symptoms (Hoy et al. 2010b). Most of the studies examining LBP have relied on point or 12-month prevalence (Hoy et al. 2010a). Many studies have not specified a minimum episode length, but the most commonly used duration of symptoms has been a minimum of one day (Hoy et al. 2010a).

2.5   LOW BACK PAIN DURING LIFE COURSE

LBP is a common condition all around the world and there are estimates that its prevalence will increase substantially in the future (Buchbinder et al. 2013, Hoy et al. 2012).

The lifetime prevalence of LBP has been reported to vary from 11 to 84% (Walker 2000). LBP is prevalent already in children and remains common throughout an individual's lifetime (Calvo-Munoz et al. 2013, Dunn et al. 2013). A meta-analysis reported a mean 12% point prevalence among children and adolescents, while a distinct increase in the prevalence of LBP with age was seen (Calvo-Munoz et al. 2013). Another systematic review of population-based studies estimated the global point prevalence of LBP to be 12%, with a 1-month prevalence of 23% (Hoy et al. 2012). The overall mean prevalence was 31%, the one-year prevalence was 38%, and the lifetime prevalence was 40%. Women had significantly higher point and annual prevalence, although no gender differences were seen for 1-year or lifetime prevalence of LBP (Hoy et al. 2012). The prevalence of LBP did not increase in men after 40 years of age, while the prevalence peaked later among women. In addition, LBP has been reported to be as prevalent in middle-aged populations as among those aged 60 or over but the prevalence seems to decline among the oldest individuals (Fejer and Leboeuf-Yde 2012). Another systematic review concluded that the prevalence of severe forms of back pain continues to increase with age, whereas less severe back pain becomes less common after a peak when the individual is 50 to 60 years of age (Dionne et al. 2006). Moreover, there are reports suggesting that the prevalence of non-specific LBP decreases with age (Määriä et al. 2009) (Shiri et al. 2010c).

One review reported a point prevalence for sciatica ranging from 1.6% to13.4%, depending on the case definition (Konstantinou and Dunn 2008). The prevalence of clinically verified sciatica in population-based samples has been less extensively studied, but has been reported to vary between 2.7% and 5.1%, with a higher prevalence among men (Heliövaara et al. 1991, Leino-Arjas et al. 2008). Only a few studies have examined radiating LBP across life course, although it has been found that the prevalence of radiating LBP increases with age (Kääriä et al. 2011, Kääriä et al. 2009, Shiri et al. 2010c). Inconsistent findings have been reported about gender differences in radiating LBP (Kääriä et al. 2011, Kääriä et al. 2006, Shiri et al. 2010c).

LBP leads to care seeking and reduced health related quality of life already in adolescence (O'Sullivan et al. 2012). Furthermore, LBP in late adolescence has been reported to predict LBP in adulthood (Hellsing and Bryngelsson 2000, Hestbaek et al. 2006). LBP is believed to be prevalent throughout life and is often recurring (Hestbaek et al. 2003, Hoy et al. 2010a). Patients with radiating LBP have a poorer prognosis when this is assessed via pain intensity, quality of life, disability or health care utilization, in comparison with subjects with non-radiating LBP (Konstantinou et al. 2013).

2.6 ROLE OF LIFESTYLE FACTORS IN LOW BACK PAIN

Previous studies have found over one hundred potential risk factors for LBP (Bakker et al. 2009). There are many environmental risk factors e.g. physical workload factors (Driscoll et al. 2014), psychosocial factors (Macfarlane et al. 2011, Taylor et al. 2014) as well as the early and adult social environment (Croft and Rigby 1994, Lallukka et al. 2014). Individual risk factors include genetic susceptibility (heritability reported to range from 30 to 46%) (Battie et al. 2007, Hestbaek et al. 2004) and lifestyle factors. Alcohol consumption is weakly associated with LBP (Ferreira et al. 2013). Sleep problems are longitudinally associated with an increased risk of both non-specific and radiating LBP in adults (Kaila-Kangas et al. 2006, Lusa et al. 2015, Miranda et al. 2008, Mork et al. 2014). The risk factors of LBP include both modifiable and non-modifiable factors (Cook et al. 2014). From a prevention perspective, it is the modifiable risk factors of LBP which require attention. Figure 1 illustrates risk factors of musculoskeletal pain and their effect during life course. Genetic susceptibility, gender and age are examples of risk factors, which usually are regarded as unmodifiable factors. In contrast, lifestyle factors are examples of modifiable individual risk factors. Overweight and obesity are some of the most commonly studied modifiable lifestyle factors.
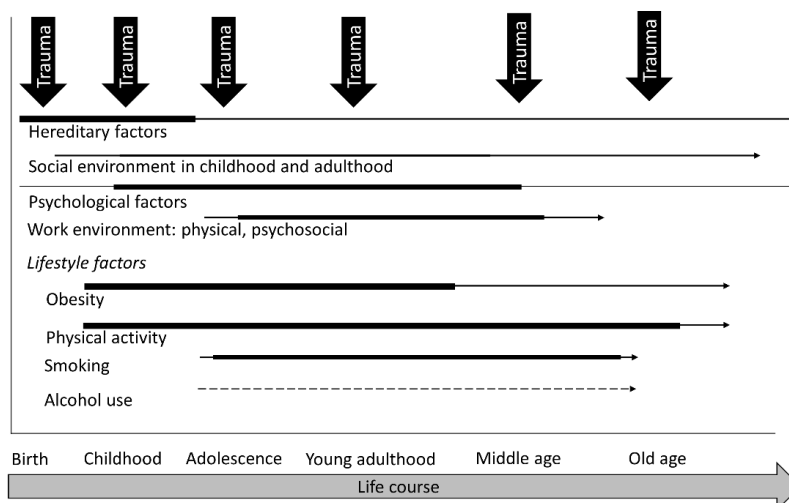
Figure 1   Conceptual model of risk factors of musculoskeletal pain during life course. Adapted from Dunn 2010.

2.6.1   OVERWEIGHT AND OBESITY

A large number of studies have examined the effects of BMI-based overweight/obesity on LBP. In 2010, Shiri and colleagues conducted a meta-analysis of studies on the association between obesity and non-specific LBP. In cross-sectional studies, BMI significantly increased the risk of LBP among both genders, but the associations were weaker for men than for women. The associations were more consistent for obesity than for overweight, with the strongest link being found between obesity and seeking care for LBP (OR 1.56, 95% CI 1.46-1.67) and chronic LBP (OR 1.43, 95% CI 1.28-1.60). In longitudinal studies, obesity but not overweight, increased the risk of having LBP for at least one day during the past year (OR 1.53, 95% CI 1.22-1.92), without any clear gender differences.

More recent longitudinal studies in adolescent and adult populations have detected stronger associations between general obesity and LBP among women than men (Heuch et al. 2013, Mikkonen et al. 2013, Nilsen et al. 2011). In a study investigating a young adult population, BMI was not associated with incident non-specific LBP (Shiri et al. 2013b). A very large cross-sectional Israeli study on the relationship of BMI and height on LBP concluded that among 17 –year old conscripts being overweight or obese was associated with LBP in a dose-response manner (Hershkovich et al. 2013). A Finnish conscript study found a significant association between obesity and a risk for recurrent LBP (Taanila et al. 2012).

The evidence for an association between weight-related measures and lumbar radicular pain or sciatica is more solid. A small Finnish conscript study reported a weak association between obesity, defined by a high body fat percentage, and radiating LBP (Karvonen et al. 1980). According to a systematic review on the association of

cardiovascular and lifestyle factors with lumbar radicular pain and clinically defined sciatica, the risk of clinically defined sciatica was increased if the individual was overweight/obesity in most of the case-control and cohort studies. (Shiri et al. 2007).

A meta-analysis assessing the associations of overweight and obesity with lumbar radicular pain and sciatica reported that both overweight and obesity showed a consistent, but modest, association in a dose-response manner with an increased risk of lumbar radicular pain and sciatica (Shiri et al. 2014). The pooled odds ratios for the association between overweight and obesity with lumbar radicular pain were 1.23 (95% CI 1.14-1.33 and 1.40 (95% CI 1.27-155), respectively with the associations with sciatica being slightly weaker. No gender differences were seen in the associations between overweight/obesity and lumbar radicular pain or sciatica.

A recent systematic review of twin studies showed that the risk of LBP or lumbar disc degeneration was increased in individuals who were overweight or obese, but the associations with LBP were weakened after controlling for genetic factors and a shared early environment. (Dario et al. 2015). The authors suggested that obesity and low back pain might share common genetic risk factors .

There are only a few studies using repeated measures of weight-related factors. A report from the British 1958 birth cohort study found that high BMI at the age of 23 but not at age of 7 predicted incidence of LBP (Power et al. 2001). However, this association became weaker after adjustment for (psychosocial factors in early life, ergonomic and psychosocial factors at work.

In the majority of epidemiologic studies, self-reported low back pain has been the assessed outcome. However, there are few longitudinal studies with register-based measures of low back outcomes. Most of them have been included in a meta-analysis on the effects of overweight and obesity on sciatica and lumbar radicular pain; this reported that overweight and obesity also displayed a significant association with both hospitalization and surgery due sciatica (Shiri et al. 2014).

A study with a 28-year follow-up claimed that high BMI exhibited an association with hospitalization for back problems other than intervertebral disk disorders (Kaila-Kangas et al. 2003). In contrast, a large population-based cohort study detected no association of overweight with hospitalization due to LBP (Mattila et al. 2008). A report from the 1966 Northern Finland Birth Cohort Study indicated that in females, being overweight at age 14 predicted an increased risk of second-time hospitalisation for surgical treatment of sciatica, while no associations were seen among males (Rivinoja et al. 2011).

2.6.2 ABDOMINAL OBESITY

There are few studies that have applied measures of abdominal obesity. However, even the paucity of evidence is conflicting when describing the association of abdominal adiposity with LBP, especially among men. In a male conscript population, waist circumference was weakly associated with an increased risk of recurrent LBP (Taanila et al. 2012). In contrast, in a population-based study of young to middle-aged adults, WC was associated with an increased risk of radiating LBP six years later among females but not males (Shiri et al. 2013b). Similarly, a case-control study found that an increased waist to hip ratio only in female patients was associated with chronic LBP and

a negative straight leg raise test, when the patients were compared to controls (Toda et al. 2000). Cross-sectional analyses in the Dutch MORGEN project with an adult population-based sample have identified associations of an increased WC with any LBP, chronic LBP and radiating LBP, but after adjustment for confounders, the associations remained consistent only in women (Han et al. 1997, Lean et al. 1998). In addition, having a WC of 102 cm or more increased the risk of being made redundant from work due to LBP (Lean et al. 1998). However, a case-control study found an inverse association between waist-to hip ratio and LBP among middle-aged women (Yip et al. 2001). A recent Norwegian study comparing different anthropometric measures of obesity with chronic LBP found that bodyweight, BMI, waist and hip circumference were all associated with chronic LBP in both genders (Heuch et al. 2015). However, after mutual adjustment for the other anthropometric measures, only body weight showed a statistically significant association with chronic LBP. The authors concluded that abdominal adiposity was unlikely to be a major contributor to the aetiology of LBP.

2.6.3 PHYSICAL ACTIVITY

There are contradictory results from studies examining the association of leisure time physical activity with the risk of LBP. Reviews of the literature in 1967-2009 have found inconsistent or no evidence for any association (Heneweer et al. 2011, Hoogendoorn et al. 1999, Sitthipornvorakul et al. 2011). On the other hand, a review of reviews and meta-analyses on the efficacy of physical activity in the prevention of LBP concluded that exercise was effective in primary and secondary prevention (Henchoz and Kai-Lik So 2008). Moreover, a meta-analysis of randomised controlled trials showed that leisure time physical activity as exercise therapy exerted a slightly favourable effect on subacute and chronic LBP (Hayden et al. 2005). Another, recent meta-analysis and review of randomised controlled trials of LBP prevention concluded that physical exercise alone could reduce the risk of LBP and when combined with educational programs, it was claimed to be likely able to prevent LBP (Steffens et al. 2016).

A large prospective population-based study reported that physical inactivity was associated with chronic LBP (Nilsen et al. 2011). In addition to varying measures of physical activity, one explanation for the conflicting evidence might be the reported U-shaped relationship between LBP and physical activity (Heneweer et al. 2012, Heneweer et al. 2009). For example, in adolescents, very active participation in physical activities has been reported to be associated with consultations for LBP (Auvinen et al. 2008).

Similarly, there is no consensus in the literature about the nature of the relationship between radiating LBP and physical activity. A systematic review revealed no consistent relationship between physical activity and radiating lumbar pain or clinically defined sciatica (Shiri et al. 2007). However, prospective studies included in the review provided some indications of an association between high levels of leisure time physical activity with an increased risk of lumbar radicular pain. Moreover, physical activity has been reported to display a U-shaped relationship also with radiating LBP in a population of young adults (Shiri et al. 2013b). In contrast, physical activity levels were

not associated with sciatica in an adolescent population (Karjalainen et al. 2013). A recent meta-analysis suggested that physical activity has a modest protective effect against the onset of lumbar radicular pain (Shiri et al. 2016).

It has been postulated that physical fitness is more strongly associated with LBP than self-reported leisure time physical activity and indeed high activity levels of strenuous physical activity have been reported to decrease the risk of hospitalization due to back disorders (Heneweer et al. 2012, Kääriä et al. 2014). Accordingly, a previous low level of physical activity did not predict, whereas a poor fitness level was predictive of non-specific LBP in a conscript population (Taanila et al. 2012).

A review of longitudinal studies on the relationship between performance in tests assessing muscle fitness, muscle endurance, or spinal mobility and future LBP concluded that trunk muscle endurance was not associated with the risk of LBP (Hamberg-van Reenen et al. 2007). The evidence was inconclusive with regard to the relationship between trunk muscle strength or mobility of the lumbar spine and the risk of LBP.

In conclusion, the relationship between physical activity and LBP seems to be U-shaped. However, more accurate methods to assess physical activity may help to clarify this complex relationship.

2.6.4   SMOKING

A meta-analysis of studies on the association of smoking and low back pain showed that current smoking was associated with a moderately increased prevalence and incidence of LBP (Shiri et al. 2010b) In cross-sectional studies, the strongest association was seen for chronic LBP and disabling LBP. Ex-smokers had a lower prevalence of LBP than current smokers. Furthermore in longitudinal studies, the incidence of LBP was stronger in adolescents than in adults.

A recent meta-analysis examining the association between smoking and radiating LBP found that current smoking modestly increased the risk of both lumbar radicular pain and clinically verified sciatica as well as herniated discs requiring hospitalisation or surgery in both genders (Shiri and Falah-Hassani 2016). Smoking has been associated with LBP also among conscripts (Taanila et al. 2012).

2.7   KNEE PAIN DURING LIFE COURSE

Knee pain is a common musculoskeletal complaint among adolescents and its prevalence increases with age (Nakamura et al. 2011, Sa et al. 2011, Urwin et al. 1998). The reported prevalence has varied between 10 and 60% in the general population, depending on gender, age and definition of knee pain (Adamson et al. 2006, Fransen et al. 2014, Thiem et al. 2013, Urwin et al. 1998). It has been estimated that every third adult aged over 40 will develop knee pain during the subsequent 12 years (Ingham et al. 2011). Knee pain is thus especially prevalent in the age group over 50 years, a time when osteoarthritis is becoming more common (Picavet and Schouten 2003, Thiem et al. 2013). Accordingly, in older subjects, osteoarthritis is an increasingly common reason for knee pain (Zhang et al. 2010). The estimates of the mean proportion of men

who will develop symptomatic knee OA during their lifetime vary from 16% to 40% (Losina et al. 2013, Murphy et al. 2008).

2.8   ROLE OF LIFESTYLE FACTORS IN KNEE PAIN

The age- and BMI-adjusted prevalence of knee pain increased during the last decades of the 20th century (Nguyen et al. 2011). Female gender, older age, previous knee injury and obesity are risk factors for the onset of knee pain (Jinks et al. 2008). Occupational risk factors for knee pain include regular heavy lifting, kneeling, crawling and construction work (Fransen et al. 2011).

Pain is the major symptom of knee OA. While the entities are inter-related, especially among the elderly, a meta-analysis concluded that knee pain was not a good indicator of knee OA (Bedson and Croft 2008). In younger individuals, injuries to cartilage, ligaments and soft tissue structures are more prevalent reasons for knee pain (Peat et al. 2001). These injuries may predispose the knee to subsequent OA. Accordingly, among middle-aged subjects, chronic knee pain is reported rather consistently to be a predecessor of OA and thus knee pain is often regarded as the first sign of knee OA (Thorstensson et al. 2009). Most studies evaluating the associations of lifestyle factors with knee pain have been conducted in older populations with knee OA. Nevertheless, there are also reports which have investigated knee pain without OA.

2.8.1   OBESITY AND OVERWEIGHT

Most work on the association between overweight or obesity with knee pain has been conducted among middle-aged and older individuals. According to a recent meta-analysis, overweight and obesity are strongly associated with knee OA among those aged 50 or over (Silverwood et al. 2015). Two recent meta-analyses have described a dose-response relationship between BMI and knee OA (Zheng and Chen 2015, Zhou et al. 2014). On the basis of a longitudinal cohort study, the population-attributable fraction of overweight or obesity for the onset of knee OA has been estimated at 25% (Silverwood et al. 2015).

High BMI and knee pain have been linked in cross-sectional studies among older people (Adamson et al. 2006, Andersen et al. 2003). Several longitudinal studies have described an association between overweight and obesity with knee pain (Fransen et al. 2014, Goulston et al. 2011, Ingham et al. 2011). Among subjects aged 50 or over without knee pain at baseline, the presence of obesity markedly predicted the onset of severe knee pain in the following 3 years (Jinks et al. 2006). The authors estimated that 43% of cases of severe knee pain could have been avoided if the obese subjects would have been only overweight.

Two longitudinal cohort studies have examined the associations of childhood weight-related measures with adult knee pain. An Australian study with a 25 year follow-up reported that childhood (7-15 years old) overweight, especially being overweight both in childhood and adulthood, was associated with future knee pain in men aged 31 to 41 years (Antony et al. 2015). In men, childhood weight was also associated with adult functional limitations due to knee problems. The British 1958 birth cohort

study examined associations of BMI across life course with adult knee pain (Macfarlane et al. 2011). Being overweight or obese as young as 16, as well as at the age of 23 or 33 years was significantly associated with one-month knee pain at the age of 45. No separate analyses were conducted for males and females.

Furthermore, there are reports from relatively small studies among predominantly female subjects without knee OA, suggesting that weight control is effective, i.e. associations of weight loss with reduced knee pain and conversely weight gain with increased knee pain (Tanamas et al. 2013, Teichtahl et al. 2015).

2.8.2 ABDOMINAL OBESITY

Several studies have detected a significant association between abdominal adiposity and knee OA. The British GOAL case-control study, conducted among older subjects referred for consideration of joint replacement surgery, reported a stronger association of abdominal obesity defined via WC with knee OA in women than in men (Holliday et al. 2011). Obesity as reflected by BMI showed a stronger association than that defined by WC, while WHR showed no association with knee OA. Cross-sectional analyses of the Longitudinal Aging Study Amsterdam showed a linear association between WC and knee OA (Heim et al. 2011). A case-control study reported that WC was associated with self-reported knee OA among middle-aged women, but not in men (Han et al. 2013). In large prospective cohort studies, WC has been significantly associated with severe knee osteoarthritis defined as total knee replacement surgery (Lohmander et al. 2009, Monira Hussain et al. 2014, Wang et al. 2009).
Evidence is lacking, whether any association between abdominal obesity and knee pain exists.

2.8.3 SMOKING

In the population-based West of Scotland Twenty-07 study of 58-year old persons, smoking was not associated with knee pain (Adamson et al. 2006). In addition, a recent meta-analysis of the risk factors for knee OA in older adults concluded that there was no association between smoking and the onset of knee OA (Silverwood et al. 2015). However, there are no population-based studies which would have examined the association of smoking and knee pain among younger subjects without knee OA.

2.8.4 PHYSICAL ACTIVITY AND KNEE TRAUMAS

Studies examining the longitudinal relationship of physical activity with knee pain without OA are lacking. Nevertheless, one systematic review claimed that although there was strong evidence for a positive association between physical activity and tibiofemoral osteophytes as well as for an inverse relationship between physical activity and cartilage defects, there were no signs of any relationship between physical activity and joint space narrowing. (Urquhart et al. 2011b). The authors concluded that current evidence suggests that physical activity is beneficial for knee joints. A systematic re-

view on risk factors for OA concluded that there was no convincing evidence that increased physical activity, without knee trauma, is associated with an increased risk of knee OA (Richmond et al. 2013). However, another recent review postulated that high level of physical activity did increase the risk of knee OA (Silverwood et al. 2015). Furthermore, individuals practising certain types of sport activity, e.g. team sports, tumbling gymnastics, seem to be more prone to knee traumas than those participating in other sports (Ingram et al. 2008, Junge et al. 2016, Mitchell et al. 2016).

Previous knee injuries have been shown to be a major predictor of knee OA (Richmond et al. 2013, Silverwood et al. 2015). Among adults, obesity has been reported to be associated with an increased risk of knee and lower leg injuries in both genders (Chasse et al. 2014). In addition, overweight and obese children and adolescents have been reported to have an increased risk of suffering lower limb injuries (Adams et al. 2013, Jespersen et al. 2014). A large study of Finnish conscripts reported a dose-response relationship between obesity defined by BMI and hospitalization after a traumatic knee injury (Kuikka et al. 2013). Another study reported that conscripts with primary patellar dislocation weighed more than controls (Sillanpää et al. 2008) There is also conflicting evidence; overweight and obesity in 4-24 year old male and female sports participants did not increase their risk of sustaining a sports injury (Kemler et al. 2015).

2.9   SEEKING HEALTH CARE DURING MILITARY SERVICE

MSDs are a major source of morbidity during military service in conscript armies (Heir and Eide 1997, Heir and Glomsaker 1996, Rosendal et al. 2003). In a Finnish study conducted during 2006-2008, 69% of all conscripts visited the military health care at least once due to a MSD (Taanila et al. 2010). Over 60% of the MSD-related visits during conscript service time were due to problems in the lower extremities and approximately 20% due to LBP (Heir and Glomsaker 1996, Taanila et al. 2009). In the study of Taanila and co-workers, 16% of the conscripts were found to have required the services of the military health care at least once due to LBP (Taanila et al. 2012). Similar incidence rates of low back pain have been reported from young military populations in Israel and USA (Milgrom et al. 2005, O'Connor and Marlowe 1993).

Being overweight has been associated with an increased risk of MSDs (Heir and Eide 1996, Taanila et al. 2010) and traumatic injuries requiring hospitalization during military service (Mattila et al. 2007). Additionally abdominal obesity, defined as WC ≥102 cm, has been associated with an increased risk of MSDs during conscript service (Taanila et al. 2010, Taanila et al. 2015). Some studies have reported that there may be a U-shaped relationship between weight-related factors and MSDs during military service (Jones et al. 1993, Taanila et al. 2015).

Both overuse injuries and traumatic injuries occur frequently during military service (Taanila et al. 2015). The majority (67%) of all MSDs occurred in the lower extremities with a further 18% in the back. Being obese was associated with the risk of traumatic injuries and also with the risk of more severe injuries resulting in loss of at least 7 service days, but the associations weakened in the multivariate model.

A low level of physical fitness, smoking and frequent alcohol use were other risk factors identified for MSDs in military populations (Heir and Eide 1996, Taanila et al. 2010). In disagreement with other studies, Mattila et al reported that those conscripts with a high physical fitness had an increased risk of injury requiring hospitalization (Mattila et al. 2007).

Some of the health problems encountered during conscript service hamper the military training profoundly and thus lead to its interruption. In Finland, mental disorders have accounted for over half of the medical reasons for interruptions of conscript service (Parkkola 1999, Sahi and Korpela 2002). MSDs are the second principal reason for medical discharge and the proportion of those interrupting due to MSDs (not including traumas) increased from 11.7% during 1997-1998 to 14.7% during 1999-2000 (Sahi and Korpela 2002). This increase is likely to be a consequence of the reformation of the military training occurring in 1998, when the shortest service length was reduced from eight to six months. At the same time, the normative maximum time to be ill during conscript service was shortened from two months to one month and this probably resulted in military physicians being more likely than earlier to recommend discharges for medical reasons (Peitso 2002).

2.10 SEEKING HEALTHCARE AS AN INDICATOR OF LATER LIFE PROBLEMS

A few studies have investigated the predictive value of health care consultations on later health problems. A population-based cohort study reported that seeking health care due to LBP at the age of 16 was associated with both mild and severe sciatic pain at the age of 18 years (Karjalainen et al. 2013). A Swedish study detected a very weak correlation between the rate of school absence at the age of 15 years with sick leave at the age of 27 (Bremberg and Mikaelsson 1985). Being occasionally, but not often, absent from school at age 16 has been reported to be predictive for adult sickness absence (Mittendorfer-Rutz et al. 2013).

2.11 DISABILITY RETIREMENT IN FINLAND

There are two complementary pension systems in Finland, the national pension scheme, and a statutory earnings-related scheme, but both systems provide the possibility of granting a DP. The administration of the compulsory scheme is decentralized to independent private pension providers such as insurance companies, company pension funds and industry-wide pension funds.

National pensions and guarantee pensions are meant for those pensioners who have no earnings-related pension or whose pension is very small. A person can be granted a full DP if his/her work capacity is reduced by at least 60% due to a chronic illness, handicap or injury and a partial DP if the work capacity is reduced by 40-60% (Finnish Centre for Pensions and Social Insurance Institution 2014). In addition to health, the person's possibilities of earning a living are also taken into account. Before

this pension can be awarded, a certificate issued by a physician with diagnoses defined according to the ICD-10 is needed.

In the national pension scheme, DR may be granted to a person aged 16–64 years, but not until the possibilities of rehabilitation of the individuals aged 16–19 have been thoroughly investigated. Only full DPs are awarded.

In the statutory earnings-related pension scheme, the DP may be granted to a person aged 18–62 years. It is required that the incapacity for work can be estimated to last for at least one year. The DP may be awarded as a full or a partial pension. A person is granted a full DP if his or her work capacity is considered to have been reduced by at least 60% and a partial DP if the work capacity is estimated to have been reduced by 40-60%. The DP may be awarded until further notice or temporarily as a rehabilitation benefit if it is expected that the person's work ability can be restored (Finnish Centre for Pensions and Social Insurance Institution 2014).

The DP ends at the age of 65 when the entitlement to the national old-age pension begins. In the earnings-related pension scheme, DPs are converted into old-age pensions when the individual reaches the age of 63, if the pension contingency occurred by 1 January 2006 or later (Finnish Centre for Pensions and Social Insurance Institution 2015). The Finnish Centre for Pensions coordinates all earnings-related pensions for permanent residents and provides essentially complete data on DR awards.

In 2008, 7.5% of the Finnish working age populations was receiving DP and the total expenditure was 3.1 billion Euros. In 2014, the corresponding figures were 6.6% and 2.9 billion, respectively (Finnish Centre for Pensions and Social Insurance Institution 2010, Finnish Centre for Pensions and Social Insurance Institution 2015).

Several non-medical factors, e.g. the coverage of the DP system and the amount of disability benefit may potentially influence the incidence of DPs (OECD 2003). Indeed, changes in Finnish society and national legislation have affected the DRs. An individual early retirement pension for elderly people was implemented in 1986 in the private sector and 1989 in the public sector. (Järvisalo et al. 2005b). The main criterion for eligibility was a permanent reduction in working capacity due to an illness. Moreover work demands and length of working career were taken into account. Originally the age criterion was 55 but it was subsequently raised. Musculoskeletal disease was the most common cause for individual early retirement pensions. Individual early retirement pensions accounted for most of the increase in the total number of DP receivers during the 1990s (Figure 2). The total number of receivers of DPs reached its peak in the mid-nineties and has subsequently declined. The morbidity behind the DPs has also changed. Traditionally there have been three major causes of DP in Finland; mental disorders, musculoskeletal diseases and cardiovascular diseases. During 1987-1994, the incidence in DP due to mental diseases increased by 10%, while the proportion of affective disorders increased by 3-fold (Salminen et al. 1997). The share of cardiovascular disease has progressively declined since the mid-seventies. The proportions of DP receivers due to mental disorders and musculoskeletal disease were nearly even in 1990, but since that date, the share due to mental causes has increased and the share due to musculoskeletal causes has declined substantially (Figure 2). In 2014, individuals receiving DP due mental disorders accounted for 47% of the total, whereas

the share of musculoskeletal diseases was only 20% (Finnish Centre for Pensions and Social Insurance Institution 2014).
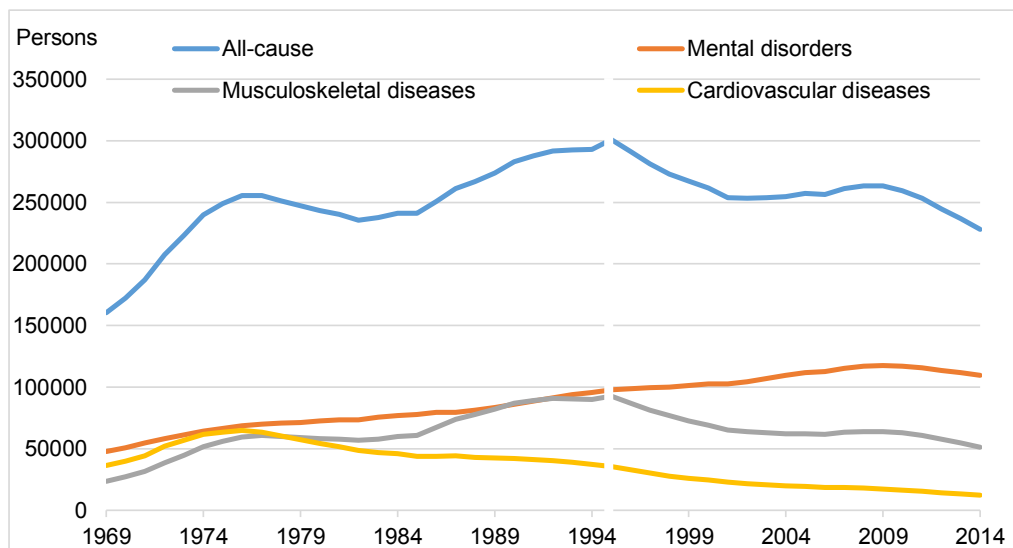
2.12 PREDICTORS OF DISABILITY RETIREMENT DUE TO MENTAL DISORDERS AND MUSCULOSKELETAL DISEASES

Risk factors of DR have been studied extensively, especially among middle-aged people. A systematic review and meta-analysis of 29 longitudinal studies examining the associations between poor health and exit from paid employment showed that self-perceived poor health had a strong effect on all-cause DP (pooled RR 3.61; 95% CI 2.44-5.35) (van Rijn et al. 2014). However, there were marked variations in the follow-up time of the various studies. The risk of DP retirement was also increased for workers with MSDs (pooled RR 2.23; 1.93-2.59) and mental health problems (1.80; 1.41-2.31). Accordingly, low self-rated health is a predictor of DR both due to mental diseases and musculoskeletal disorders (Hagen et al. 2002, Karpansalo et al. 2004, Pietiläinen et al. 2011, Samuelsson et al. 2013). In a recent longitudinal study of employees aged 45-64 years, self-reported chronic musculoskeletal or psychological health problems at baseline increased the risk of receiving disability benefits three years later (Leijten et al. 2015). A Danish prospective study in nurses' aides found that chronic back pain at baseline predicted DP 15 year later (Jensen et al. 2012). Musculoskeletal pain pre-

dicted the risk of DP due to low back disorders over 30 years in the Finnish Twin Co-hort Study (Pietikäinen et al. 2011). Sickness absence due to back pain or a depressive episode were also predictive of the award of DP due to all-cause, musculoskeletal and mental causes in the next 5 years in a large cohort study (Dorner et al. 2015).

People with lower education and thus lower socioeconomic status are at an increased risk of DR (Johansson et al. 2012, Leinonen et al. 2012, Robroek et al. 2015). This holds true for DP due to mental diseases and musculoskeletal disorders, the relative risk being especially increased for the latter (Bruusgaard et al. 2010).

Self-perceived high psychological stress in daily activities predicted all-cause DP in a large Finnish twin study (Ropponen et al. 2014). Symptoms of anxiety and depression have been found to predict DP due to all-cause, mental disorders and somatic conditions in population-based studies with a follow-up ranging from 1 to 7 years (Knudsen et al. 2010, Mykletun et al. 2006). In the aforementioned study of Mykletun and co-workers, the associations were stronger for individuals aged 20-44 than for their older counterparts. A Finnish study of middle-aged workers claimed that common mental disorders were associated with DR due to all-cause and due to mental disorders with a weaker association being found for DR due musculoskeletal diseases (Lahelma et al. 2015).

A large number of studies have scrutinised the associations of workplace factors and DR. Several psychosocial factors at work have been reported to increase the risk of DR (Ahola et al. 2009, Hinkka et al. 2013, Krause et al. 1997, Krokstad et al. 2002, Laine et al. 2009, Sinokki et al. 2010). In cause-specific analyses, low job control has been associated with an increased risk of DR due to MSDs and mental disorders (Lahelma et al. 2012), whereas job strain was associated only with DP due musculo-skeletal diseases (Mäntyniemi et al. 2012). Physical work demands, loading, lifting, muscle strain and uncomfortable work positions are likely to increase the risk of all-cause DR in different settings (Friis et al. 2007, Krause et al. 1997, Krokstad et al. 2002, Ropponen et al. 2014). Physical work load and demands have generally been reported to be risk factors for DR due musculoskeletal diseases (Hagen et al. 2002, Järvholm et al. 2014, Karpansalo et al. 2002, Lahelma et al. 2012).

2.12.1 LIFESTYLE FACTORS AND DISABILITY RETIREMENT

Many studies have investigated the relationship between obesity and DR (K. Neovius et al. 2008, Rissanen et al. 1990, Robroek et al. 2013). A meta-analysis of 28 longitudinal studies revealed that obesity (RR 1.53, 95% CI 1.27-1.53) and to a lesser degree, overweight (RR 1.16, 95% CI 1.08-1.24) were risk factors for DP (Robroek et al. 2013). Interestingly, the meta-analysis showed stronger associations for obesity in Scandinavian studies than in others. The association between BMI and disability benefits has been reported to be stronger among workers with lower education (Robroek et al. 2015).

Obesity and pain are significantly comorbid and probably have a negative mutual impact on each other (Okifuji and Hare 2015). In two Nordic cohort studies, multisite musculoskeletal pain predicted all-cause DR, with the association with DR due MSDs being especially strong (Haukka et al. 2015, Overland et al. 2012). In a large Swedish

twin study, the number of pain sites predicted DR due to musculoskeletal diseases over a 23 year follow-up (Ropponen et al. 2013c).

Poor physical fitness has also been associated with the risk of all-cause DP as well as DP due to mental disorders and musculoskeletal diseases (Karpansalo et al. 2003). Accordingly, a lack of physical activity increased the risk of all-cause DP (Robroek et al. 2013, Robroek et al. 2015). Smoking has been reported to be a strong risk factor and it has displayed a dose-response relationship for DR (Claessen et al. 2010, Husemoen et al. 2004, Koskenvuo et al. 2011). Being a persistent smoker predicted DP both due to musculoskeletal diseases and specifically due to LBP, even after adjusting for several factors, including familial factors (Ropponen et al. 2013a).

Abundant alcohol use and problem drinking have been described as risk factors for DPs due to all-cause and mental disorders, but not due to musculoskeletal diseases (Korhonen et al. 2015, Salonsalmi et al. 2012). A follow-up study of a cohort of Swedish men born in 1949-51 claimed that risky drinking behaviour reported during conscription was associated with an increased risk of DPs, especially before the age of 40 years (Sidorchuk et al. 2012). In contrast, a Finnish study reported that heavy drinkers without a diagnosis of alcohol abuse disorder were not at increased risk of DR (Kaila-Kangas et al. 2015). Sleep disturbances increases the risk of all-cause DR as well as DR due to MSDs or mental diseases (Lallukka et al. 2011, Ropponen et al. 2013b, Sivertsen et al. 2006).

2.12.2 COMORBIDITY OF MENTAL AND MUSCULOSKELETAL DISORDERS AND WORK DISABILITY

Mental disorders and musculoskeletal diseases often occur concurrently (Dersh et al. 2002). Especially depressive disorders and anxiety have been reported to be associated with musculoskeletal pain, in particular with LBP (Beesdo et al. 2010, Demyttenaere et al. 2006, Demyttenaere et al. 2008, Hagen et al. 2006, Tsang et al. 2008). A cross-sectional population-based study reported the co-occurrence of self-reported musculoskeletal pain and depressive symptoms were more strongly associated with reduced self-rated physical work ability than either symptomatology alone (Shiri et al. 2013a). A Dutch study with a nationally representative sample revealed that comorbidity consisting of mental and physical disorders was common and related to self-reported work loss days (Buist-Bouwman et al. 2005). Co-occurring chronic back pain and mental disorders exerted a synergistic effect on work loss days during the previous year. Accordingly, a recent nationwide Swedish study detected a synergistic effect of back problems (sick leave or specialized care) and common mental disorders (sick leave, specialized care or prescription of antidepressant) on the risk of all-cause DP during a 5-year follow-up among 16-64 year persons (Dorner et al. 2016). Additionally, in a population-based Finnish study, it was found that in particular, co-morbidity of common mental and musculoskeletal disorders shortened the time to DR during the follow-up period (Kaila-Kangas et al. 2014).

2.12.3 EARLY LIFE PREDICTORS OF DISABILITY RETIREMENT

Most previous studies have focused on adulthood determinants of DR and thus little is known about the risk factors in childhood, youth and early adulthood. Nevertheless, in the Nordic countries, some studies have been conducted especially among conscripted men

Even early life events might have an impact on disability in adult life. A recent study postulated that higher birthweight would be associated with a decreased risk of DP due to all causes and mental disorders in men (von Bondorff et al. 2015). A Swedish prospective cohort study, with a 26-year follow-up, found that several socioeconomic factors in adolescence predicted male adult sickness absence, e.g. low educational achievements and unemployment (Mittendorfer-Rutz et al. 2013).

Adverse conditions in youth and adolescence may exert of major impact in the social gradients in disability retirement (Upmark et al. 2001). A large longitudinal Finnish study showed that adults having experienced several childhood adversities displayed an increased risk for DR retirement, in a dose-response relationship, compared to subjects reporting no adversities in childhood (Harkonmäki et al. 2007).

Several large Scandinavian cohort studies using data from military conscription registers and national DP registers have analysed the associations of various predictors at the age of 18 with DPs. Young men receiving a psychiatric diagnosis at conscription have an elevated risk of later DP due to mental as well as somatic disorders over a follow-up of 21 years (Upmark et al. 1999). Several psychosocial factors identified when the men were conscripted predicted later DPs (Upmark et al. 1997, Upmark et al. 1999). Large follow-up studies of conscripted men in Norway and Sweden have reported that a lower cognitive ability in late adolescence was predictive of DPs in both early and later adulthood, in a dose-response manner (Gravseth et al. 2008, Sörberg et al. 2013). Low scoring in cognitive ability tests during conscription has been associated with subsequent DPs due to psychiatric disorders at ages 20-42 years (Upmark et al. 1999). In a population-based study examining both genders, low intelligence at age 12-13 predicted DP due to all causes as well as musculoskeletal and mental disorders (Lundin et al. 2015).

In other studies based on the Swedish Military Conscription Register, BMI at the age of 18 showed a J-shaped association with DP due to all and psychiatric causes. (Kark et al. 2010, Karnehed et al. 2007, M. Neovius et al. 2008). Furthermore, being overweight or obese elevated the risk of DPs due to musculoskeletal causes (M. Neovius et al. 2008). In addition, a Norwegian study with a follow-up until the age of 36 years, found that the presences of either underweight or obesity during conscription were associated with an increased risk of all-cause DP (Gravseth et al. 2008).

A large cohort study with a follow-up of 38 years exploiting the Swedish conscription register and data on DPs from the Social Insurance Register found that smoking at the age of 18-19 years in 1969-1970 was a strong predictor of adult DP and that there was a dose-response in this relationship. Nonetheless, there was no combined effect of smoking with overweight/obesity on the risk of DP (Neovius et al. 2010). Excessive alcohol use in late adolescence has been reported to predict later DPs (Sidorchuk et al. 2012, Upmark et al. 1997, Upmark et al. 1999).

3 OBJECTIVES OF THE STUDY

There is limited information of early indicators of knee and low back problems and disability retirement due to musculoskeletal diseases and mental disorders. The registers of the Finnish Defence Forces provide unique data on health and lifestyle factors of a nationally representative sample of young men. The main aim of this thesis was to clarify how early health-related and lifestyle factors influence future musculoskeletal health and work disability by adopting a life course approach.

This thesis consists of four studies. The specific objectives were the following:

1. To describe temporal trends and patterns of healthcare utilisation during compulsory military service (I)

2. To study the impact of overweight and obesity and other life style factors on back and knee problems over the life course (II, III)

3. To explore possible differences in the associations of general and abdominal obesity with low back and knee outcomes (II, III)

4. To examine the extent to which knee problems during military service determine later functional limitations of the knee (III)

5. To study whether seeking medical advice during military service increases the risk of all-cause disability retirement and disability retirement due to mental disorders and musculoskeletal diseases (IV)

4 MATERIALS AND METHODS

Study I assessed temporal trends in seeking health care during military service covering 40 years using data from the registers of the Finnish Defence Force. In studies II – IV, predictors were obtained from the registers of the Finnish Defence Forces and outcomes from the Health 2000 Study and the registers of the Social Insurance Institution (SII) and the Finnish Centre for Pensions (FCP). Figure 3 describes the timing of data collection.
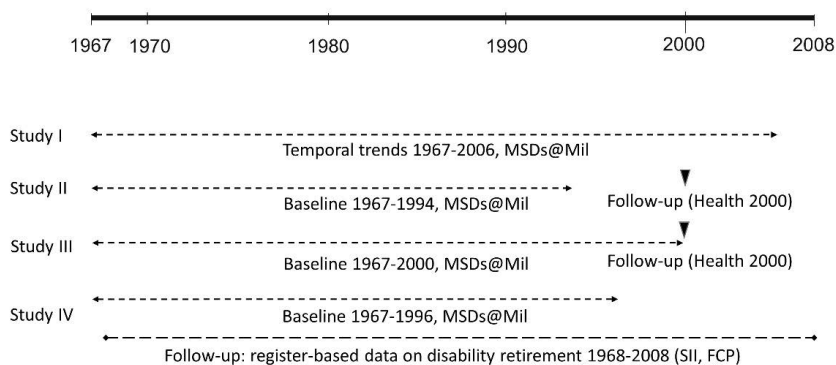
Figure 3   Time line of the studies of this thesis.

4.1 STUDY SAMPLE

4.1.1 SAMPLING OF THE STUDY POPULATION

Random samples of the 1,894 individuals aged 18-29 and 8,028 individuals aged 30 or over living in mainland Finland and alive in 1.7.2000 was drawn at the Social Insurance Institution of Finland using the population census data as the sampling frame. Both the household population and people living in institutions were included in the sample. A stratified two-stage cluster sampling design was developed jointly by Statistics Finland experts and the National Public Health Institute of Finland (KTL, nowadays THL) research team (Laiho et al. 2008). The proportion of men was 51.7% in the younger and 45.3% in the older populations.

4.1.2 MUSCULOSKELETAL DISORDERS IN MILITARY SERVICE STUDY (MSDS@MIL)

The study base of the MSDs@Mil study comprised all men in the random sample aged 18 to 50 years (n=2843). The Finnish conscript register contains personal and military training information, e.g. data on prior health and pre-service health examinations needed to determine the young men's fitness for service as well as medical records from health utilization during military service. Eligible for the studies in this thesis were the men whose military records were available. The military records were searched from the register of the Finnish Defence Forces for 2843 men; of those 2639 (93%) were identified.

4.1.3 THE HEALTH 2000 STUDY

Of the random sample aged 30 and over 89% participated in the home interview and 85% in the clinical examinations, while 80% of the younger men were interviewed (Heistaro 2008).

4.1.4 POPULATION AND DESIGN OF THE I-IV STUDIES

Due to divergent aims, the study populations of the four studies had different inclusion and exclusion criteria. Table 2 summaries the key elements of the individual studies. Figure 4 shows the formation of the samples for studies I-IV.

Study I
The study was a time trend study. The study population comprised the conscripts who successfully completed their 6-12 month military service during the study period 1967-2006 (n=2296).

Study II
The study used a longitudinal design, with pre-military health examinations as baseline and the Health 2000 Study as the follow-up. Participants consisted of the 1713 (91.8%) men eligible for military service during 1967-1994. Baseline and follow-up data were available for a total of 1536 men (81.4% of the initial random sample). After exclusion of participants with missing data on outcomes, 1385 men (74.2% of the initial random sample) were available for analyses.

Study III
The pre-service health examinations and the records of consultations to health care during conscript service (1967-2000) formed the data for the baseline. Of the random sample eligible were men who had entered their military service prior to the Health 2000 Study. After exclusions of participants with missing data, 1913 men (67.2% of the random sample) were available for analyses.

Study IV
Study IV used a longitudinal design. In this study, data from pre-service examinations and health service consultations were also used as baseline and follow-up data were acquired from retirement registers. All men scheduled for military service during 1967-1996 (n=2563, i.e. born in 1948-1978) were eligible. Men who entered military service during 1967-1996 (n=2069, 80.7% of the eligible sample) comprised the sample for the study. The sample was stratified into three groups on the basis of the service year: 1967-1976, 1977-1986, and 1987-1996.

Random Population Sample drawn for Health 2000 Study
- Subjects aged 30 years or over, n=8028
- Subjects aged 18-29 years, n=1894

Excluded → Women, n= 5304 / Men > 50 years, n=1775

Random Population Sample of men in 2000, aged 18-50 (sample for MSDs@Mil), n= 2843

Excluded → Military health data not available, n=204

MSDs@Mil Study
Men aged 18-50 years, n= 2639

Study I n=2296

Study II n=1385

Study III n=1913

Study IV n=2069

Figure 4   Formation of the study samples of this thesis

Table 2. *Description of the studies.*

Study	Study design	Primary focus	Inclusion criteria	Exclusion criteria	n	Length of follow-up	Source of follow-up information	Main determinants	Outcome
I	Longitudinal, descriptive	Temporal trends in health care visits during 40 years	Entered military service in 1967-2006	Discontinued service	2296	Time trends during 40 years	Medical files of conscripts	n/a	Medical consultations due to MSDs
II	Longitudinal	Life course determinants of back problems	Eligible for military service in 1967-1994	Missing data on outcomes and/or determinants	1385	Mean 20.5 years range 6-33 years	Health 2000	Overweight/obese at the age of 20, in adulthood and over life course	1-month prevalence of LBP, clinically defined low back syndrome and sciatica
III	Longitudinal	Life course determinants of knee pain Pathways to functional limitations	Entered military service prior to Health 2000	Missing data on outcomes and/or determinants Discontinued due to knee problems	1913	Mean 15.7 years range 1 month – 33 years	Health 2000	Overweight/obese at the age of 20, in adulthood and over life course. Health care visits due to knee problems during military service	1-month prevalence of knee pain, functional limitations due to knee problems
IV	Longitudinal	Early life determinants of disability retirement	Eligible for military service 1967-1996.	Did not enter military service or entered after 1996	2069	Mean 26.2 years, 95% CI 25.9-26.6	Retirement register	Health care visits due to musculoskeletal or mental problems during military service	Disability retirement: all-cause, mental disorders, musculoskeletal diseases

4.2 DATA SOURCES

4.2.1 MILITARY SERVICE IN FINLAND

The military service for conscripts lasted for a period of 8 or 11 months until 1.1.1989, when a new duration of service time length of 9.5 months was added, and again in 1998 the service time range changed to 6-12 months. The content of military training has remained similar since the 1960s. The conscripts spend the first two months in basic training; it is basically the same for all conscripts: various types of physical training (including combat training) account for almost half of the approximately 300 hours allotted since the late 1990s. After the basic training period, the amount of moderate and high-intensity physical training is slightly reduced and the emphasis is placed more on combat-training.

Some changes have been implemented, e.g. in 1998, when the shortest service period was further curtailed and physical training as well as training in terrain increased. The physical training programme was also modified into gradually increasing in terms of its strenuousness to better provide sufficient capacity during the shortened service period without leading to an increase in overuse injuries. Due to these temporal changes, year of service was included as a covariate in some of the analyses. Interrupting the military service due to health reasons has become more common during the time period covered by this thesis (Parkkola 1999).

4.2.2 MILITARY SERVICE MEDICAL RECORDS, CALL-UP HEALTH EXAMINATIONS AND HEALTH CARE DURING MILITARY SERVICE

All information on the compulsory military service (healthcare records, health and lifestyle questionnaires. military performance data etc.) was collected from the registers of the Finnish Defence Forces using personal identity numbers.

Each spring, all 18-year old men are obligated to attend a preliminary physical examination, usually performed by a general practitioner in a public health centre. This examination includes a structured health questionnaire on life style, prior diseases, injuries and treatments, as well as current health problems. During the following fall, these young men are summoned to obligatory call-ups, which include a detailed medical examination. The objective for the examination is to assess the health and fitness for service. During the first two weeks of the conscript's service, the garrison physician re-evaluates his mental and physical health for a third time to check whether there have been any changes after the health examination at the call-up and to confirm his fitness for service.

During the service, the basic healthcare services are available through the health care centres in the garrisons; during the time course covered by this thesis project, they were mostly called garrison hospitals. The conscripts have the right to consult a nurse or a physician when a health problem arises. Specialist services were available at military hospitals during this study and due to structural reforms, regional civilian

partnership hospitals have been used in the 2000s. The health services and medicines included in the healthcare provided by the Defence Forces are free of charge for conscripts.

Detailed information of health examinations and visits to the military healthcare units as well as other health-related information were coded from the military service medical records in THL. Medical data were coded primarily by a physician, with experience from the military healthcare system, into a computer-assisted interview and survey tool (Blaise Survey Software©, Statistics Netherlands). Coding criteria and methods were created by the research team and pilot-tested and modified accordingly before the final coding process. The repeatability of the coding system was verified with test coding by the same coder(s) in the beginning, middle, and end of the coding process, using the medical data from 75 conscripts.

Other project workers coded the data from health questionnaires and other military health and training files. These data included service time and length, weight and height measured at the health examinations as well as observations noted by the physician at the health examinations.

All coded data were tested for formal correctness. Although permissible limits and logical conditions were incorporated in the Blaise program, this was not entirely successful. Upper and lower limit checks were made as well as logical checks. In addition, distributions of variables were scrutinized and erroneous data corrected. The checks and cleaning of data were supervised by personnel from THL and made in the same manner as conducted in the Health 2000 Study (Alha and Rinne 2008).

4.2.3   THE HEALTH 2000 STUDY

The Health 2000 Study was carried out between September 2000 and July 2001 by the National Institute of Public Health in 80 health care districts all over the country (Aromaa and Koskinen 2004, Heistaro 2008). The main objective of the study was to obtain up-to-date information of major public health problems (e.g. musculoskeletal and mental disorders), their determinants and treatment as well as on functioning and work ability. The methods of data collection were interviews, questionnaires, measurements and clinical examination.

The field survey contained a home interview for subjects aged 18-29 and those aged 30 or over. In connection with the home-visit interview, participants were given a basic questionnaire, which they were asked to complete. The interview and questionnaires covered a large number of lifestyle and health-rated items, including musculoskeletal symptoms and functional limitations (Aromaa 2008). The field survey for subjects aged 30 or older also included an extensive health examination. Height, weight and waist circumference were measured. The young adults did not undergo a health examination.

The purpose of the clinical examination was to medically assess the presence of major chronic diseases in the subject, to determine the need for treatment for those diseases and to assess the subject's level of functional capacity (Reunanen and Heliövaara 2008). Specially trained physicians took a history and performed a standard clinical examination; its main focus was on circulatory diseases and musculoskeletal disorders. The thorough examination of the musculoskeletal system included the

spine and the joints. The lumbar spine examination included testing for signs of pain in the nerve root.

Detailed description of the data collection, participation rates at different stages of the Health 2000 Study as well as the forms used in the Health 2000 Study are available online http://www.terveys2000.fi/ .

4.2.4   REGISTERS

In Finland, people with a chronic illness, disability, or injury that has been verified by a physician with a medical certificate and assessed as causing considerable and long-lasting decreased work ability are entitled to a part-time or full-time DP (Gould 2003). The Social Insurance Institution of Finland has registers of those individuals receiving national pensions and guarantee pensions, which are awarded if the earnings-related pension is small or none. The Finnish Centre for Pensions coordinates all earnings-related pensions for permanent residents and provides essentially complete data on DR awards in its retirement register. Aggregate data of pensions paid by the Social Insurance Institution and the earnings-related pension scheme are compiled in a joint statistical data warehouse. The register data are primarily used for ensuring uniform pension decisions, harmonisation of pensions from different schemes and calculation of different pensions. The data in the registers include comprehensive information on all awarded pension benefits, e.g. which kind of pension benefit has been awarded, start and end dates, main and secondary diagnoses. The diagnoses of chronic illnesses in the national pension registers are classified according to the International Statistical Classification of Diseases and Related Health Problems, Eight, Ninth and Tenth Revisions (ICD-8, -9 and -10, Finnish versions of ICD-classifications 1969, 1987, 1996).

4.3   OUTCOMES

In study I, the main outcome was visits (with their causes) to the garrison healthcare. In study II, the clinically defined back outcomes were diagnoses of chronic low back syndrome or sciatica. The symptom-based outcome measures included one-month prevalence of non-specific and radiating LBP (study II) as well as self-reported knee pain during previous 30 days and functional limitations due to knee pain (study III). The main outcomes in study IV were incident DR (permanent, temporary, full-time, part-time) with their diagnoses prior to 1 January 2009.

4.3.1   HEALTH CARE VISITS (STUDY I)

All consultations to garrison healthcare due to any reason were collated. Visits due to MSDs were identified and the following information of each MSD visit was coded: date; care provider (physician, nurse or conscript medics); symptoms; diagnoses (if applicable); anatomical site; first-time or a recurrent visit for the same reason; other concomitant musculoskeletal symptoms; possible etiological mechanism (overuse; prior injury; acute trauma; other; unknown) and exemptions from duty. The total

number of visits due to any reason was calculated and recorded, time trends were explored.

4.3.2   LOW BACK AND KNEE PAIN (STUDY II, III)

In the Health 2000 Study, information on musculoskeletal symptoms was collected during interview. Low back symptoms were enquired with the following questions: "Have you ever had low back pain? (Yes/no)". Those who answered yes were asked about recent pain and about the type of pain: "Have you had low back pain during the preceding 30 days? (yes/no)"; "If you had low back pain, did it radiate? (0=no, 1=below the knee, 2=above the knee)".

Data on knee pain were obtained with the following questions: "Have you during the previous month (30 days) had pain, aches or motion soreness in one or several joints? (yes/no)". Those who had answered yes were enquired about the location of the pain by showing them a body diagram. Left and right knee were coded separately.

4.3.3   FUNCTIONAL LIMITATIONS DUE TO KNEE PROBLEMS (STUDY III)

Functional limitations were enquired with the question: "Have you during the last month had walking difficulties or limping due to a knee problem? (Yes/no)".

4.3.4   CLINICALLY DEFINED LOW BACK OUTCOMES (STUDY II)

The chronic low back syndrome and sciatica were diagnosed during the clinical examination by specially trained physicians using predefined criteria (Reunanen and Heliövaara 2008). Low back symptoms with a duration of at least three months overall were considered as being chronic. All diagnoses were categorized as 0=no, 1=probable, 2=definite. The diagnoses were classified as probable when the subject did not currently have symptoms, or when the criteria of the previous diagnoses were vague. In study II, a clinically defined low back outcome was designated if the subject had a probable or definite diagnosis.

Diagnostic assessment of the clinical examination was in some cases not accurate enough due time constraints and lack of background information. Consequently, several of the clinical diagnoses were later checked and corrected (if needed) using additional information e.g. from all available register information.

4.3.5   DISABILITY RETIREMENT (STUDY IV)

Data on all DR events and their main and secondary diagnoses were obtained from the national registers of the Finnish Centre for Pensions and the Social Insurance Institution of Finland. All DPs granted any time between 1 January 1968 and 1 January 2009 were linked to the MSDs@Mil data via the personal identity numbers. The linkage was

done by personnel at THL. All-cause DR comprised all incident DRs at any time between 1 January 1968 and 1 January 2009. The interest in this thesis was 1) all-cause DR, 2) DR due to mental disorders and 3) DR due musculoskeletal diseases.

4.4 DETERMINANTS

4.4.1 HEALTH CARE VISITS DURING MILITARY SERVICE

The reason for all visits due to musculoskeletal and mental problems were coded and their total number calculated. All hospitalisations at the garrison healthcare, specialist healthcare in public or private hospitals were recorded (date; diagnosis; possible surgery and recommended exemptions), as well as any other relevant information concerning mental or musculoskeletal problems. Visits due to musculoskeletal problems were classified according to their aetiology into traumatic (recent, accidental) and non-traumatic injuries. The reason for possible interruption of military service was also identified.

4.4.2 PRE-MILITARY HEALTH EXAMINATIONS

Musculoskeletal and mental symptoms and findings were recorded at call-up prior to the conscript service and health examinations during the first two weeks of military service. The information was obtained from the medical files.

4.4.3 LIFESTYLE FACTORS AT BASELINE

The weight and height of the conscripts were measured with the men in their underwear during the health examination by nurses or trained medics at the garrison health centres. Data on smoking and physical activity were collected with a health and lifestyle questionnaire.

BMI was calculated by dividing weight (kg) with the square of height (m²). In study II, baseline BMI was dichotomized into BMI < 25 kg/m² (normal) and ≥25 kg/m² (overweight/obese). In study III, BMI at baseline was dichotomized into two categories: 1) BMI < 29.7 kg/m² (non-obese) and 2) BMI ≥29.7 kg/m² (obese), based on trajectory analysis (see Statistical analyses).

The conscripts were classified as smokers if they answered "yes" to the question "Do you smoke?" The frequency of physical activity was inquired in the pre-military health questionnaire with a 3- or 4- category question, depending on the year it was used. In order to achieve a synchronized classification, the conscripts were classified as physically active, if the conscripts answered that they participated in strenuous physical exercise causing breathlessness at least once a week.

4.4.4 WEIGHT-RELATED MEASURES AT FOLLOW-UP

During the health examination in Health 2000 Study, *height and weight* were measured (Reunanen 2008) (Heliövaara 2008). Overweight and obesity were defined based on BMI using the WHO recommendation BMI < 25 kg/m2 (normal), 25–29.9 kg/m2 (overweight), and ≥30 kg/m2 (obese) (WHO 1995).

Waist circumference (WC) was measured (Reunanen 2008) and categorized using the WHO recommendation < 94 cm (normal), 94-102 cm (increased risk of metabolic complications), and ≥102 cm (substantially increased risk of metabolic complications) (WHO 2011).

Furthermore, waist-to-height ratio (WHtR) was calculated by dividing measured waist circumference with measured height. WHtR has been shown to be a valid tool for assessing obesity-associated health risks (Schneider et al. 2010). The WHtR was dichotomised using the proposed cut-off value of 0.5 (Ashwell and Hsieh 2005).

4.4.5 BODY MASS INDEX DURING LIFE COURSE

Height at the age of 20 years and weight at the ages of 20, 30, 40 and 50 years were inquired at follow-up, if applicable.

In studies II and III, repeated measures of BMI values (at baseline, self-reported at the age of 30, 40 and 50 years and measured at follow-up) were used to construct a variable that characterized life course BMI. This was constructed by calculating age-standardized Z-scores (mean = 0, standard deviation = 1) for each time-point measure, which were averaged across time-points (Kivimäki et al. 2008).

In study II, baseline and follow-up BMI were used to obtain a variable to describe overweight or obesity during life course, consisting of six categories. The categories were defined as the following: 1) both baseline and follow-up BMI < 25 kg/m² (normal weight at both time points), 2) baseline BMI < 25 kg/m² and follow-up BMI ranged between 25-29.9 kg/m², 3) baseline BMI < 25 kg/m² and follow-up BMI ≥ 30 kg/m²,4) baseline BMI ≥ 25 kg/m² and follow-up BMI < 25 kg/m², 5) baseline BMI ≥ 25 kg/m² and follow-up BMI ranged between 25-29.9 kg/m², 6) baseline BMI ≥ 25 kg/m² and follow-up BMI ≥ 30 kg/m².

4.4.6 ACCURACY OF SELF-REPORTED HEIGHT AND WEIGHT

For all men, measurements were available at baseline and self-reported data at follow-up for height and weight at the age of 20. Additionally, for men aged 30, 40, or 50 at follow-up, both measured and self-reported weight were available. Comparison of BMI based on self-reported and measured height and weight exhibited high correlation coefficients (Pearson r) of at least 0.80 for the studied age groups. With less recall time, the correlation coefficient increased towards 1.0. Our data suggest that recall bias is relatively minor and self-reported data could reliably be used as a proxy for the subjects' height and weight, when calculating BMI and constructing life course measures for BMI.

4.5   POTENTIAL CONFOUNDERS

The length and time of military service (the first day of service) were obtained from military files. Data on length of education (in years), smoking, physical activity and physical heaviness of work were collected during the home interview at follow-up. The subjects were inquired about how physically demanding their work was via the following question: "Does your present/last occupation/job involve heavy physical work, in which you have to lift or carry heavy items, dig, shovel or pound?" Daily smokers were classified as smokers. Those men who reported that they engage in sufficient physical exercise to cause sweating for at least 30 minutes at least once a week were classified as physically active.

4.6   STATISTICAL ANALYSES

The analyses were carried out using SAS 9.4 (SAS Institute, Cary, NC, USA) (Table 3).

4.6.1   IMPUTATION OF MISSING DATA (STUDY II, III)

Missing values on smoking and physical activity at baseline were imputed using the missing data propensity score method (Rosenbaum and Rubin 1983).

4.6.2   ANALYSES OF TEMPORAL TRENDS OF HEALTH CARE SEEKING DURING MILITARY SERVICE (STUDY I)

The military service time of the subjects was classified into 5-year periods when analysing the frequencies of consultations, number of consultations per conscript and anatomical distribution of musculoskeletal problems. Due to the small numbers of subjects in the early and late years of the study, years 1967-69 were pooled with the subsequent 5-year group (1970-1974) and years 2005-2006 with the preceding 5-year group (2000-2004). Cochran-Armitage Trend Test was used to explore trends in proportion-type outcome measures (e.g. proportion of conscripts seeking medical advice due to MSDs). The distribution of the visits to the healthcare units has been presented by 5-year-groups. When analysing the distribution of conscripts according to the number of MSD-consultations, the length of the military service was taken into account and classified into ≤ 240 and > 240 days. In the summary of the thesis 10-year time periods were used for descriptive purposes.

4.6.3   ANALYSES OF THE ASSOCIATIONS OF WEIGHT-RELATED MEASURES WITH LOW BACK AND KNEE OUTCOMES (STUDY II, III)

Since the outcomes were based on prevalence, prevalence ratios (PR) were used to measure the longitudinal and odds ratios (OR) to measure the cross-sectional associations between weight-related variables and low back and knee outcomes.

The effects of baseline and life course BMI on low back and knee outcomes at follow-up were studied with the Cox regression model with the total length of time of follow-up being assigned to each individual. The Cox model was used instead of logistic regression in order to avoid undue inflation of estimates of associations between weight-related measures and low back and knee problems (Barros and Hirakata 2003, Thompson et al. 1998). The prevalence ratios (PR) and their 95% confidence intervals (95% CI) were adjusted for age (low back and knee outcomes) and smoking at baseline (low back outcomes) and length of education (years) (low back and knee outcomes) and physical heaviness of work at follow-up (knee outcomes).

The cross-sectional associations of weight-related measures with the outcomes at follow-up were studied with binary logistic regression models. The odds ratios (ORs) and their 95% confidence intervals (95% CI) were adjusted for the potential confounders mentioned above. It was also tested whether adjustment for physical activity would affect the observed associations.

4.6.4 BMI TRAJECTORIES DURING LIFE COURSE (STUDY II AND III)

To examine whether different life course trends in BMI were associated with the outcomes, the BMI trajectories were plotted using a semiparametric group-based modelling strategy by PROC TRAJ in SAS. This method was developed for analysing longitudinal data, changes over time, and identifying distinct latent groups of those subjects who tended to have a similar profile over time (trajectories) (Jones and Nagin 2007; Nagin 1999). The Bayesian information criterion (BIC) was used as the basis for selecting the optimal model, number of trajectories and their shape. In the analysis, repeated BMI measures were used (baseline and follow-up BMI for 18-29 years old, baseline BMI, BMI at the age of 30 and follow-up BMI for 30-39 years old and baseline BMI, BMI at the age of 30, 40 and follow-up BMI for 40-50 years old). With continuous data, the normal distribution was used as the underlying statistical model.

4.6.5 PATHWAYS TO DEVELOPMENT OF FUNCTIONAL LIMITATIONS DUE TO KNEE PROBLEMS (STUDY III)

To examine pathways to the development of functional limitations due to knee problems at follow-up, we tested if the association between baseline obesity and functional limitations at follow-up were mediated by the military health care visits due to knee problems. We followed the Baron and Kenny process (Baron and Kenny 1986), which uses four steps of the multiple regression model to establish the mediation. First, we assessed the effect of baseline obesity on functional limitations at follow-up. Second, we examined the effect of health care visits on functional limitations. Third, we estimated the effect of baseline obesity on health care visits. Fourth, we assessed the effect of baseline obesity on functional limitations with inclusion of health care visits into the model. All associations were studied with the Cox regression model and adjusted for age. The direct and indirect (mediating) effects were further tested using a bias-corrected bootstrap procedure with the SAS process macro (http://www.processmacro.org/), developed by Preacher and Hayes (Preacher and Hayes 2004).

4.6.6   DISABILITY RETIREMENT (STUDY IV)

The distribution of visits due to any health problem, or due to mental or musculoskeletal problems was very skewed and varied by the year of service as well as service length. Therefore, the service year adjusted Z-scores were calculated for each type of visits and this score was used in the analyses. Associations between seeking health care (visits due to health problems per service month) during military service and DR were assessed using a Cox proportional hazard regression analysis. Hazard ratios (HRs) and their 95% confidence intervals (95% CIs) were calculated. All analyses were performed for each service time stratum. The pooled HRs were estimated using Mantel-Haenszel method.

The follow-up of each subject started from the first day after completion or interruption of military service and continued until the beginning of DP or some other pension, death, or end of follow-up (01.01.2009), whichever came first. Subjects who retired due to other reasons (i.e. age, n=3) or died during follow-up (n=39) were censored. The follow-up time was counted in days.

The proportional hazard assumption was assessed visually through inspection of the log-log hazards plots of all predictors, and was found to be satisfactory.

Kaplan−Meier survival curves were plotted to illustrate the time to DR for each category of the determinant variable (visits due to musculoskeletal and mental problems). To test whether visits due to mental and musculoskeletal disorders associated in a synergistic manner with DR, the RERI between visits due to mental and musculoskeletal disorders was calculated (Li and Chambless 2007). An interaction between two risk factors on an additive scale is present, if the relative excess risk due to interaction (RERI) is not equal to zero. If the RERI is above zero, this is indicative of synergism between two risk factors.

Additionally we examined whether pre-military BMI confounded these associations.

4.6.7   SENSITIVITY ANALYSES (STUDY II, III)

Sensitivity analyses were carried out in order to examine whether exclusion of subjects with symptoms or signs at baseline would affect the observed associations.

Table 3. Methods for statistical analyses used in the studies.

Study	Main study questions	Method of analysis
I	Trends in proportion of conscripts seeking medical advice due to MSDs	Cochran-Armitage Trend Test
I	Trends in numbers of MSD-related medical consultations per conscript	Poisson regression model
II and III	Effects of baseline and life course weight-related factors on the outcomes at follow-up	Cox regression model
II and III	Cross-sectional associations of weight-related measures with low back and knee outcomes at follow-up.	Binary logistic regression models
III	Pathways to the development of functional limitations due to knee problems at follow-up	Multiple regression model, Baron and Kenny process
IV	Associations between seeking medical advice during military service and disability retirement	Cox proportional hazard regression analysis
IV	Time to disability retirement for visits due to musculoskeletal and mental problems during military service	Kaplan–Meier survival curves

4.7 ETHICAL CONSIDERATIONS

The Section for Epidemiology and Public Health of the Ethics Committee of the Hospital District of Helsinki and Uusimaa approved the study design of the Health 2000 Study 31 May 2000. The MSDs@Mil study was approved by The Ethics Committee of the Finnish Institute of Occupational Health in December 2007.

The subjects participating in Health 2000 Study were given written information (also mentioning the use of register data) in connection with the home interviews by Statistics Finland staff and later in connection with the health examination, and in both situations trained staff were available to answer any questions. The subjects were asked to sign an informed consent form. The consent contained a section requesting permission for using their data in studies on health, various diseases and their determinants, including linkage with a number of registers, e.g. those containing information on DR.

5   RESULTS

5.1   TEMPORAL TRENDS AND PATTERNS OF HEALTHCARE CARE UTILISATION DURING COMPULSORY MILITARY SERVICE (I, IV)

Nearly all (89.1%; 95% CI 87.7-90.4) conscripts who entered military service during 1967-1996 sought medical advice at least once; they made a median of 4 visits (inter-quartile interval, IQI, 2 – 8) during the service period. Taking into account the length of the service, the median number was 0.5 visits per service month among the men who had completed their military service but it was markedly higher (1.9 visits per service month) in those who interrupted their service (Table 4). There was a linear increasing trend in visits during the study period. A conspicuously high increase was seen among those who did not complete their military service, their relative number of visits becoming 5-fold, while it doubled among those who completed their service.

Table 4. Median and interquartile range (IQR) of healthcare visits due to any reason during military service relative to the service length (visits per service month).

Completion of military service	1967-1976	1977-1986	1987-1996	1967-1996
	IQR	*IQR*	*IQR*	*IQR*
All	n=587	n=758	n=724	n=2069
	0.3 (0.1-0.6)	0.4 (0.2-0.8)	0.7 (0.4-1.4)	0.5 (0.2-0.9)
Did not complete the military service	n=24	n=26	n=61	n=111
	0.6 (0.02-2.8)	1.3 (0.0-2.0)	3.0 (1.2-4.2)	1.9 (0.5-3.6)
Completed the military service	n=563	n=732	n=663	n=1958
	0.3 (0.01-0.6)	0.4 (0.2-0.8)	0.6 (0.3-1.2)	0.5 (0.2-0.9)

Visits due to musculoskeletal problems were common and the proportion of men requesting medical advice due to musculoskeletal reasons increased during the study period (Table 5). The proportion of men seeking medical advice at least once due to a mental problem or due to both mental and musculoskeletal problems increased dramatically, i.e. tripling in the service period from 1967-1976 to 1987-1996.

Table 5. *Co-occurrence of visits due musculoskeletal and mental problems during military service by 10-year service periods.*

Visits	1967-1976 (n=587)		1977-1986 (n=758)		1987-1996 (n=724)		1967-1996 (n=2069)	
	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)	n	% (95% CI)
No visits due to musculoskeletal or mental problems	283	48.3 (44.1-52.3)	292	38.6 (35.0-42.1)	138	19.1 (16.3-22.1)	713	34.5 (32.4-36.5)
Due to musculoskeletal problems	273	46.5 (42.5-50.6)	411	54.2 (50.7-57.7)	472	65.2 (61.7-68.6)	1156	55.9 (53.7-58.0)
Due to mental problems	19	3.2 (2.1-5.0)	35	4.6 (3.3- 6.4)	69	9.5 (7.8-11.9)	123	5.9 (3.0-7.1)
Due to both musculoskeletal and to mental problems	12	2.0 (1.1-3.6)	20	2.6 (1.7-4.1)	45	6.2 (4.7-8.2)	77	3.7 (3.0-4.6)

mong the conscripts who completed their military service during 1967-2006, six out of ten utilized the military healthcare service at least once due to musculoskeletal problems, mostly during the first 8-10 weeks (basic training period) (Table 6).

Table 6. *Number of conscripts in the sample, and number and proportion of conscripts with MSD-related visits during 1967-2006 among those who completed their service, n=2296.*

Service year period	Sample	Conscripts with MSD-related visits			
		Basic training period		Entire service period	
	n	n	%	n	%
1967-1979	785	209	26.6	366	46.6
1980-1989	732	267	36.5	439	60.0
1990-2006	779	311	37.0	534	68.5
1967-2006	2296	787	34.3	1339	58.3

The proportion of the conscripts who visited the military health care service at least 6 times during their service due to MSDs increased from 3% to 15% during the study period 1967-2006. Accordingly, the proportion of conscripts who did not visit the military health care at all due to MSDs decreased to approximately half during the study period.

The proportion of the conscripts who consulted the military health care for symptoms in at least 4 body areas increased from 1% to 11% during the study period 1967-2006.

With respect to all medical consultations due to musculoskeletal problems, two out of every three concerned problems of the lower limb, typically in the foot/ankle and knee region. Lower back problems were also common. No temporal trend was seen in the anatomical distribution of the problems.
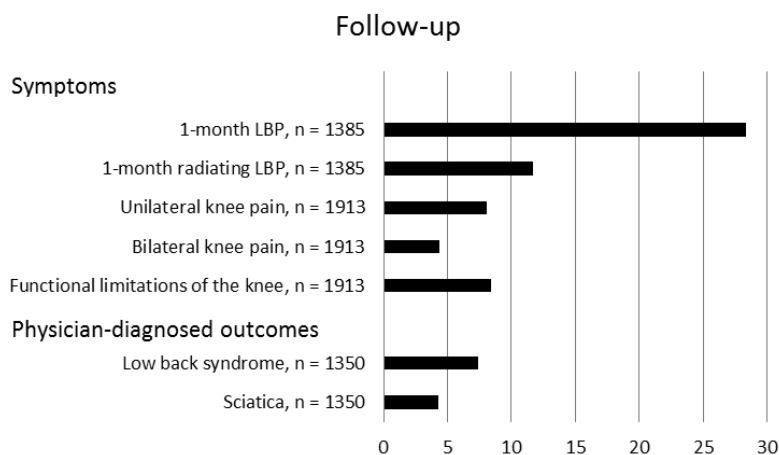
5.2 PREVALENCE OF KNEE AND LOW BACK OUTCOMES (II, III)

In approximately 8% of the men, during the pre-military health examinations (baseline) the examining physician had made a note of low back symptoms or signs, whereas knee symptoms were rare (Figure 5a). Also at follow-up, low back symptoms were more common than knee problems. (Figure 5b). Physician-diagnosed low back disorders were not as common as symptom-based low back outcomes.

Figure 5

Baseline

Knee symptoms or signs, n= 1913

Low back symptoms/signs, n= 1385

Spinal symptoms/signs, n= 1385

0 5 10 15 20 25 30
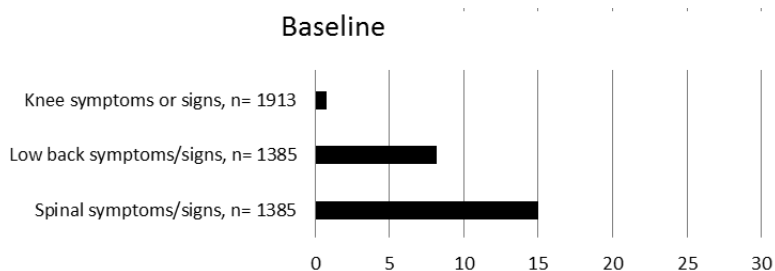
Figure 5a   Prevalence (%) of low back symptoms or signs at baseline.

Follow-up

Symptoms

1-month LBP, n = 1385

1-month radiating LBP, n = 1385

Unilateral knee pain, n = 1913

Bilateral knee pain, n = 1913

Functional limitations of the knee, n = 1913

Physician-diagnosed outcomes

Low back syndrome, n = 1350

Sciatica, n = 1350

0 5 10 15 20 25 30

Figure 5b   Prevalence (%) of low back and knee outcomes at follow-up.

5.3   DIFFERENCES IN THE ASSOCIATION OF GENERAL AND ABDOMINAL OBESITY WITH BACK AND KNEE OUTCOMES (II, III)

Neither BMI values nor waist circumference were associated with non-specific LBP. Both general (BMI ≥30 kg/m2) and abdominal obesity (WtHR > 0.5) were associated with radiating LBP (Table 7). A dose-response relationship was detected between categorical BMI and unilateral knee pain. Abdominal obesity was also associated with unilateral knee pain, with the risk being increased for those with waist circumference ≥ 94 cm.

The exclusion of subjects with baseline spinal symptoms or signs strengthened the observed associations between abdominal obesity defined based by waist circumference and radiating LBP (OR 1.62, 95% CI 1.05-1.78). In contrast, adjustment for knee problems prior to and during military service exerted only a minor effect on the estimates for knee pain.

None of the weight-related variables were associated with the clinically defined low back outcomes.

Continuous BMI was significantly associated with functional limitations due to knee problems at follow-up (Table 8). There was a tendency towards a dose-response association between categorical BMI and functional limitations of the knee. Similarly, abdominal obesity as defined by waist-to-height ratio, tended to increase the odds of functional knee limitations.

Table 7.   Cross-sectional associations between weight-related factors and self-reported musculoskeletal symptoms during previous 30 days.

Weight-related measure	One-month prevalence of low back pain				One-month prevalence of knee pain					
	LBP		Radiating LBP		Unilateral		Bilateral		Any	
	OR[a]	95% CI[a]	OR[a]	95% CI[a]	OR[a]	95% CI[a]	OR[a]	95% CI[a]	OR[a]	95% CI[a]
BMI (continuous)[b]	0.95	0.84-1.07	1.16	0.99-1.35	**1.30**	**1.11-1.51**	1.12	0.91-1.38	**1.51**	**1.13-2.02**
BMI (categorical)										
< 25 kg/m²	1.00		1.00		1.00		1.00		1.00	
25 to 29.9 kg/m²	1.03	0.80-1.34	1.42	0.97-2.08	**1.67**	**1.23-2.26**	1.42	0.96-2.12	**1.58**	**1.23-2.02**
≥ 30 kg/m²	0.88	0.61-1.25	**1.64**	**1.02-2.65**	**2.16**	**1.52-3.08**	1.38	0.80-2.38	**1.86**	**1.40-2.53**
Waist circumference (continuous)[c]	1.00	0.88-1.12	1.15	0.98-1.35	1.18	0.99-1.41	1.08	0.85- 1.38	1.15	0.99-1.33
Waist circumference (categorical)										
< 94 cm	1.00		1.00		1.00		1.00		1.00	
94 to 101.9 cm	1.11	0.83-1.47	1.03	0.69-1.53	**1.67**	**1.23-2.26**	1.42	0.96-2.12	1.16	0.86-1.55
≥ 102 cm	1.03	0.77-1.39	1.31	0.88-1.96	**1.64**	**1.19-2.25**	0.95	0.57-1.58	**1.38**	**1.04-1.82**
Waist to height ratio										
normal (≤ 0.5)	1.00		1.00		1.00		1.00		1.00	
critical (> 0.5)	0.96	0.76 -1.22	**1.44**	**1.02 to 2.04**	1.25	0.94-1.66	1.26	0.83-1.91	1.26	0.99-1.60

LBP, low back pain; BMI, body mass index; OR, odds ratio; CI, confidence interval
[a]Odds ratios and their 95% CIs are adjusted for age, smoking and education.
[b]Continuous variable, one standard deviation increase, corresponding to 4.0 kg/m² for follow-up BMI.
[c]Continuous variable, one standard deviation increase, corresponding to 11 cm for waist circumference at follow-up.

Table 8. *Cross-sectional associations of weight-related measures with physician-diagnosed back problems and self-reported functional limitations due to knee problems at follow-up.*

Weight-related measure	Chronic LBP syndrome (100/1350, 7.4%) OR[a]	95% CI[a]	Sciatica, assessed by physician (58/1350, 4.3%) OR[a]	95% CI[a]	Functional limitations due to knee problems (160/1913, 8.4%) OR[a]	95% CI[a]
BMI[a] (continuous)[b]	1.09	0.90 to 1.33	1.10	0.86 to 1.41	**1.21**	**1.04-1.42**
BMI (categorical)						
< 25 kg/m²	1.00		1.00		1.00	
25-29.9 kg/m²	0.95	0.60 to 1.51	0.84	0.47 to 1.51	1.21	0.92-1.58
≥ 30 kg/m²	1.13	0.63 to 2.00	1.04	0.50 to 2.15	1.40	0.97-2.01
Waist circumference (continuous)[c]	1.13	0.92 to 1.38	1.18	0.92 to 1.52	1.16	0.96-1.41
Waist circumference (categorical)						
< 94 cm	1.00		1.00		1.00	
94-101.9 cm	1.04	0.63 to 1.73	0.91	0.47 to 1.75	1.22	0.86-1.75
≥ 102 cm	1.24	0.75 to 2.03	1.19	0.64 to 2.23	1.11	0.77-1.60
Waist to height ratio						
normal (≤ 0.5)	1.00		1.00		1.00	
critical (> 0.5)	1.33	0.75 to 1.72	0.88	0.52 to 1.49	1.32	0.97-1.81

LBP, low back pain; BMI, body mass index; OR, odds ratio; CI, confidence interval.
[a]Odds ratios and their 95% CIs are adjusted for age, smoking and education.
[b]Continuous variable, one standard deviation increase, corresponding to 4.0 kg/m² for follow-up BMI.
[c]Continuous variable, one standard deviation increase, corresponding to 11 cm for waist circumference at follow-up.

5.4 LIFE COURSE TRENDS IN BMI

In the trajectory analysis of BMI of the men who entered military service prior to the Health 2000 Study, a model including three life course BMI trajectories displayed the best fit (Figure 6). The men whose BMI stayed within a normal range (BMI 21.0; 95% CI 20.9-21.1 at baseline and 23.8; 95% CI 23.6-23.9) during the follow-up formed the largest BMI trajectory (Normal BMI).

The men who in the pre-military health examination (baseline) had a normal BMI and became overweight during follow-up (baseline BMI 24.2, 95% CI 24.1-24.4; follow-up BMI 28.7, 95% CI 28.5-28.8) made up the second largest trajectory (Development of overweight). The smallest trajectory (Development of severe obesity) consisted of those men who were borderline obese at baseline and became severely obese during the follow-up (baseline BMI 29.7, 95% CI 29.3-30.1; follow-up BMI 35.2, 95% CI 34.8-35.6).
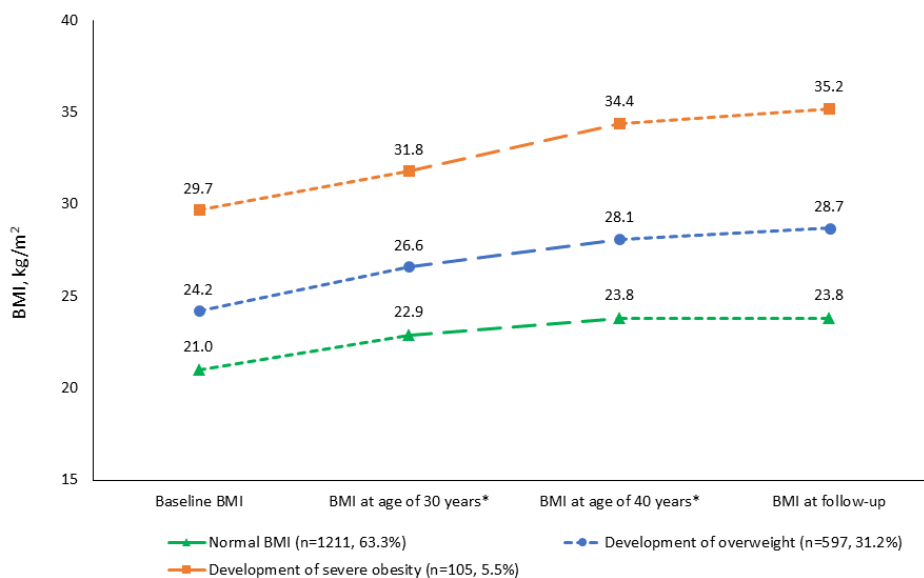
Figure 6   Life course trends in BMI, model with three trajectories.
*BMI at age of 30 and 40 years were used when applicable.

5.5 THE IMPACT OF OBESITY AND OTHER LIFESTYLE FACTORS ON BACK AND KNEE PROBLEMS OVER THE LIFE COURSE (II, III)

5.5.1 ASSOCIATIONS OF BMI AND OTHER LIFESTYLE FACTORS WITH SELF-REPORTED MUSCULOSKELETAL SYMPTOMS DURING THE LIFE COURSE

Baseline values as well as life course BMI (BMI Z-score) were statistically significantly associated with both one-month radiating LBP and knee pain. A one standard deviation increase in baseline BMI (corresponding to 3.0 kg/m² and 3.1 kg/m² for radiating low back pain and knee pain, respectively) was associated with a 26% increase in the risk of radiating LBP and a 38% increase in the risk of knee pain (Table 9). A one-unit increment in the Z-score (corresponding to 2.92 and 3.02 units of BMI, respectively) was associated with a 23% increase in the risk of radiating LBP and a 32% increase in the risk of knee pain.

Men who were borderline obese at baseline and developed severe obesity during the follow-up, had an increased risk of radiating LBP, while the risk of knee pain was increased already for those who had normal BMI at baseline and developed overweight during follow-up.

No clear associations were seen for non-specific LBP nor for bilateral knee pain. Being a smoker or physically active at baseline was not associated with LBP, radiating LBP or knee pain at follow-up.

Sensitivity analyses excluding those subjects with baseline spinal or knee symptoms or signs, caused only negligible changes in the observed associations.

Table 9 *Longitudinal associations of BMI at baseline, during the life course and BMI trajectories across the life course with self-reported one-month low back and knee pain.*

Weight parameter	One-month prevalence of low back pain n=1363				One-month prevalence of knee pain n=1913					
	LBP		Radiating LBP		Unilateral (154, 8.1%)		Bilateral (85, 4.4%)		Any (239, 12.5%)	
	PR[a]	95% CI[a]	PR[a]	95% CI[a]	PR[a]	95% CI[a]	PR[a]	95% CI[a]	PR[a]	95% CI[a]
BMI at baseline[b]	1.07	0.96-1.19	**1.26**	**1.08-1.46**	**1.38**	**1.19-1.59**	1.06	0.84-1.34	**1.26**	**1.11-1.42**
Life course BMI (Z –score)[c]	0.99	0.86-1.14	**1.23**	**1.03-1.48**	**1.32**	**1.11-1.56**	1.07	0.84-1.36	**1.21**	**1.05-1.38**
Life course BMI trajectory										
Normal weight all the time	1.00		1.00		1.00		1.00		1.00	
Development of overweight	0.82	0.66-1.02	1.12	0.80-1.56	**1.63**	**1.14-2.31**	1.30	0.82-2.07	**1.51**	**1.13-2.02**
Development of severe obesity	0.93	0.58-1.48	**1.92**	**1.08-3.40**	**2.00**	**1.09-3.77**	1.09	0.42-2.83	**1.80**	**1.05-3.08**

LBP, low back pain; BMI, body mass index; PR, prevalence ratio; CI, confidence interval.
[a]Prevalence ratios and their 95% CIs are adjusted for age, smoking and education.
[b]Continuous variable, one standard deviation increase, corresponding to 3.0 kg/m² for baseline BMI for back outcomes and 3.1 kg/m² for knee outcomes.
[c]One-unit increment in Z-score, corresponding to 2.92 units of BMI during follow-up for low back outcomes and 3.o2 units of BMI for knee outcomes.

5.5.2 ASSOCIATIONS OF BMI AND OTHER LIFESTYLE FACTORS WITH PHYSICIAN-DIAGNOSED LOW BACK DISORDERS AND FUNCTIONAL LIMITATIONS OF THE KNEE DURING LIFE COURSE

No longitudinal associations were seen between BMI and physician-diagnosed low back disorders (Table 10). BMI at baseline predicted functional limitations due to knee pain at follow-up. Borderline obese men at baseline who became severely obese during follow-up had an increased risk of functional limitations - PR 1.93, 95% CI 1.07-3.48, whereas there was no excess risk of functional limitations for those who had normal BMI at baseline and become overweight during follow-up. The life course BMI Z-score was significantly associated with functional limitations of the knee. A one-unit increment of Z-score (corresponding to 3.02 kg/m2) increased the risk of experiencing knee pain by 21%.

No associations were detected between smoking or physical activity status at baseline and the clinically defined low back outcomes or functional limitations of the knee at follow-up.

No change in the observed associations occurred in the sensitivity analyses when subjects with baseline spinal or knee symptoms or signs were excluded.

Table 10. *Longitudinal associations of BMI at baseline, during life course and BMI trajectories across life course with physician-diagnosed low back disorders and self-reported functional limitations of the knee.*

Weight parameter	Chronic LBP syndrome n= 1350		Sciatica, assessed by physician n=1350		Functional limitations due to knee problems n=1913	
	PR[a]	95% CI[a]	PR[a]	95% CI[a]	PR[a]	95% CI[a]
BMI at baseline[b]	1.18	0.96-1.44	1.15	0.89-1.50	**1.27**	**1.10-1.47**
Life course BMI (Z –score)[c]	1.09	0.87-1.36	1.10	0.83-1.46	**1.21**	**1.03-1.43**
Life course BMI trajectory						
Normal weight all the time	-	-	-	-	1.00	
Development of overweight	-	-	-	-	1.13	0.79-1.61
Development of severe obesity	-	-	-	-	**1.93**	**1.07-3.48**

LBP, low back pain; BMI, body mass index; PR, prevalence ratio; CI, confidence interval
[a]Prevalence ratios and their 95% CIs are adjusted for age, smoking and education.
[b]Continuous variable, one standard deviation increase, corresponding to 3.0 kg/m2 for baseline BMI for back outcomes and 3.1 kg/m2 for knee outcomes.
[c]One-unit increment in Z-score, corresponding to 2.92 units of BMI during follow-up for low back outcomes and 3.02 units of BMI for knee outcomes.

5.6 THE INFLUENCE OF KNEE PROBLEMS DURING MILITARY SERVICE ON LATER FUNCTIONAL LIMITATIONS OF THE KNEE (III)

Being borderline obese at baseline increased the likelihood of seeking medical advice especially due to accidental knee injury (Figure 7). The association of baseline borderline obesity with functional limitations due to knee problems at follow-up was reduced when visits due to knee problems during military service were entered into the model (from OR 2.62; 95% CI 1.34-5.14 to 2.39; 95% CI 1.21-4.72). This suggests that visits attributable to an accidental knee injury partly mediated the found longitudinal associations.
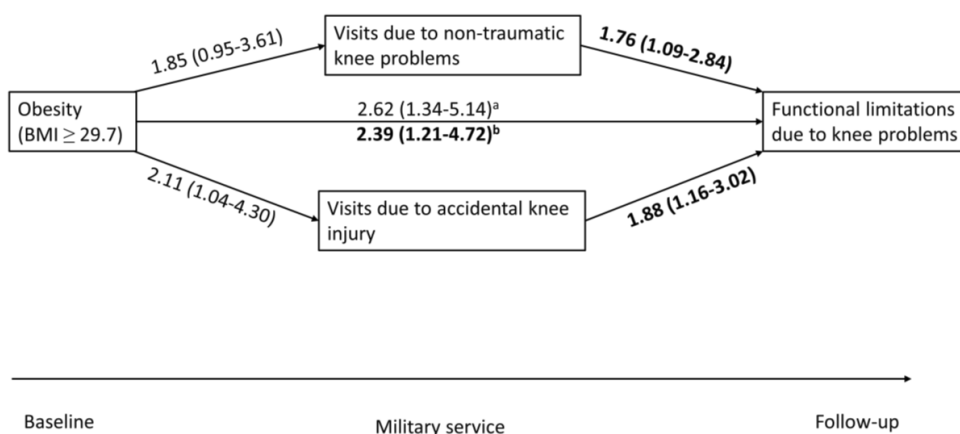
Figure 7   Model of pathways to functional limitations of the knee.
[a]Crude odds ratio
[b]Odds ratio with all visits due to knee problems in the model.

5.7 SEEKING MEDICAL ADVICE DURING MILITARY SERVICE AND THE RISK OF ALL-CAUSE DISABILITY RETIREMENT AND DISABILITY RETIREMENT DUE TO MENTAL DISORDERS AND MUSCULOSKELETAL DISEASES (IV)

5.7.1 CUMULATIVE INCIDENCE OF DISABILITY RETIREMENT

During 1968-2008, the cumulative incidence of all-cause DRs in the random sample was 8.8% (95% CI 7.8-10.0). In more detail, the cumulative incidence of DRs due to mental disorders was 4.3% (3.6-5.2), whereas that attributable to musculoskeletal diseases was 1.4% (1.0-1.9). Nearly all (95%) of the DRs were granted as full-time and permanent. The proportion of the men having received all-cause DR was especially high among those who did not enter military service. Furthermore, DR due to all causes and mental problems was especially prevalent among the men who had interrupted their military service during 1967-1996 (18.9%, 95% CI 12.7-27.3), compared with their counterparts who completed their service (6.0%, 95% CI 5.1-7.2). Over half (59%) of the DR cases among those who interrupted their service were due to mental disorders. On average, DR due to musculoskeletal diseases was awarded later (mean time to retirement 26.7; 95% CI 24.1-29.2 years) than DR due to mental (mean time to retirement 21.3; 95% CI 19.1-23.6 years).

5.7.2 ASSOCIATIONS BETWEEN SEEKING MEDICAL ADVICE DURING MILITARY SERVICE AND DISABILITY RETIREMENT DUE TO ALL-CAUSE, MENTAL DISORDERS AND MUSCULOSKELETAL DISEASES

The risk of all-cause disability was associated with frequently seeking healthcare, with the risk being most pronounced among those conscripts who served during the period 1987-1996, when the hazard ratio was 1.72 (95% CI 1.42-2.07) for one visit per service month (Figure 8). Seeking health care due to mental or musculoskeletal problems predicted all-cause DR among those who did their national service during 1967-1976 and 1987-1996.

An association between visits due to any health problem and DR due to musculoskeletal diseases was only observed among those men who served in 1967-1976 (HR 1.59, 95% CI 1.27-2.00).
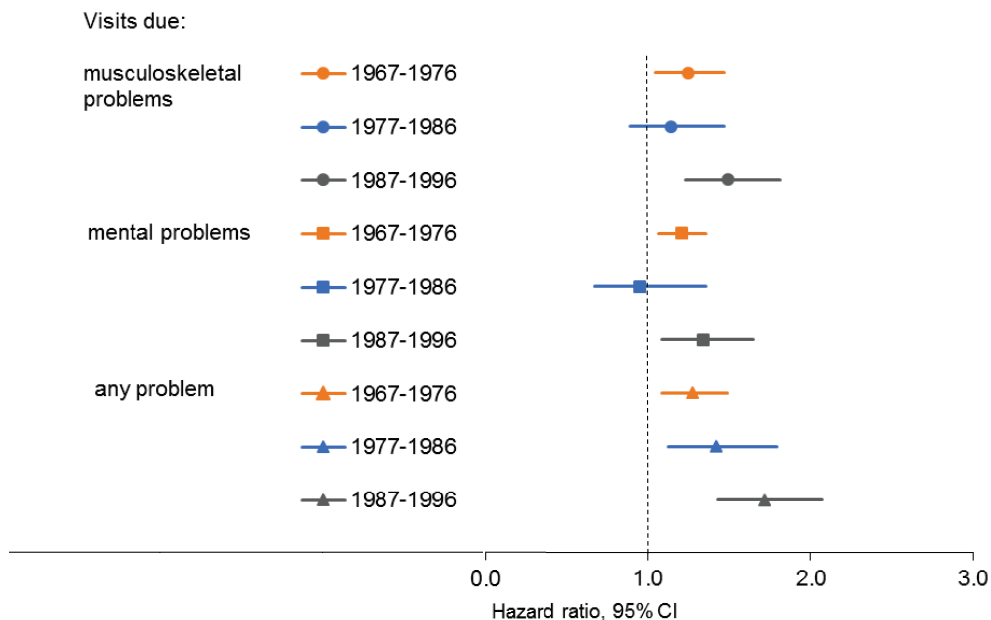
Figure 8 Association between seeking medical advice (visits per service month) during conscript service and all-cause disability retirement by service time strata. Hazard ratios per one SD in the number of visits.

Visits due to musculoskeletal problems: one SD corresponds to 0.2 visits per service month for conscript service during 1967-1976, 0.4 visits per service month for military service during 1977-1986 and 0.8 visits per month for military service during 1987-1996.

Visits due to mental problems: one SD corresponds to 0.1 visits per service month for conscript service during 1967-1976, 0.3 visits per service month for military service during 1977-1986 and 0.7 visits per month for conscript service during 1987-1996.

Visits due to any problem: one SD corresponds to 0.6 visits per service month for conscript service during 1967-1986 and 1.2 visits per month for military service during 1987-1996.

Men who visited military healthcare due to both musculoskeletal and mental problems had increased hazards of all-cause DR (HR 5.16, 95% CI 2.88-9.09), compared to those who did not seek medical advice due to either problem (Table 11). The relative excess risk due to the interaction of seeking medical advice for both problems was statistically significant (RERI 3.34, 95% CI 1.16-5.52). In addition, the risk of DR due to mental disorders was distinctly increased among those men who had sought medical advice due to both musculoskeletal and mental problems, though the relative excess risk due to interaction was not statistically significant.

Table 11. *Associations between seeking medical advice during military service (visits due to health problems per service month) and disability retirement.*

Reason for seeking medical advice		All-cause disability		Disability due to mental disorders	
	n	HR	95% CI	HR	95% CI
No visits due to musculoskeletal or mental problems	867	1.00		1.00	
Visits due to					
musculoskeletal, but not due to mental problems	1079	1.21	0.84-1.76	0.73	0.40-1.32
mental problems, but not due to musculoskeletal problems	46	1.56	0.58-4.20	2.62	0.87-7.89
both mental and musculoskeletal problems	77	**5.16**	**2.88-9.09**	**4.58**	**2.04-10.33**

6 DISCUSSION

6.1 MAIN FINDINGS

Of the lifestyle factors in early adulthood we found that being overweight was a significant determinant of musculoskeletal problems of the low back and knee later in life. If a conscript had needed to visit the military health care service due to both musculoskeletal and mental problems, this clearly increased his overall risk of DR – in particular due to mental disorders.

Musculoskeletal health concerns, especially those of the lower extremity and the low back, were among the main reasons for seeking medical advice during military service. Obesity predicted seeking medical help for knee problems during military service. Traumatic knee injuries occurring during military service partly mediated the observed association between obesity at baseline and functional limitations of the knee at follow-up. The numbers of conscripts seeking medical advice increased sharply during the study period. For instance, there was a tripling in the proportion of men seeking medical advice due to a mental problem or due to both mental and musculoskeletal problems at least once during their military service.

6.2 INTERPRETATION OF THE FINDINGS

6.2.1 THE IMPACT OF OVERWEIGHT AND OBESITY ON BACK AND KNEE PROBLEMS OVER LIFE COURSE

As far as we are aware, there are no prior studies examining the accumulated effects of overweight/obesity on LBP or knee pain using composite life course information of BMI. However, the results of this thesis can be compared with those of the British 1958 birth cohort study. That study showed that a high BMI value at the age of 23 predicted the incidence of LBP at age 32 to 33 in both genders (Power et al. 2001). Furthermore, being overweight or obese at the age of 16 and/or 23 predicted knee pain at the age of 45 (Macfarlane et al. 2011). An Australian study showed that if a boy was overweight at the age of 7 to 15 years and especially being overweight both in childhood and adulthood, then he was likely to suffer with knee pain, stiffness and dysfunction when aged 31 to 41 years (Antony et al. 2015). Furthermore, obesity has been associated with knee pain already among 17 year-old adolescents (Deere et al. 2012). Finally, weight gain has been reported to be associated with worsened knee pain and weight loss with relief from knee symptoms (Tanamas et al. 2013). In our study, the development of mere overweight was associated with knee pain and the development of severe obesity predicted functional limitations.

In the current thesis, we found that being overweight or obese increased the risk of radiating, but not non-specific LBP. This is in agreement with the results emerging from a recent meta-analysis, in which both overweight and obesity were consistently, though modestly, associated with the risk of lumbar radicular pain (Shiri et al. 2014).

Previous studies, not separating radiating and non-specific LBP, have reported inconsistent associations between weight-related factors and LBP (Nilsen et al. 2011, Rohrer et al. 1994, Shiri et al. 2010a, Taanila et al. 2012).

In line with the published literature, we observed weaker associations for physician-diagnosed sciatica than self-reported lumbar radicular pain (Heliövaara et al. 1991, Jhawar et al. 2006, Shiri et al. 2014). However, in a large cross-sectional study of 17-year old male Israeli conscripts, more consistent associations between BMI and low back problems were seen for clinically defined outcomes than for symptoms (Hershkovich et al. 2013).

Recent meta-analyses imply that there is a dose-response relationship between BMI and knee OA, with even being overweight still conferring a considerable risk (Zheng and Chen 2015, Zhou et al. 2014). Accordingly, the longitudinal results of this thesis indicate that the existence of overweight is a significant predictor of knee pain and functional limitations later in life. Further weight gain during the life course adds to the risk. The prevalence of knee pain increases with age (Arokoski et al. 2007) and this kind of pain is the major symptom encountered with knee OA (Zhang et al. 2010). Nevertheless, the degree of association between pain and OA of the knee has varied in the literature (Bedson and Croft 2008, Kinds et al. 2011). Generally knee OA is a disease which is diagnosed after the age of 50 and is less common in men (Cross et al. 2014, Pereira et al. 2011). This explains why we had only a few cases of knee OA in our population of men aged 50 or less. Although most subjects with knee pain did not have clinical OA, it is possible that their knee problems are an indicator of OA developing later in life.

Kuikka and co-workers have previously shown that obesity increases the risk of knee injuries requiring hospitalisation during military service (Kuikka et al. 2013). Knee injuries are associated with the onset of knee pain among middle-aged women (Jinks et al. 2008) and are a major risk factor for the future development of knee OA (Richmond et al. 2013). In our study, obesity significantly increased the risk of knee problems (traumatic and non-traumatic) during military service. Moreover, our findings suggest that obesity might increase the risk of functional limitations of the knee via injury.

Overall, the results of this thesis indicate that being overweight during young adulthood increases the risk of radiating LBP, knee pain and functional limitations due to knee problems later in life. There is an elevated risk of knee pain and functional limitations also in those normal weight young males who become overweight or obese during their life course. These findings emphasize the importance of early prevention of obesity.

6.2.2 DIFFERENCES IN THE ASSOCIATIONS OF GENERAL AND ABDOMINAL OBESITY WITH LOW BACK AND KNEE OUTCOMES

Both general and abdominal obesity were associated with radiating LBP, unilateral knee pain and functional limitations of the knee. With respect to unilateral knee pain, the associations were stronger for general than abdominal obesity, whereas there were no differences between the two types of obesity in the associations detected with radiating LBP. Consistent with our results, the population-based longitudinal Young Finns

study showed a similar association of general and abdominal obesity with incident radiating LBP (Shiri et al. 2013b). However, in a population-based cross-sectional study, the association with disc herniation symptoms was stronger for general than abdominal obesity in the male participants (Han et al. 1997). Similarly, results from the HUNT study revealed BMI to be a slightly stronger determinant than waist circumference of non-specific chronic LBP among men (Heuch et al. 2015). The findings of this thesis indicating that both types of obesity are associated with radiating low back pain in the same manner imply that the distribution of fat mass may not be critical for provoking radiating LBP. Indeed, an increased fat mass in the extremities has been reported to be associated with LBP intensity and disability (after adjustment for fat and lean mass in the total body) (Urquhart et al. 2011a).

Most previous studies using measures of abdominal obesity have examined knee OA, not knee pain, in older populations and have reported inconsistent findings. A Dutch cross-sectional study reported a linear association between waist circumference and knee OA (Heim et al. 2011). However, waist circumference showed a weaker association than BMI with knee OA in a case-control study (Holliday et al. 2011). In contrast, abdominal adiposity has been associated with total knee replacement in large cohort studies (Monira Hussain et al. 2014, Wang et al. 2009).

6.2.3 PATHOMECHANICAL PATHWAYS FOR OBSERVED ASSOCIATIONS OF GENERAL AND ABDOMINAL OBESITY WITH LOW BACK AND KNEE OUTCOMES

The mechanisms linking obesity with pain are complex and only partly understood. The present evidence indicates that both mechanical and metabolic-inflammatory pathways play a role (Janke et al. 2007, Okifuji and Hare 2015, Vincent et al. 2012) and that they may interact in a complex way (Berenbaum et al. 2013).

BMI reflects body weight, regardless of its composition of fat mass and lean mass, and thus it reflects long-lasting exposure of excess mechanical loads, especially on the weight bearing joints. Should the body mass become greater, this will increase the knee joint load in a linear manner, accounting for up to 80% of the variation in peak compressive load during gait (Sanford et al. 2014). Moreover, people who are overweight or obese, experience a relative loss of muscle mass and gain of fat mass, leading to lower relative muscle strength in the lower limbs (Vincent et al. 2012). These changes alter the biomechanics of the knee joint and gait.

Overweight and obesity could increase the mechanical load on the spine by causing a higher compression or tear on tissues and structures in the lumbar spine (Adams et al. 2015, Samartzis et al. 2013). Severely obese persons are reported to exert significantly higher disk compression forces while lifting objects compared to persons with normal weight (Singh et al. 2015). In accordance, magnetic resonance imaging of the lumbar spine has detected an association of high BMI with decreased signal intensity of the intervertebral disks and reduced disc height (Liuke et al. 2005, Takatalo et al. 2013, Urquhart et al. 2014). Furthermore, measures of abdominal obesity have been associated with lumbar disk degeneration in males (Takatalo et al. 2013). In addition, it has been reported that obese people have an increased risk of bodily injury (Hu et

al. 2009, Janssen et al. 2011). A history of work-related back injury has been linked with future LBP (Nolet et al. 2016).

In contrast to BMI, which reflects general obesity, measures of abdominal adiposity, such as waist circumference, waist-to-hip ratio and waist-to-height ratio, represent better the metabolically and inflammatory active fat tissue. Obesity, in particular abdominal obesity, leads to the accumulation of adipose tissue, which is the largest endocrine organ in the body. Adipocytes in the fat tissue release pro-inflammatory cytokines, both classical ones, such as interleukins and TNF-α, as well as adipokines, which in turn generate a chronic low-grade systemic inflammation (Berenbaum et al. 2013, Sowers and Karvonen-Gutierrez 2010, Vincent et al. 2012). The pro-inflammatory cytokines may induce pain (Sowers and Karvonen-Gutierrez 2010). There is evidence that adipocytokines, such as leptin, participate in the modulation of the inflammation process in the joint (Vuolteenaho et al. 2014).

Involvement of multiple joints may reflect systemic effects, as was seen in a previous longitudinal study, where a stronger association of baseline BMI was seen with bilateral knee pain rather than the unilateral counterpart in middle-aged women after 14 years of follow-up (Goulston et al. 2011). Our finding of an association of excess weight regardless of anatomical distribution, with unilateral knee pain, but not with bilateral pain, especially in younger people, could be a consequence of both systemic and local factors (e.g. trauma).

6.2.4 THE ASSOCIATION OF SEEKING MEDICAL ADVICE DURING MILITARY SERVICE WITH THE RISK OF DISABILITY RETIREMENT

If a conscript was frequently seeking medical advice due to any reason during military service this predicted all-cause DR. This implies that seeking medical advice is a sign that there is a health-related problem present in this young man and it points to the possibility of a poorer prognosis for future work ability from both a short-term and longer perspective. Due to the long follow-up period of our study, spanning four decades, several temporal changes have taken place, which probably affect the DR incidence between different service time periods. Treatments and rehabilitation possibilities have evolved, e.g. patients with LBP are no longer recommended to lie resting in bed, instead these kinds of limitations are nowadays avoided (Low back pain: Current Care Guidelines Abstract 2015). The proportions of persons receiving DP due to a mental disorder or musculoskeletal disease have changed considerably during the follow-up time. For example, the proportion of male DP awarded due to with mental disorders has increased from 31% in 1995 to 43% in 2008, while there has been a decrease from 27% to 22% in the proportion of receivers of DP due to musculoskeletal diseases (Finnish Centre for Pensions 2015).

The proportion of DP applications rejected by the national pension scheme authorities increased in the latter part of the 1970s and in the first part of the 1990s and the proportion of fail decisions approximately doubled during 1986-1995 (Huunan-Seppälä et al. 2002). The rejected proportion for MSD-related applications was approximately double that of other diagnostic groups during 1986-2000 (Huunan-Seppälä et al. 2002). The increase in rejected DP applications continued after the turn of the century, being 25.7% in the national pension scheme and 21.7% in the statutory

earnings-related pension scheme in 2008 (Blomgren and Virta 2011). As the pension system has changed from a disease-centred point of view to focusing on what functional capacity remains for the worker, the criteria for granting DPs have likely also changed.

Not entering service, interrupting service and frequently visiting military healthcare were all associated with DR. These findings suggest that it is possible to identify those young men who carry increased risk of being granted DR due to mental disorders within the next few years after their military service. Our findings coincide with the time when the relative importance of mental disorders as a cause for DR increased in Finland (Salminen et al. 1997). However, Finnish males of conscription age utilize the mental health services rather rarely (Kaskeala et al. 2015). Men exempted from military service comprise a group with a wide range of psychosocial problems, and recently a psychosocial support programme targeted at young men exempted from compulsory military or civil service has been developed in Finland (Appelqvist-Schmidlechner et al. 2010a). This psychosocial support programme aims at prevention of psychosocial problems and encourages the promotion of general well-being among these young men. Although the effects are limited to decreased psychological distress (Appelqvist-Schmidlechner et al. 2010a), the Time Out! programme has been widely adopted during recent years. The age-based health examinations conducted in primary schools also attempt to identify children with physical or psychosocial problems.

Earlier studies have shown that common mental disorders among the middle-aged or older workers predict both all-cause DR and DR due to mental disorders (Knudsen et al. 2010, Lahelma et al. 2015, Mykletun et al. 2006). Our study examined early adulthood determinants of DR, an area which has rarely been studied. Nevertheless, consistent with our results, a study utilizing the Swedish conscript register found that young men with a psychiatric diagnosis at conscription had an elevated risk of DP, particularly due to mental disorders, during two decades of follow-up (Upmark et al. 1999).

An association of visits due any problem with DR due musculoskeletal diseases was seen only in the oldest cohort; this is probably attributable to the relatively late manifestation of disabling musculoskeletal problems.

The co-occurrence of mental and musculoskeletal problems is common in working populations and has been reported to be associated with a conspicuously increased risk of work disability among adult working populations (Buist-Bouwman et al. 2005, Kaila-Kangas et al. 2014). The association of both musculoskeletal and mental problems with all-cause DR in our study displayed a synergistic interaction. Similarly, in a recent nationwide Swedish register study, back pain and common mental disorders exerted a synergistic effect on the risk of DP during a follow- up of 5 years (Dorner et al. 2016). The findings stress the importance of identifying adolescents and young adults with both musculoskeletal and mental symptoms, in order to be able to provide timely support and rehabilitation.

6.2.5 TEMPORAL TRENDS AND PATTERNS OF HEALTHCARE CARE UTILISATION DURING MILITARY SERVICE

Our finding showing that most conscripts sought medical advice due to musculoskeletal problems during 1967-2006 is in line with the results from another Finnish conscript study (Taanila et al. 2010). Military service increases the loading of lower limbs due to the increased physical training and carrying of loads (Knapik et al. 2004). The high proportion (2/3) of problems in the lower extremities is in agreement with the findings of previous studies in conscript armies (Heir and Glomsaker 1996, Mattila et al. 2007, Rosendal et al. 2003, Taanila et al. 2009). The standards of clothing, footwear and other military equipment have gradually evolved, for example special jogging shoes were introduced into physical training during the 1980s and 1990s. Nonetheless, lower limb problems have remained very common. In addition to imposing strain on the lower limbs, the increased physical training and carrying heavy loads are burdens on the spine. LBP was another common musculoskeletal complaint in our study and the cumulative incidence (17%) during military service is consistent with previously published findings in both conscript and professional armies (Heir and Glomsaker 1996, Milgrom et al. 1993, Milgrom et al. 2005, O'Connor and Marlowe 1993, Taanila et al. 2012).

One novel finding is the temporal increase in care seeking due to either any reason or to musculoskeletal problems among conscripts. We are not aware of studies on contemporary conscript populations. There has been no similar increase in healthcare visits to school health services or public healthcare in Finland (Kivimäki et al. 2007, Sotkanet 2015). The increased rate of seeking care during military service cannot be directly compared to that of a civilian population. Due to the nature of the service, a medical certificate is needed to allow the conscript to be temporarily exempted from duty, which is one reason why medical services are readily available. No major change in the availability of health care services in the Finnish Defence Forces has taken place during the four decades of the study that could account for the increase in healthcare utilization. While it is true that musculoskeletal pain is becoming more common among young people (Hakala et al. 2002) and this may partly explain the increase, nonetheless the findings in the pre-military health examinations did not reveal any consistent temporal trend in musculoskeletal symptoms or findings prior to military service.

The increasing body weight and reduced aerobic and muscle physical fitness among Finnish conscripts during the last decades have been well documented (Santtila et al. 2006). Nonetheless, the proportion of Finnish men reporting that they exercise at least 2-3 times weekly has increased (Helakorpi et al. 2008). For most young men, entering military service leads to a remarkable increase in physical activity, especially in activities requiring aerobic fitness. Since the main goals for the physical training and the actual physical requirements of military service have remained the same, an imbalance might have occurred towards the end of our follow-up time i.e. a mismatch between the reduced physical capacity of the conscripts and the unchanged requirements of military service. Increased physical activity leads to increased load on the lower extremities, which in turn increases the risk of injuries (Jones and Knapik 1999). However, the association between physical activity and LBP is far from clear (Heneweer et al. 2011). A U-shaped relationship between physical activity and non-specific LBP has

been suggested to exist in children and adolescents (Jones and Macfarlane 2005) and a similar association has been reported for radiating LBP among young adults (Shiri et al. 2013b). Moreover, overweight and obesity have been associated with seeking care due to low-back pain both in cross-sectional and prospective studies (Shiri et al. 2010a). Nonetheless, assessing the reasons for this increasing trend was beyond the aims of the study.

In general, the increasing numbers of discharges from military service for medical reasons and the increasing frequency of visits to the garrison health care services over time may reflect inadequate physical capacity to meet the requirements of the Defence Forces. Interventions to address the problems of insufficient physical fitness to allow conscripts to cope with the military training have been initiated since the turn of the millennium. Conscripts have been divided into ability groups based on prior physical activity and Nordic walking sessions have been introduced instead of running. Recently, even social media has been used to provide future conscripts with a safe and effective fitness programme during the 3 months preceding military service (http://www.marsmars.fi). The increasing trend of consultations seems to have subsided during the last years of our study, which might reflect the beneficial impact of some of these preventive measures. The conscript service is also mentally demanding (new circumstances, spells of sleep deprivation, new responsibilities, being subordinate) and it forces the conscripts to adapt to a new social environment (e.g. constantly being a member of a group, dormitory accommodation). Furthermore, it may not always be possible to take into consideration personal wishes regarding service location and length (The Finnish Defence Forces 2016). Visits due to mental problems were not nearly as frequent as those due to MSDs, but have increased markedly during our study period. The increase in health care utilization may be an indication of maladaptation to changes in daily routines. The proportion of Finnish men aged 15-24 feeling stressed doubled during 1978-2007 (Helakorpi et al. 2008). Indeed, poor coping has been associated with LBP in a cross-sectional study of Swedish conscripts (Leboeuf-Yde et al. 2006). Moreover, poor ability to cope with stress predicted both leg pain and LBP among Danish conscripts after 3 months of service (Larsen and Leboeuf-Yde 2006). It has also been postulated that young people have become more helpless when facing minor health problems, leading to increased care seeking (Haukilahti et al. 2008).

Seeking care may also serve as a temporary escape from less motivating activities which are traditionally part of military service. Some conscripts may exaggerate their health problems, believing it may help exclude them from duty temporarily or even permanently. On the other hand, very motivated men, e.g. those applying for reserve officer training, may try to minimize their problems and manage without any visits to healthcare. It is possible that individuals' attitude towards care seeking might have changed. It has been argued that the societal acceptance of illness has increased e.g. LBP is no longer stigmatized as a reason for temporary or permanent reason causing work disability (Croft 2000, Palmer et al. 2000). Altered attitudes and behaviour might therefore be one cause behind the increased frequency of care seeking.

Even though the proportion of young men being exempted from military service has remained reasonably stable, the proportion of those discontinuing their service due to health reasons has increased substantially (Appelqvist-Schmidlechner et al.

2010b, Parkkola 1999, Sahi and Korpela 2002). The most common reason for discontinuing service has been mental disorders, but the proportion of men interrupting due to MSDs increased markedly towards the end of 20th century (Sahi and Korpela 2002). The interruption rate increased during the follow-up period, thus it is reasonable to conclude that the men who complete their service are healthier than before.

6.3 METHODOLOGICAL CONSIDERATIONS

The primary strengths of the present studies are that they have a longitudinal design, used weight-related data from several time points during the life course, accessing information on health behaviour, symptoms and disease at baseline, during military service and at follow-up. In all studies in this thesis, the same random study population base of men aged 18-50 years was used and the records of military service in a forty year period from 1967 to 2006 were examined. The sample drawn for the Health 2000 Study represents the Finnish adult population well because of the random two-stage clustering sampling and high participation rate. The Health 2000 Study provided comprehensive data on covariates and the predictors as well as both self-reported and physician-diagnosed outcomes. In addition, we had the opportunity to link the military service data from 1967 to 1996 with register data on DR from 1968 to 2008.

We were able to examine the associations of lifestyle and health-related factors during military service with the outcomes covering a wide time span, providing a unique opportunity to examine time trends. Owing to the high representativeness of our sample and the high participation rate in the Health 2000 Study, the findings in studies II and III are generalizable to all men in Finland. Furthermore, the results of study IV on the associations of early health problems with DR could be generalized to countries with universal conscription and a comparable social security system.

Military medical records could be obtained from the archives of the Finnish Defence Forces for almost all men in the sample. Therefore, we had detailed information on pre-service health and lifestyle as well as health care utilization during military service for nearly the entire sample. Due to the obligatory nature of the military service, the medical records reliably record all visits to healthcare during service. While the records capture especially well those conscripts with severe or disabling musculoskeletal or mental problems, also relatively benign health problems may demand a visit to the healthcare unit, as possibilities for self-care and self-administered rest are limited.

In studies II and III, both general and central obesity were based on measured anthropometrical data. In addition, we had information on height at age of 20 and weight for each age decennium. For weight at 20 years and for those who were (20), 30, 40 or 50 at follow-up, we could compare validated self-reported and measured weight. Due to the fact that we had repeated data on weight, we could study the associations of early overweight/obesity, change in BMI and life course exposure to overweight with low back and knee outcomes. However, BMI is not an ideal measure of obesity, especially in men (Rothman 2008). At follow-up, we were able to use measures of both general and abdominal obesity.

Our low back outcomes comprised both self-reported symptoms and physician-diagnosed entities, while the knee outcomes included both knee pain and self-assessed

functional limitations due to knee problems. Since we had access to data on knee injuries occurring during military service, this provided us with an opportunity to explore the interactive effects of obesity and knee injuries in early adulthood on the development of knee pain and functional limitations later in life.

Having both comprehensive military service health and DR register data made it possible to examine the association of objectively measured early health indicators and DR during 4 decades and compare different lengths of follow-up. The skewed distribution of the number of healthcare visits during military service detected in study I and the diverse lengths of service time as well as the increasing frequency of visits with time were taken into account in the analysis.

There are, however, some limitations to consider when interpreting the findings of this thesis. Since our study population was sampled in 2000 and only those alive and living in Finland at the time of sampling formed the study base, health-based selection may have attenuated some of the observed findings for the oldest persons in our population. Furthermore, for unknown reasons, many medical records for men born in 1949 were not found, therefore men having served in the late 1960s were underrepresented in the studies. This may have introduced a selection bias, likely diluting the observed associations. The limitations may have influenced the statistical power to detect cause-specific associations for musculoskeletal diseases in the analyses of DR. Nonetheless, there was no selection bias regarding the outcomes of the studies.

Although we could adjust for the length of military service, we could not take into account whether the type of training during military service confounded the care seeking trends or the observed associations with knee outcomes and DR. Even though there were no major changes in the content of the military training during our study, the actual training has evolved. There may be modifications in training which influence care seeking. Moreover, the basic training period is the same for all conscripts, but thereafter the training changes moderately between the different branches of service. There might also be changes in clinical practice in the military health care system, of which we were not aware. Nonetheless, the right to seek care did remain the same throughout the study (Sahi 2009). The information at the pre-military health examinations and medical consultations were not originally written for scientific use and may therefore not be fully consistent.

We were not able to study the associations of abdominal adiposity across the life course, as WC was measured only at follow-up. Although information of earlier weight was self-reported at follow-up, the validity of this information proved to be high.

Owing to the small proportion of overweight or obese men at baseline, we were not able to study whether those individuals losing weight during the follow up would have a decreased risk of low back or knee symptoms at follow-up. Due to the study design, we were not also able to explore the timing of the onset of low back or knee pain.

Our population was below 50 at follow-up, when many clinical outcomes are rare. Therefore no statistically significant associations were seen between weight-related measures and the clinically defined outcomes. Similarly, most men were too young at follow-up to enable us to detect an association between medical consultations and DR due to musculoskeletal diseases. Knee problems and injuries were identified prior to and during military service, but we have no information on possible knee injuries occurring during the follow-up period. Moreover, functional limitations of the knee were

self-assessed and data were acquired with a single question. Furthermore, information on the intensity and/or chronicity of knee pain was lacking. Since knee pain is a major component of knee OA, it would have been interesting to study the relationship of weight-related measures across the life course with knee OA. However, due to the age of our population, physician-diagnosed knee OA was a rare condition (n=6) and thus we were not able to use it as an outcome.

Our classification of physical activity prior to military service was rather crude and based on self-reported data, therefore the possibility of misclassification cannot be excluded.

In general, it is unlikely that our study was affected by low statistical power, because the associations of medical consultations during military service with all-cause DR were all statistically significant. In addition, the analytical methods chosen are appropriate for examining an infrequent event. Neither educational level nor the socio-economic status of the parents were included in the DR analyses, since risk factors for health problems during childhood were outside the scope of the study. However, it is possible that residual confounding is present, as we had only limited data on potential confounders.

As the study concerned time periods, when women did not perform military service, all of the subjects were male. Therefore we could not explore gender differences. Furthermore, it was not our intention to study reasons for any changes in the trends to explain why conscripts seek out healthcare during their military service.

7 SUMMARY AND CONCLUSIONS

1. The results show that over four decades there has been a notable increase in health care seeking due to any reason and due to musculoskeletal problems among conscripts in Finland. The majority of the care seeking was related to problems in the lower extremities. No specific reason for the steady increase in health care seeking could be detected. This may imply that the increase in healthcare utilization during military service may rather reflect general changes at the individual and societal level, than an actual decline in young men's musculoskeletal health.

2. The findings indicate that being overweight or obese in young adulthood as well as during the life course increases the risk of suffering radiating LBP and knee pain as well as limping or walking difficulties due to a knee problem later in life. Even being overweight in late adolescence is associated with a high likelihood of further weight gain and later knee problems. Overall, late adolescence seems to be a critical life period, when weight status has a potential to predict future health problems.

3. The results revealed that both types of obesity, general and abdominal, were similarly associated with radiating LBP and knee pain. Functional limitations of the knee were more strongly associated with general than abdominal obesity.

4. It was found that obesity doubled the risk of accidental knee injuries during military service that in turn led to functional limitations of the knee later in life. These findings provide support for the theory that the mechanical pathways play a role in the development of knee disability.

5. The results indicate that health problems, in particular mental problems, in early adulthood are important predictors of DR. Comorbidity of musculoskeletal and mental problems in late adolescence was found to be especially detrimental for future work ability.

8   RECOMMENDATIONS

Adolescence and young adulthood seem to be a critical period for the development of adult musculoskeletal health among men. Preventing overweight in teenagers and young adults, and avoiding further weight gain during the life course may help prevent the future development of radiating LBP as well as knee pain and associated disability. Traumatic and over-exertion injuries of the lower extremities as well as the early identification of mental problems should remain a focus for preventive actions in military service. This information can be used to implement effective preventive interventions regarding weight management and injury prevention. More studies with a life course approach will be needed to investigate whether other crucial time windows can be found. In order to detect other critical time periods for preventive action, further research should focus on collecting information regarding lifestyle factors and health during the entire life span. Risk indicators for both musculoskeletal and mental disability could be identified and preventive measures effectively targeted for complete age classes via the school healthcare system during adolescence and in occupational health services for young adults entering working life.

Future research should investigate the impact of weight and musculoskeletal health throughout the life course on overall health and work ability after the age of 50 years. Moreover, the role of early lifestyle and health-related factors for musculoskeletal and mental health and disability retirement among females needs to be addressed. Finally, future research should elucidate risk factors for knee osteoarthritis from a life course perspective e.g. information on knee injuries occurring during different life stages.

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REFERENCES

Adams, A. L., Kessler, J. I., Deramerian, K., Smith, N., Black, M. H., Porter, A. H., Jacobsen, S. J. and Koebnick, C. Associations between childhood obesity and upper and lower extremity injuries. *Inj Prev* 2013;*19:* 191-7.

Adams, M. A., Lama, P., Zehra, U. and Dolan, P. Why do some intervertebral discs degenerate, when others (in the same spine) do not? *Clin Anat* 2015;*28:* 195-204.

Adamson, J., Ebrahim, S., Dieppe, P. and Hunt, K. Prevalence and risk factors for joint pain among men and women in the West of Scotland Twenty-07 study. *Ann Rheum Dis* 2006;*65:* 520-4.

Ahola, K., Gould, R., Virtanen, M., Honkonen, T., Aromaa, A. and Lönnqvist, J. Occupational burnout as a predictor of disability pension: a population-based cohort study. *Occup Environ Med* 2009;*66:* 284-90; discussion 282-3.

Airaksinen, O., Brox, J. I., Cedraschi, C., Hildebrandt, J., Klaber-Moffett, J., Kovacs, F., Mannion, A. F., Reis, S., Staal, J. B., Ursin, H., Zanoli, G. and Pain, C. B. W. G. o. G. f. C. L. B. Chapter 4. European guidelines for the management of chronic nonspecific low back pain. *Eur Spine J* 2006;*15 Suppl 2:* S192-300.

Alha, P. and Rinne, S. Checking and recording data. in Heistaro, S., (ed.) *Methodology Report: Health 2000 Survey*. Publications of the National Public Health Institute. National Public Health Institute, Helsinki, 2008: 172-179. Available: http://www.julkari.fi/handle/10024/78185 [Accessed 12.8.2016].

Andersen, R. E., Crespo, C. J., Bartlett, S. J., Bathon, J. M. and Fontaine, K. R. Relationship between body weight gain and significant knee, hip, and back pain in older Americans. *Obes Res* 2003;*11:* 1159-62.

Antony, B., Jones, G., Venn, A., Cicuttini, F., March, L., Blizzard, L., Dwyer, T., Cross, M. and Ding, C. Association between childhood overweight measures and adulthood knee pain, stiffness and dysfunction: a 25-year cohort study. *Ann Rheum Dis* 2015;*74:* 711-7.

Appelqvist-Schmidlechner, K., Upanne, M., Henriksson, M., Parkkola, K. and Stengård, E. Effects of a Psycho-Social Support Programme for Young Men – Randomised Trial of the Time Out! Getting Life Back on Track Programme. *Int J Ment Health Promot* 2010a;*12:* 14-24.

Appelqvist-Schmidlechner, K., Upanne, M., Henriksson, M., Parkkola, K. and Stengård, E. Young men exempted from compulsory military or civil service in Finland--a group of men in need of psychosocial support? *Scand J Public Health* 2010b;*38:* 168-76.

Arokoski, P. A., Manninen, P., Kröger, H., Heliövaara, M., Nykyri, E., O., I. and Hip and knee pain and osteoarthritis. in Kaila-Kangas, L., (ed.) *Musculoskeletal disorders and diseases in Finland, Results of the Health 2000 Survey*. Publications of the National Public Health Institute. National Public Health Institute, Helsinki, 2007: 8-13. Available: http://www.terveys2000.fi/julkaisut/2007b25.pdf [Accessed 11.12.2015].

Aromaa, A. Basic questionnaire (questionnaire 1). in Heistaro, S., (ed.) *Methodology Report: Health 2000 Survey*. Publications of the National Public Health Institute. National Public Health Institute, 2008: 50-53. Available: http://www.julkari.fi/handle/10024/78185 [Accessed 2.3.2016].

Aromaa, A. and Koskinen, S., eds. *Health and Functional Capacity in Finland - Baseline Results of the Health 2000 Health Examination Survey.* Publications of the National Public Health Institute. National Public Health Institute, Helsinki, 2004. Available: http://urn.fi/URN:NBN:fi-fe201204193452 [Accessed 2.3.2016].

Ashwell, M. and Hsieh, S. D. Six reasons why the waist-to-height ratio is a rapid and effective global indicator for health risks of obesity and how its use could simplify the international public health message on obesity. *Int J Food Sci Nutr* 2005;*56:* 303-7.

Auvinen, J., Tammelin, T., Taimela, S., Zitting, P. and Karppinen, J. Associations of physical activity and inactivity with low back pain in adolescents. *Scand J Med Sci Sports* 2008;*18:* 188-94.

Bakker, E. W., Verhagen, A. P., van Trijffel, E., Lucas, C. and Koes, B. W. Spinal mechanical load as a risk factor for low back pain: a systematic review of prospective cohort studies. *Spine (Phila Pa 1976)* 2009;*34:* E281-93.

Barros, A. J. and Hirakata, V. N. Alternatives for logistic regression in cross-sectional studies: an empirical comparison of models that directly estimate the prevalence ratio. *BMC Med Res Methodol* 2003;*3:* 21.

Battie, M. C., Videman, T., Levalahti, E., Gill, K. and Kaprio, J. Heritability of low back pain and the role of disc degeneration. *Pain* 2007;*131:* 272-80.

Bedson, J. and Croft, P. R. The discordance between clinical and radiographic knee osteoarthritis: a systematic search and summary of the literature. *BMC Musculoskelet Disord* 2008;*9:* 116.

Beesdo, K., Jacobi, F., Hoyer, J., Low, N. C., Hofler, M. and Wittchen, H. U. Pain associated with specific anxiety and depressive disorders in a nationally representative population sample. *Soc Psychiatry Psychiatr Epidemiol* 2010;*45:* 89-104.

Ben-Shlomo, Y. and Kuh, D. A life course approach to chronic disease epidemiology: conceptual models, empirical challenges and interdisciplinary perspectives. *Int J Epidemiol* 2002;*31:* 285-93.

Berenbaum, F., Eymard, F. and Houard, X. Osteoarthritis, inflammation and obesity. *Curr Opin Rheumatol* 2013;*25:* 114-8.

Blomgren, J. and Virta, L. *Kansaneläkejärjestelmän työkyvyttömyyseläkkeiden hylkäykset vuosina 2005–2011 (Rejections of disability pensions in the statutory pension system during 2005–2011). [in Finnish]*. KELA, tutkimusosasto, Helsinki. 2011. Available: http://hdl.handle.net/10138/37004 [Accessed 16.08.2016].

Bremberg, S. and Mikaelsson, B. Predictability of school absence for rate of sick leave. *Scand J Soc Med* 1985;*13:* 181-4.

Bruusgaard, D., Smeby, L. and Claussen, B. Education and disability pension: a stronger association than previously found. *Scand J Public Health* 2010;*38:* 686-90.

Buchbinder, R., Blyth, F. M., March, L. M., Brooks, P., Woolf, A. D. and Hoy, D. G. Placing the global burden of low back pain in context. *Best Pract Res Clin Rheumatol* 2013;*27:* 575-89.

Buist-Bouwman, M. A., de Graaf, R., Vollebergh, W. A. and Ormel, J. Comorbidity of physical and mental disorders and the effect on work-loss days. *Acta Psychiatr Scand* 2005;*111:* 436-43.

Calvo-Munoz, I., Gomez-Conesa, A. and Sanchez-Meca, J. Prevalence of low back pain in children and adolescents: a meta-analysis. *BMC Pediatr* 2013;*13:* 14.

Chasse, M., Fergusson, D. A. and Chen, Y. Body mass index and the risk of injury in adults: a cross-sectional study. *Int J Obes (Lond)* 2014;*38:* 1403-9.

Claessen, H., Arndt, V., Drath, C. and Brenner, H. Smoking habits and occupational disability: a cohort study of 14,483 construction workers. *Occup Environ Med* 2010;*67:* 84-90.

Cole, T. J., Bellizzi, M. C., Flegal, K. M. and Dietz, W. H. Establishing a standard definition for child overweight and obesity worldwide: international survey. *BMJ* 2000;*320:* 1240-3.

Collishaw, S. Annual research review: Secular trends in child and adolescent mental health. *J Child Psychol Psychiatry* 2015;*56:* 370-93.

Cook, C. E., Taylor, J., Wright, A., Milosavljevic, S., Goode, A. and Whitford, M. Risk factors for first time incidence sciatica: a systematic review. *Physiother Res Int* 2014;*19:* 65-78.

Croft, P. Is life becoming more of a pain? *BMJ* 2000;*320:* 1552-3.

Croft, P. R. and Rigby, A. S. Socioeconomic influences on back problems in the community in Britain. *J Epidemiol Community Health* 1994;*48:* 166-70.

Cross, M., Smith, E., Hoy, D., Nolte, S., Ackerman, I., Fransen, M., Bridgett, L., Williams, S., Guillemin, F., Hill, C. L., Laslett, L. L., Jones, G., Cicuttini, F., Osborne, R., Vos, T., Buchbinder, R., Woolf, A. and March, L. The global burden of hip and knee osteoarthritis: estimates from the global burden of disease 2010 study. *Ann Rheum Dis* 2014;*73:* 1323-30.

Dario, A. B., Ferreira, M. L., Refshauge, K. M., Lima, T. S., Ordonana, J. R. and Ferreira, P. H. The relationship between obesity, low back pain, and lumbar disc degeneration when genetics and the environment are considered: a systematic review of twin studies. *Spine J* 2015;*15:* 1106-17.

Deere, K. C., Clinch, J., Holliday, K., McBeth, J., Crawley, E. M., Sayers, A., Palmer, S., Doerner, R., Clark, E. M. and Tobias, J. H. Obesity is a risk factor for musculoskeletal pain in adolescents: findings from a population-based cohort. *Pain* 2012;*153:* 1932-8.

Demyttenaere, K., Bonnewyn, A., Bruffaerts, R., Brugha, T., De Graaf, R. and Alonso, J. Comorbid painful physical symptoms and depression: prevalence, work loss, and help seeking. *J Affect Disord* 2006;*92:* 185-93.

Demyttenaere, K., Bonnewyn, A., Bruffaerts, R., De Graaf, R., Haro, J. M. and Alonso, J. Comorbid painful physical symptoms and anxiety: prevalence, work loss and help-seeking. *J Affect Disord* 2008;*109:* 264-72.

Dersh, J., Gatchel, R. J., Polatin, P. and Mayer, T. Prevalence of psychiatric disorders in patients with chronic work-related musculoskeletal pain disability. *J Occup Environ Med* 2002;*44:* 459-68.

Dionne, C. E., Dunn, K. M. and Croft, P. R. Does back pain prevalence really decrease with increasing age? A systematic review. *Age Ageing* 2006;*35:* 229-34.

Dorner, T. E., Alexanderson, K., Svedberg, P., Ropponen, A., Stein, K. V. and Mittendorfer-Rutz, E. Sickness absence due to back pain or depressive episode and the risk of all-cause and diagnosis-specific disability pension: A Swedish cohort study of 4,823,069 individuals. *Eur J Pain* 2015;*19:* 1308-20.

Dorner, T. E., Alexanderson, K., Svedberg, P., Tinghog, P., Ropponen, A. and Mittendorfer-Rutz, E. Synergistic effect between back pain and common mental disorders and the risk of future disability pension: a nationwide study from Sweden. *Psychol Med* 2016;*46:* 425-36.

Driscoll, T., Jacklyn, G., Orchard, J., Passmore, E., Vos, T., Freedman, G., Lim, S. and Punnett, L. The global burden of occupationally related low back pain: estimates from the Global Burden of Disease 2010 study. *Ann Rheum Dis* 2014;*73:* 975-81.

Dunn, K. M. Extending conceptual frameworks: life course epidemiology for the study of back pain. *BMC Musculoskelet Disord* 2010;*11:* 23.

Dunn, K. M., Hestbaek, L. and Cassidy, J. D. Low back pain across the life course. *Best Pract Res Clin Rheumatol* 2013;*27:* 591-600.

Ells, L. J., Lang, R., Shield, J. P., Wilkinson, J. R., Lidstone, J. S., Coulton, S. and Summerbell, C. D. Obesity and disability - a short review. *Obes Rev* 2006;*7:* 341-5.

European Commission. *Health in the European Union*. Special Eurobarometer, 2007. Available: http://ec.europa.eu/public_opinion/archives/ebs/ebs_272e_en.pdf [Accessed 16.8.2016].

Fejer, R. and Leboeuf-Yde, C. Does back and neck pain become more common as you get older? A systematic literature review. *Chiropr Man Therap* 2012;*20:* 24.

Ferreira, P. H., Pinheiro, M. B., Machado, G. C. and Ferreira, M. L. Is alcohol intake associated with low back pain? A systematic review of observational studies. *Man Ther* 2013;*18:* 183-90.

Finnish Centre for Pensions. *The statistical database of The Finnish Centre for Pensions*. Finnish Centre for Pensions. 2015. Available: [Accessed 17.1.2015].

Finnish Centre for Pensions and Social Insurance Institution. *Statistical Yearbook of Pensioners in Finland 2008*. Finnish Centre for Pensions, Helsinki. 2010. Available: http://www.etk.fi/wp-content/uploads/Statistical_yearbook_of_pensioners_in_Finland_2008.pdf [Accessed 4.8.2016].

Finnish Centre for Pensions and Social Insurance Institution. *Statistical Yearbook of Pensioners in Finland 2013.* Finnish Centre for Pensions, Helsinki. 2014. Available: http://www.etk.fi/wp-content/uploads/2015/10/Statistical%20yearbook%20of%20pensioners%20in%20Finland%202013.pdf [Accessed 4.8.2016].

Finnish Centre for Pensions and Social Insurance Institution. *Statistical Yearbook of Pensioners in Finland 2014.* Finnish Centre for Pensions, Helsinki. 2015. Available: http://www.etk.fi/wp-content/uploads/Statistical_yearbook_of_pensioners_in_Finland_2014.pdf [Accessed 4.8.2016].

Fransen, M., Agaliotis, M., Bridgett, L. and Mackey, M. G. Hip and knee pain: role of occupational factors. *Best Pract Res Clin Rheumatol* 2011;*25:* 81-101.

Fransen, M., Su, S., Harmer, A., Blyth, F. M., Naganathan, V., Sambrook, P., Le Couteur, D. and Cumming, R. G. A longitudinal study of knee pain in older men: Concord Health and Ageing in Men Project. *Age Ageing* 2014;*43:* 206-12.

Freedman, D. S., Khan, L. K., Serdula, M. K., Dietz, W. H., Srinivasan, S. R. and Berenson, G. S. The relation of childhood BMI to adult adiposity: the Bogalusa Heart Study. *Pediatrics* 2005;*115:* 22-7.

Friis, K., Ekholm, O., Hundrup, Y. A., Obel, E. B. and Gronbaek, M. Influence of health, lifestyle, working conditions, and sociodemography on early retirement among nurses: the Danish Nurse Cohort Study. *Scand J Public Health* 2007;*35:* 23-30.

Gould, R. Disability pensions in Finland. In Prinz, C., (ed.) *European Disability Pension Policies*, Ashgate, Vienna. 165-196. 2003.

Goulston, L. M., Kiran, A., Javaid, M. K., Soni, A., White, K. M., Hart, D. J., Spector, T. D. and Arden, N. K. Does obesity predict knee pain over fourteen years in women, independently of radiographic changes? *Arthritis Care Res (Hoboken)* 2011;*63:* 1398-406.

Gravseth, H. M., Bjerkedal, T., Irgens, L. M., Aalen, O. O., Selmer, R. and Kristensen, P. Influence of physical, mental and intellectual development on disability in young Norwegian men. *Eur J Public Health* 2008;*18:* 650-5.

Hagen, E. M., Svensen, E., Eriksen, H. R., Ihlebaek, C. M. and Ursin, H. Comorbid subjective health complaints in low back pain. *Spine (Phila Pa 1976)* 2006;*31:* 1491-5.

Hagen, K. B., Tambs, K. and Bjerkedal, T. A prospective cohort study of risk factors for disability retirement because of back pain in the general working population. *Spine (Phila Pa 1976)* 2002;*27:* 1790-6.

Hakala, P., Rimpelä, A., Salminen, J. J., Virtanen, S. M. and Rimpelä, M. Back, neck, and shoulder pain in Finnish adolescents: national cross sectional surveys. *BMJ* 2002;*325:* 743.

Hamberg-van Reenen, H. H., Ariens, G. A., Blatter, B. M., van Mechelen, W. and Bongers, P. M. A systematic review of the relation between physical capacity and future low back and neck/shoulder pain. *Pain* 2007;*130:* 93-107.

Han, C. D., Yang, I. H., Lee, W. S., Park, Y. J. and Park, K. K. Correlation between metabolic syndrome and knee osteoarthritis: data from the Korean National Health and Nutrition Examination Survey (KNHANES). *BMC Public Health* 2013;*13:* 603.

Han, T. S., Schouten, J. S., Lean, M. E. and Seidell, J. C. The prevalence of low back pain and associations with body fatness, fat distribution and height. *Int J Obes Relat Metab Disord* 1997;*21:* 600-7.

Harkonmäki, K., Korkeila, K., Vahtera, J., Kivimäki, M., Suominen, S., Sillanmäki, L. and Koskenvuo, M. Childhood adversities as a predictor of disability retirement. *J Epidemiol Community Health* 2007;*61:* 479-84.

Haukilahti, R.-L., I, V., H, H., H, H., M, I., S, K. and al, e. The patient's role has changed – from the doctors' point of view. *Journal of Social Medicine* 2008;*45:* 187–196.

Haukka, E., Kaila-Kangas, L., Ojajärvi, A., Saastamoinen, P., Holtermann, A., Jorgensen, M. B., Karppinen, J., Heliövaara, M. and Leino-Arjas, P. Multisite musculoskeletal pain predicts medically certified disability retirement among Finns. *Eur J Pain* 2015;*19:* 1119-28.

Hayden, J. A., van Tulder, M. W., Malmivaara, A. V. and Koes, B. W. Meta-analysis: exercise therapy for nonspecific low back pain. *Ann Intern Med* 2005;*142:* 765-75.

Heim, N., Snijder, M. B., Heymans, M. W., Deeg, D. J., Seidell, J. C. and Visser, M. Optimal cutoff values for high-risk waist circumference in older adults based on related health outcomes. *Am J Epidemiol* 2011;*174:* 479-89.

Heir, T. and Eide, G. Age, body composition, aerobic fitness and health condition as risk factors for musculoskeletal injuries in conscripts. *Scand J Med Sci Sports* 1996;*6:* 222-7.

Heir, T. and Eide, G. Injury proneness in infantry conscripts undergoing a physical training programme: smokeless tobacco use, higher age, and low levels of physical fitness are risk factors. *Scand J Med Sci Sports* 1997;*7:* 304-11.

Heir, T. and Glomsaker, P. Epidemiology of musculoskeletal injuries among Norwegian conscripts undergoing basic military training. *Scand J Med Sci Sports* 1996;*6:* 186-91.

Heistaro, S., Arokoski, J., Kröger, H., Leino-Arjas, P., Riihimäki, H., Nykyri, E. and Heliövaara, M. Back pain and chronic low back pain syndrome. in Kaila-Kangas, L., (ed.) *Musculoskeletal disorders and diseases in Finland.* Publications of the National Public Health Institute. National Public Health Institute, Helsinki, 2007: 14-18. Available: http://urn.fi/URN:NBN:fi-fe201204193328 [Accessed 3.4.2016].

Heistaro, S., ed. *Methodology Report: Health 2000 Survey.* Publications of the National Public Health Institute. National Public Health Institute, Helsinki, 2008. Available: http://urn.fi/URN:NBN:fi-fe201204193320 [Accessed 2.3.2016].

Helakorpi, S., Prättälä, R. and Uutela, A. *Health Behaviour and Health among the Finnish Adult Population, Spring 2007.* National Public Health Institute, Helsinki, 2008. Available: http://www.julkari.fi/bitstream/handle/10024/78308/2008b06.pdf?sequence=1 [Accessed 12.5.2016].

Heliövaara, M. Health Examination. Measurement point 2. in Heistaro, S., (ed.)
    Methodology Report: Health 2000 Survey. Publications of the National Public
    Health Institute. National Public Health Institute, 2008: 66-71. Available:
    http://www.julkari.fi/handle/10024/78185 [Accessed 2.3.2016].

Heliövaara, M., Impivaara, O., Sievers, K., Melkas, T., Knekt, P., Korpi, J. and Aromaa, A.
    Lumbar disc syndrome in Finland. *J Epidemiol Community Health* 1987;*41:* 251-8.

Heliövaara, M., Mäkela, M., Knekt, P., Impivaara, O. and Aromaa, A. Determinants of
    sciatica and low-back pain. *Spine (Phila Pa 1976)* 1991;*16:* 608-14.

Hellsing, A. L. and Bryngelsson, I. L. Predictors of musculoskeletal pain in men: A twenty-
    year follow-up from examination at enlistment. *Spine (Phila Pa 1976)* 2000;*25:*
    3080-6.

Henchoz, Y. and Kai-Lik So, A. Exercise and nonspecific low back pain: a literature review.
    Joint Bone Spine 2008;*75:* 533-9.

Heneweer, H., Picavet, H. S., Staes, F., Kiers, H. and Vanhees, L. Physical fitness, rather than
    self-reported physical activities, is more strongly associated with low back pain:
    evidence from a working population. *Eur Spine J* 2012;*21:* 1265-72.

Heneweer, H., Staes, F., Aufdemkampe, G., van Rijn, M. and Vanhees, L. Physical activity
    and low back pain: a systematic review of recent literature. *Eur Spine J* 2011;*20:* 826-
    45.

Heneweer, H., Vanhees, L. and Picavet, H. S. Physical activity and low back pain: a U-shaped
    relation? *Pain* 2009;*143:* 21-5.

Hershkovich, O., Friedlander, A., Gordon, B., Arzi, H., Derazne, E., Tzur, D., Shamis, A. and
    Afek, A. Associations of body mass index and body height with low back pain in
    829,791 adolescents. *Am J Epidemiol* 2013;*178:* 603-9.

Hestbaek, L., Iachine, I. A., Leboeuf-Yde, C., Kyvik, K. O. and Manniche, C. Heredity of low
    back pain in a young population: a classical twin study. *Twin Res* 2004;*7:* 16-26.

Hestbaek, L., Leboeuf-Yde, C., Kyvik, K. O. and Manniche, C. The course of low back pain
    from adolescence to adulthood: eight-year follow-up of 9600 twins. *Spine (Phila Pa
    1976)* 2006;*31:* 468-72.

Hestbaek, L., Leboeuf-Yde, C. and Manniche, C. Low back pain: what is the long-term
    course? A review of studies of general patient populations. *Eur Spine J* 2003;*12:* 149-
    65.

Heuch, I., Heuch, I., Hagen, K. and Zwart, J. A. Body mass index as a risk factor for
    developing chronic low back pain: a follow-up in the Nord-Trondelag Health Study.
    Spine (Phila Pa 1976) 2013;*38:* 133-9.

Heuch, I., Heuch, I., Hagen, K. and Zwart, J. A. A Comparison of Anthropometric Measures
    for Assessing the Association between Body Size and Risk of Chronic Low Back Pain:
    The HUNT Study. *PLoS One* 2015;*10:* e0141268.

Hinkka, K., Kuoppala, J., Vaananen-Tomppo, I. and Lamminpaa, A. Psychosocial work
    factors and sick leave, occupational accident, and disability pension: a cohort study of
    civil servants. *J Occup Environ Med* 2013;*55:* 191-7.

Holliday, K. L., McWilliams, D. F., Maciewicz, R. A., Muir, K. R., Zhang, W. and Doherty, M. Lifetime body mass index, other anthropometric measures of obesity and risk of knee or hip osteoarthritis in the GOAL case-control study. *Osteoarthritis Cartilage* 2011;*19:* 37-43.

Hoogendoorn, W. E., van Poppel, M. N., Bongers, P. M., Koes, B. W. and Bouter, L. M. Physical load during work and leisure time as risk factors for back pain. *Scand J Work Environ Health* 1999;*25:* 387-403.

Hoy, D., Bain, C., Williams, G., March, L., Brooks, P., Blyth, F., Woolf, A., Vos, T. and Buchbinder, R. A systematic review of the global prevalence of low back pain. *Arthritis Rheum* 2012;*64:* 2028-37.

Hoy, D., Brooks, P., Blyth, F. and Buchbinder, R. The Epidemiology of low back pain. *Best Pract Res Clin Rheumatol* 2010a;*24:* 769-81.

Hoy, D., March, L., Brooks, P., Woolf, A., Blyth, F., Vos, T. and Buchbinder, R. Measuring the global burden of low back pain. *Best Pract Res Clin Rheumatol* 2010b;*24:* 155-65.

Hoy, D. G., Smith, E., Cross, M., Sanchez-Riera, L., Blyth, F. M., Buchbinder, R., Woolf, A. D., Driscoll, T., Brooks, P. and March, L. M. Reflecting on the global burden of musculoskeletal conditions: lessons learnt from the global burden of disease 2010 study and the next steps forward. *Ann Rheum Dis* 2015;*74:* 4-7.

Hu, F. Measurements of Adiposity and Body Composition. In Hu, F., (ed.) *Obesity Epidemiology*., Oxford University Press, New York City. 53–83. 2008.

Hu, H. Y., Chou, Y. J., Chou, P., Chen, L. K. and Huang, N. Association between obesity and injury among Taiwanese adults. *Int J Obes (Lond)* 2009;*33:* 878-84.

Husemoen, L. L., Osler, M., Godtfredsen, N. S. and Prescott, E. Smoking and subsequent risk of early retirement due to permanent disability. *Eur J Public Health* 2004;*14:* 86-92.

Huunan-Seppälä, A., Järvisalo, J., Laine, A., Pirttimäki, R., Rissanen, P., Seppälä, M.-L., Talo, S. and Virta, S. *Työkyvyttömyyseläkehakemusten hylkäämiseen liittyvien ongelmien ehkäisystä. (About the prevention of problems related to rejection of disability pension applications) [in Finnish]*. KELA (SII), Helsinki. 2002. Available: http://hdl.handle.net/10250/3396 [Accessed 16.8.2016].

Ingham, S. L., Zhang, W., Doherty, S. A., McWilliams, D. F., Muir, K. R. and Doherty, M. Incident knee pain in the Nottingham community: a 12-year retrospective cohort study. *Osteoarthritis Cartilage* 2011;*19:* 847-52.

Ingram, J. G., Fields, S. K., Yard, E. E. and Comstock, R. D. Epidemiology of knee injuries among boys and girls in US high school athletics. *Am J Sports Med* 2008;*36:* 1116-22.

Janke, E. A., Collins, A. and Kozak, A. T. Overview of the relationship between pain and obesity: What do we know? Where do we go next? *J Rehabil Res Dev* 2007;*44:* 245-62.

Janssen, I., Bacon, E. and Pickett, W. Obesity and its relationship with occupational injury in the canadian workforce. *J Obes* 2011;*2011:* 531403.

Jensen, L. D., Ryom, P. K., Christensen, M. V. and Andersen, J. H. Differences in risk factors for voluntary early retirement and disability pension: a 15-year follow-up in a cohort of nurses' aides. *BMJ Open* 2012;*2:*

Jespersen, E., Verhagen, E., Holst, R., Klakk, H., Heidemann, M., Rexen, C. T., Franz, C. and Wedderkopp, N. Total body fat percentage and body mass index and the association with lower extremity injuries in children: a 2.5-year longitudinal study. *Br J Sports Med* 2014;*48:* 1497-502.

Jhawar, B. S., Fuchs, C. S., Colditz, G. A. and Stampfer, M. J. Cardiovascular risk factors for physician-diagnosed lumbar disc herniation. *Spine J* 2006;*6:* 684-91.

Jinks, C., Jordan, K. and Croft, P. Disabling knee pain--another consequence of obesity: results from a prospective cohort study. *BMC Public Health* 2006;*6:* 258.

Jinks, C., Jordan, K. P., Blagojevic, M. and Croft, P. Predictors of onset and progression of knee pain in adults living in the community. A prospective study. *Rheumatology (Oxford)* 2008;*47:* 368-74.

Johansson, E., Leijon, O., Falkstedt, D., Farah, A. and Hemmingsson, T. Educational differences in disability pension among Swedish middle-aged men: role of factors in late adolescence and work characteristics in adulthood. *J Epidemiol Community Health* 2012;*66:* 901-7.

Jones, B. H., Bovee, M. W., Harris, J. M., 3rd and Cowan, D. N. Intrinsic risk factors for exercise-related injuries among male and female army trainees. *Am J Sports Med* 1993;*21:* 705-10.

Jones, B. H. and Knapik, J. J. Physical training and exercise-related injuries. Surveillance, research and injury prevention in military populations. *Sports Med* 1999;*27:* 111-25.

Jones, G. T. and Macfarlane, G. J. Epidemiology of low back pain in children and adolescents. *Arch Dis Child* 2005;*90:* 312-6.

Junge, T., Runge, L., Juul-Kristensen, B. and Wedderkopp, N. Risk Factors for Knee Injuries in Children 8 to 15 Years: The CHAMPS Study DK. *Med Sci Sports Exerc* 2016;*48:* 655-62.

Järvholm, B., Stattin, M., Robroek, S. J., Janlert, U., Karlsson, B. and Burdorf, A. Heavy work and disability pension - a long term follow-up of Swedish construction workers. *Scand J Work Environ Health* 2014;*40:* 335-42.

Järvisalo, J., Andersson, B., Boedeker, W. and Houtman, I., eds. *Mental disorders as a major challenge in prevention of work disability, Social Security and Health Reports,* KELA, The Social Security Institution, Finland, Helsinki. 2005a.

Järvisalo, J., Raitasalo, R., Salminen, J. K., Klaukka, T. and Kinnunen, E. Depression and other mental disorders, sickness absenteisim and work disability pensions in Finland. In Järvisalo, J., Andersson, B., Boedeker, W. and Houtman, I., (eds.) *Mental disorders as a major challenge in prevention of work disability*, KELA, The Social Security Institution, Finland, Helsinki. 27-59. 2005b.

Kaila-Kangas, L., Haukka, E., Miranda, H., Kivekas, T., Ahola, K., Luukkonen, R., Shiri, R., Kaaria, S., Heliovaara, M. and Leino-Arjas, P. Common mental and musculoskeletal

disorders as predictors of disability retirement among Finns. *J Affect Disord* 2014;*165:* 38-44.

Kaila-Kangas, L., Kivekäs, T., Laitinen, J., Koskinen, A., Härkänen, T., Hirvonen, L. and Leino-Arjas, P. Abstinence and current or former alcohol use as predictors of disability retirement in Finland. *Scand J Public Health* 2015;*43:* 373-80.

Kaila-Kangas, L., Kivimäki, M., Härma, M., Riihimäki, H., Luukkonen, R., Kirjonen, J. and Leino-Arjas, P. Sleep disturbances as predictors of hospitalization for back disorders-a 28-year follow-up of industrial employees. *Spine (Phila Pa 1976)* 2006;*31:* 51-6.

Kaila-Kangas, L., Leino-Arjas, P., Karppinen, J., Viikari-Juntura, E., Nykyri, E. and Heliövaara, M. History of physical work exposures and clinically diagnosed sciatica among working and nonworking Finns aged 30 to 64. *Spine (Phila Pa 1976)* 2009;*34:* 964-9.

Kaila-Kangas, L., Leino-Arjas, P., Riihimäki, H., Luukkonen, R. and Kirjonen, J. Smoking and overweight as predictors of hospitalization for back disorders. *Spine (Phila Pa 1976)* 2003;*28:* 1860-8.

Karjalainen, U., Paananen, M., Okuloff, A., Taimela, S., Auvinen, J., Männikkö, M. and Karppinen, J. Role of environmental factors and history of low back pain in sciatica symptoms among Finnish adolescents. *Spine (Phila Pa 1976)* 2013;*38:* 1105-11.

Kark, M., Neovius, M. and Rasmussen, F. Obesity status and risk of disability pension due to psychiatric disorders. *Int J Obes (Lond)* 2010;*34:* 726-32.

Karnehed, N., Rasmussen, F. and Kark, M. Obesity in young adulthood and later disability pension: a population-based cohort study of 366,929 Swedish men. *Scand J Public Health* 2007;*35:* 48-54.

Karpansalo, M., Lakka, T. A., Manninen, P., Kauhanen, J., Rauramaa, R. and Salonen, J. T. Cardiorespiratory fitness and risk of disability pension: a prospective population based study in Finnish men. *Occup Environ Med* 2003;*60:* 765-9.

Karpansalo, M., Manninen, P., Kauhanen, J., Lakka, T. A. and Salonen, J. T. Perceived health as a predictor of early retirement. *Scand J Work Environ Health* 2004;*30:* 287-92.

Karpansalo, M., Manninen, P., Lakka, T. A., Kauhanen, J., Rauramaa, R. and Salonen, J. T. Physical workload and risk of early retirement: prospective population-based study among middle-aged men. *J Occup Environ Med* 2002;*44:* 930-9.

Karvonen, M. J., Viitasalo, J. T., Komi, P. V., Nummi, J. and Järvinen, T. Back and leg complaints in relation to muscle strength in young men. *Scand J Rehabil Med* 1980;*12:* 53-9.

Kaskeala, L., Sillanmäki, L. and Sourander, A. Help-seeking behaviour among Finnish adolescent males. *Nord J Psychiatry* 2015;*69:* 605-12.

Kautiainen, S., Koivisto, A. M., Koivusilta, L., Lintonen, T., Virtanen, S. M. and Rimpelä, A. Sociodemographic factors and a secular trend of adolescent overweight in Finland. *Int J Pediatr Obes* 2009;*4:* 360-70.

Kautiainen, S., Rimpelä, A., Vikat, A. and Virtanen, S. M. Secular trends in overweight and obesity among Finnish adolescents in 1977-1999. *Int J Obes Relat Metab Disord* 2002;*26:* 544-52.

Kemler, E., Vriend, I., Paulis, W. D., Schoots, W., van Middelkoop, M. and Koes, B. Is overweight a risk factor for sports injuries in children, adolescents, and young adults? *Scand J Med Sci Sports* 2015;*25:* 259-64.

Kinds, M. B., Welsing, P. M., Vignon, E. P., Bijlsma, J. W., Viergever, M. A., Marijnissen, A. C. and Lafeber, F. P. A systematic review of the association between radiographic and clinical osteoarthritis of hip and knee. *Osteoarthritis Cartilage* 2011;*19:* 768-78.

Kivimäki, H., Saaristo, V., Kosunen, E., Rimpelä, A., Wiss, K. and Rimpelä, M. Kouluterveydenhuollon käynnit 1994–2005 – Toteutuiko tasa-arvo terveyskeskusten välillä informaatio-ohjauksen aikakaudella? [in Finnish]. *Sos Lääketiet Aikak – Journal of Social Medicine* 2007;*44:* 207-215.

Kivimäki, M., Smith, G. D., Timpson, N. J., Lawlor, D. A., Batty, G. D., Kähönen, M., Juonala, M., Rönnemaa, T., Viikari, J. S., Lehtimäki, T. and Raitakari, O. T. Lifetime body mass index and later atherosclerosis risk in young adults: examining causal links using Mendelian randomization in the Cardiovascular Risk in Young Finns study. *Eur Heart J* 2008;*29:* 2552-60.

Knapik, J. J., Reynolds, K. L. and Harman, E. Soldier load carriage: historical, physiological, biomechanical, and medical aspects. *Mil Med* 2004;*169:* 45-56.

Knudsen, A. K., Overland, S., Aakvaag, H. F., Harvey, S. B., Hotopf, M. and Mykletun, A. Common mental disorders and disability pension award: seven year follow-up of the HUSK study. *J Psychosom Res* 2010;*69:* 59-67.

Konstantinou, K. and Dunn, K. M. Sciatica: review of epidemiological studies and prevalence estimates. *Spine (Phila Pa 1976)* 2008;*33:* 2464-72.

Konstantinou, K., Hider, S. L., Jordan, J. L., Lewis, M., Dunn, K. M. and Hay, E. M. The impact of low back-related leg pain on outcomes as compared with low back pain alone: a systematic review of the literature. *Clin J Pain* 2013;*29:* 644-54.

Korhonen, T., Smeds, E., Silventoinen, K., Heikkilä, K. and Kaprio, J. Cigarette smoking and alcohol use as predictors of disability retirement: A population-based cohort study. *Drug Alcohol Depend* 2015;*155:* 260-6.

Koskenvuo, K., Broms, U., Korhonen, T., Laitinen, L. A., Huunan-Seppälä, A., Keistinen, T., Autti-Rämö, I., Kaprio, J. and Koskenvuo, M. Smoking strongly predicts disability retirement due to COPD: the Finnish Twin Cohort Study. *Eur Respir J* 2011;*37:* 26-31.

Krause, N., Lynch, J., Kaplan, G. A., Cohen, R. D., Goldberg, D. E. and Salonen, J. T. Predictors of disability retirement. *Scand J Work Environ Health* 1997;*23:* 403-13.

Krokstad, S., Johnsen, R. and Westin, S. Social determinants of disability pension: a 10-year follow-up of 62 000 people in a Norwegian county population. *Int J Epidemiol* 2002;*31:* 1183-91.

Kuczmarski, R. J., Ogden, C. L., Grummer-Strawn, L. M., Flegal, K. M., Guo, S. S., Wei, R., Mei, Z., Curtin, L. R., Roche, A. F. and Johnson, C. L. CDC growth charts: United States. *Adv Data* 2000;1-27.

Kuh, D. and Ben-Schlomo, Y. Introduction. In Kuh, D., Ben-Schlomo, Y. and Ezra, S., (eds.) *A life course approach to chronic disease epidemiology*, Oxford University Press, Oxford. 2004.

Kuh, D., Ben-Shlomo, Y., Lynch, J., Hallqvist, J. and Power, C. Life course epidemiology. *J Epidemiol Community Health* 2003;*57:* 778-83.

Kuikka, P. I., Pihlajamäki, H. K. and Mattila, V. M. Knee injuries related to sports in young adult males during military service - incidence and risk factors. *Scand J Med Sci Sports* 2013;*23:* 281-7.

Kulkarni, K., Karssiens, T., Kumar, V. and Pandit, H. Obesity and osteoarthritis. *Maturitas* 2016;*89:* 22-8.

Kääriä, S., Kirjonen, J., Telama, R., Kaila-Kangas, L. and Leino-Arjas, P. Does strenuous leisure time physical activity prevent severe back disorders leading to hospitalization? *Eur Spine J* 2014;*23:* 508-11.

Kääriä, S., Leino-Arjas, P., Rahkonen, O., Lahti, J., Lahelma, E. and Laaksonen, M. Risk factors of sciatic pain: a prospective study among middle-aged employees. *Eur J Pain* 2011;*15:* 584-90.

Kääriä, S., Luukkonen, R., Riihimäki, H., Kirjonen, J. and Leino-Arjas, P. Persistence of low back pain reporting among a cohort of employees in a metal corporation: a study with 5-, 10-, and 28-year follow-ups. *Pain* 2006;*120:* 131-7.

Kääriä, S., Solovieva, S. and Leino-Arjas, P. Associations of low back pain with neck pain: a study of industrial employees with 5-, 10-, and 28-year follow-ups. *Eur J Pain* 2009;*13:* 406-11.

Lahelma, E., Laaksonen, M., Lallukka, T., Martikainen, P., Pietiläinen, O., Saastamoinen, P., Gould, R. and Rahkonen, O. Working conditions as risk factors for disability retirement: a longitudinal register linkage study. *BMC Public Health* 2012;*12:* 309.

Lahelma, E., Pietiläinen, O., Rahkonen, O. and Lallukka, T. Common mental disorders and cause-specific disability retirement. *Occup Environ Med* 2015;*72:* 181-7.

Laiho, J., Djerf, K. and Lehtonen, R. Sampling Design. in Heistaro, S., (ed.) *Methodology Report: Health 2000 Survey*. Publications of the National Public Health Institute. National Public Health Institute, 2008: 13-15. Available: http://urn.fi/URN:NBN:fi-fe201204193320 [Accessed 2.3.2016].

Laine, S., Gimeno, D., Virtanen, M., Oksanen, T., Vahtera, J., Elovainio, M., Koskinen, A., Pentti, J. and Kivimäki, M. Job strain as a predictor of disability pension: the Finnish Public Sector Study. *J Epidemiol Community Health* 2009;*63:* 24-30.

Lallukka, T., Haaramo, P., Lahelma, E. and Rahkonen, O. Sleep problems and disability retirement: a register-based follow-up study. *Am J Epidemiol* 2011;*173:* 871-81.

Lallukka, T., Viikari-Juntura, E., Raitakari, O. T., Kähönen, M., Lehtimäki, T., Viikari, J. and Solovieva, S. Childhood and adult socio-economic position and social mobility as determinants of low back pain outcomes. *Eur J Pain* 2014;*18:* 128-38.

Larsen, K. and Leboeuf-Yde, C. Coping and back problems: a prospective observational study of Danish military recruits. *J Manipulative Physiol Ther* 2006;*29:* 619-25.

Lean, M. E., Han, T. S. and Seidell, J. C. Impairment of health and quality of life in people with large waist circumference. *Lancet* 1998;*351:* 853-6.

Leboeuf-Yde, C., Larsen, K., Ahlstrand, I. and Volinn, E. Coping and back problems: analysis of multiple data sources on an entire cross-sectional cohort of Swedish military recruits. *BMC Musculoskelet Disord* 2006;*7:* 39.

Leijten, F. R., de Wind, A., van den Heuvel, S. G., Ybema, J. F., van der Beek, A. J., Robroek, S. J. and Burdorf, A. The influence of chronic health problems and work-related factors on loss of paid employment among older workers. *J Epidemiol Community Health* 2015;*69:* 1058-65.

Leino-Arjas, P., Kauppila, L., Kaila-Kangas, L., Shiri, R., Heistaro, S. and Heliövaara, M. Serum lipids in relation to sciatica among Finns. *Atherosclerosis* 2008;*197:* 43-9.

Leinonen, T., Martikainen, P. and Lahelma, E. Interrelationships between education, occupational social class, and income as determinants of disability retirement. *Scand J Public Health* 2012;*40:* 157-66.

Li, R. and Chambless, L. Test for additive interaction in proportional hazards models. *Ann Epidemiol* 2007;*17:* 227-36.

Lim, S. S., Vos, T., Flaxman, A. D., Danaei, G., Shibuya, K., Adair-Rohani, H., Amann, M., Anderson, H. R., Andrews, K. G., Aryee, M., Atkinson, C., Bacchus, L. J., Bahalim, A. N., Balakrishnan, K., Balmes, J., Barker-Collo, S., Baxter, A., Bell, M. L., Blore, J. D., Blyth, F., Bonner, C., Borges, G., Bourne, R., Boussinesq, M., Brauer, M., Brooks, P., Bruce, N. G., Brunekreef, B., Bryan-Hancock, C., Bucello, C., Buchbinder, R., Bull, F., Burnett, R. T., Byers, T. E., Calabria, B., Carapetis, J., Carnahan, E., Chafe, Z., Charlson, F., Chen, H., Chen, J. S., Cheng, A. T., Child, J. C., Cohen, A., Colson, K. E., Cowie, B. C., Darby, S., Darling, S., Davis, A., Degenhardt, L., Dentener, F., Des Jarlais, D. C., Devries, K., Dherani, M., Ding, E. L., Dorsey, E. R., Driscoll, T., Edmond, K., Ali, S. E., Engell, R. E., Erwin, P. J., Fahimi, S., Falder, G., Farzadfar, F., Ferrari, A., Finucane, M. M., Flaxman, S., Fowkes, F. G., Freedman, G., Freeman, M. K., Gakidou, E., Ghosh, S., Giovannucci, E., Gmel, G., Graham, K., Grainger, R., Grant, B., Gunnell, D., Gutierrez, H. R., Hall, W., Hoek, H. W., Hogan, A., Hosgood, H. D., 3rd, Hoy, D., Hu, H., Hubbell, B. J., Hutchings, S. J., Ibeanusi, S. E., Jacklyn, G. L., Jasrasaria, R., Jonas, J. B., Kan, H., Kanis, J. A., Kassebaum, N., Kawakami, N., Khang, Y. H., Khatibzadeh, S., Khoo, J. P., Kok, C., Laden, F., Lalloo, R., Lan, Q., Lathlean, T., Leasher, J. L., Leigh, J., Li, Y., Lin, J. K., Lipshultz, S. E., London, S., Lozano, R., Lu, Y., Mak, J., Malekzadeh, R., Mallinger, L., Marcenes, W., March, L., Marks, R., Martin, R., McGale, P., McGrath, J., Mehta, S., Mensah, G. A., Merriman, T. R., Micha, R., Michaud, C., Mishra, V., Mohd Hanafiah, K., Mokdad, A. A., Morawska, L., Mozaffarian, D., Murphy, T., Naghavi, M., Neal, B., Nelson, P. K., Nolla, J. M., Norman, R., Olives, C., Omer, S. B., Orchard, J., Osborne, R., Ostro, B., Page, A., Pandey, K. D., Parry, C. D., Passmore, E., Patra, J., Pearce, N., Pelizzari, P. M., Petzold, M., Phillips, M. R., Pope, D., Pope, C. A., 3rd, Powles, J., Rao, M., Razavi, H., Rehfuess, E. A., Rehm, J. T., Ritz, B., Rivara, F. P., Roberts, T., Robinson, C., Rodriguez-Portales, J. A., Romieu, I., Room, R., Rosenfeld, L. C., Roy, A., Rushton,

L., Salomon, J. A., Sampson, U., Sanchez-Riera, L., Sanman, E., Sapkota, A., Seedat, S., Shi, P., Shield, K., Shivakoti, R., Singh, G. M., Sleet, D. A., Smith, E., Smith, K. R., Stapelberg, N. J., Steenland, K., Stockl, H., Stovner, L. J., Straif, K., Straney, L., Thurston, G. D., Tran, J. H., Van Dingenen, R., van Donkelaar, A., Veerman, J. L., Vijayakumar, L., Weintraub, R., Weissman, M. M., White, R. A., Whiteford, H., Wiersma, S. T., Wilkinson, J. D., Williams, H. C., Williams, W., Wilson, N., Woolf, A. D., Yip, P., Zielinski, J. M., Lopez, A. D., Murray, C. J., Ezzati, M., AlMazroa, M. A. and Memish, Z. A. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012;*380:* 2224-60.

Liuke, M., Solovieva, S., Lamminen, A., Luoma, K., Leino-Arjas, P., Luukkonen, R. and Riihimäki, H. Disc degeneration of the lumbar spine in relation to overweight. *Int J Obes (Lond)* 2005;*29:* 903-8.

Lohmander, L. S., Gerhardsson de Verdier, M., Rollof, J., Nilsson, P. M. and Engström, G. Incidence of severe knee and hip osteoarthritis in relation to different measures of body mass: a population-based prospective cohort study. *Ann Rheum Dis* 2009;*68:* 490-6.

Losina, E., Weinstein, A. M., Reichmann, W. M., Burbine, S. A., Solomon, D. H., Daigle, M. E., Rome, B. N., Chen, S. P., Hunter, D. J., Suter, L. G., Jordan, J. M. and Katz, J. N. Lifetime risk and age at diagnosis of symptomatic knee osteoarthritis in the US. *Arthritis Care Res (Hoboken)* 2013;*65:* 703-11.

Low back pain: Current Care Guidelines Abstract. Working group appointed by the Finnish Medical Society Duodecim and Societas Medicinae Physicalis et Rehabilitationis Fennia. The Finnish Medical Society Duodecim, Helsinki. 2015. Available: http://www.käypähoito.fi/web/english/guidelineabstracts/guideline?id=ccs00106 [Accessed 11.9.2016].

Lundin, A., Sorberg Wallin, A., Falkstedt, D., Allebeck, P. and Hemmingsson, T. Intelligence and Disability Pension in Swedish Men and Women Followed from Childhood to Late Middle Age. *PLoS One* 2015;*10:* e0128834.

Lusa, S., Miranda, H., Luukkonen, R. and Punakallio, A. Sleep disturbances predict long-term changes in low back pain among Finnish firefighters: 13-year follow-up study. *Int Arch Occup Environ Health* 2015;*88:* 369-79.

Lynch, J. and Smith, G. D. A life course approach to chronic disease epidemiology. *Annu Rev Public Health* 2005;*26:* 1-35.

Macfarlane, G. J., de Silva, V. and Jones, G. T. The relationship between body mass index across the life course and knee pain in adulthood: results from the 1958 birth cohort study. *Rheumatology (Oxford)* 2011;*50:* 2251-6.

March, L., Smith, E. U., Hoy, D. G., Cross, M. J., Sanchez-Riera, L., Blyth, F., Buchbinder, R., Vos, T. and Woolf, A. D. Burden of disability due to musculoskeletal (MSK) disorders. *Best Pract Res Clin Rheumatol* 2014;*28:* 353-66.

Mattila, V. M., Kuronen, P. and Pihlajamäki, H. Nature and risk factors of injury hospitalization in young adults: a follow-up of 135,987 military conscripts. *Scand J Public Health* 2007;*35:* 418-23.

Mattila, V. M., Saarni, L., Parkkari, J., Koivusilta, L. and Rimpelä, A. Predictors of low back pain hospitalization--a prospective follow-up of 57,408 adolescents. *Pain* 2008;*139:* 209-17.

Mikkonen, P. H., Laitinen, J., Remes, J., Tammelin, T., Taimela, S., Kaikkonen, K., Zitting, P., Korpelainen, R. and Karppinen, J. Association between overweight and low back pain: a population-based prospective cohort study of adolescents. *Spine (Phila Pa 1976)* 2013;*38:* 1026-33.

Milgrom, C., Finestone, A., Lev, B., Wiener, M. and Floman, Y. Overexertional lumbar and thoracic back pain among recruits: a prospective study of risk factors and treatment regimens. *J Spinal Disord* 1993;*6:* 187-93.

Milgrom, C., Finestone, A., Lubovsky, O., Zin, D. and Lahad, A. A controlled randomized study of the effect of training with orthoses on the incidence of weight bearing induced back pain among infantry recruits. *Spine (Phila Pa 1976)* 2005;*30:* 272-5.

Miranda, H., Viikari-Juntura, E., Punnett, L. and Riihimäki, H. Occupational loading, health behavior and sleep disturbance as predictors of low-back pain. *Scand J Work Environ Health* 2008;*34:* 411-9.

Mitchell, J., Graham, W., Best, T. M., Collins, C., Currie, D. W., Comstock, R. D. and Flanigan, D. C. Epidemiology of meniscal injuries in US high school athletes between 2007 and 2013. *Knee Surg Sports Traumatol Arthrosc* 2016;*24:* 715-22.

Mittendorfer-Rutz, E., Hensing, G., Westerlund, H., Backheden, M. and Hammarstrom, A. Determinants in adolescence for adult sickness absence in women and men: a 26-year follow-up of a prospective population based cohort (Northern Swedish cohort). *BMC Public Health* 2013;*13:* 75.

Monasta, L., Lobstein, T., Cole, T. J., Vignerova, J. and Cattaneo, A. Defining overweight and obesity in pre-school children: IOTF reference or WHO standard? *Obes Rev* 2011;*12:* 295-300.

Monira Hussain, S., Wang, Y., Cicuttini, F. M., Simpson, J. A., Giles, G. G., Graves, S. and Wluka, A. E. Incidence of total knee and hip replacement for osteoarthritis in relation to the metabolic syndrome and its components: a prospective cohort study. *Semin Arthritis Rheum* 2014;*43:* 429-36.

Mork, P. J., Vik, K. L., Moe, B., Lier, R., Bardal, E. M. and Nilsen, T. I. Sleep problems, exercise and obesity and risk of chronic musculoskeletal pain: the Norwegian HUNT study. *Eur J Public Health* 2014;*24:* 924-9.

Murphy, L., Schwartz, T. A., Helmick, C. G., Renner, J. B., Tudor, G., Koch, G., Dragomir, A., Kalsbeek, W. D., Luta, G. and Jordan, J. M. Lifetime risk of symptomatic knee osteoarthritis. *Arthritis Rheum* 2008;*59:* 1207-13.

Murray, C. J., Vos, T., Lozano, R., Naghavi, M., Flaxman, A. D., Michaud, C., Ezzati, M., Shibuya, K., Salomon, J. A., Abdalla, S., Aboyans, V., Abraham, J., Ackerman, I., Aggarwal, R., Ahn, S. Y., Ali, M. K., Alvarado, M., Anderson, H. R., Anderson, L. M., Andrews, K. G., Atkinson, C., Baddour, L. M., Bahalim, A. N., Barker-Collo, S., Barrero, L. H., Bartels, D. H., Basanez, M. G., Baxter, A., Bell, M. L., Benjamin, E. J., Bennett, D., Bernabe, E., Bhalla, K., Bhandari, B., Bikbov, B., Bin Abdulhak, A., Birbeck, G., Black, J. A., Blencowe, H., Blore, J. D., Blyth, F., Bolliger, I., Bonaventure, A., Boufous, S., Bourne, R., Boussinesq, M., Braithwaite, T., Brayne, C.,

Bridgett, L., Brooker, S., Brooks, P., Brugha, T. S., Bryan-Hancock, C., Bucello, C., Buchbinder, R., Buckle, G., Budke, C. M., Burch, M., Burney, P., Burstein, R., Calabria, B., Campbell, B., Canter, C. E., Carabin, H., Carapetis, J., Carmona, L., Cella, C., Charlson, F., Chen, H., Cheng, A. T., Chou, D., Chugh, S. S., Coffeng, L. E., Colan, S. D., Colquhoun, S., Colson, K. E., Condon, J., Connor, M. D., Cooper, L. T., Corriere, M., Cortinovis, M., de Vaccaro, K. C., Couser, W., Cowie, B. C., Criqui, M. H., Cross, M., Dabhadkar, K. C., Dahiya, M., Dahodwala, N., Damsere-Derry, J., Danaei, G., Davis, A., De Leo, D., Degenhardt, L., Dellavalle, R., Delossantos, A., Denenberg, J., Derrett, S., Des Jarlais, D. C., Dharmaratne, S. D., Dherani, M., Diaz-Torne, C., Dolk, H., Dorsey, E. R., Driscoll, T., Duber, H., Ebel, B., Edmond, K., Elbaz, A., Ali, S. E., Erskine, H., Erwin, P. J., Espindola, P., Ewoigbokhan, S. E., Farzadfar, F., Feigin, V., Felson, D. T., Ferrari, A., Ferri, C. P., Fevre, E. M., Finucane, M. M., Flaxman, S., Flood, L., Foreman, K., Forouzanfar, M. H., Fowkes, F. G., Fransen, M., Freeman, M. K., Gabbe, B. J., Gabriel, S. E., Gakidou, E., Ganatra, H. A., Garcia, B., Gaspari, F., Gillum, R. F., Gmel, G., Gonzalez-Medina, D., Gosselin, R., Grainger, R., Grant, B., Groeger, J., Guillemin, F., Gunnell, D., Gupta, R., Haagsma, J., Hagan, H., Halasa, Y. A., Hall, W., Haring, D., Haro, J. M., Harrison, J. E., Havmoeller, R., Hay, R. J., Higashi, H., Hill, C., Hoen, B., Hoffman, H., Hotez, P. J., Hoy, D., Huang, J. J., Ibeanusi, S. E., Jacobsen, K. H., James, S. L., Jarvis, D., Jasrasaria, R., Jayaraman, S., Johns, N., Jonas, J. B., Karthikeyan, G., Kassebaum, N., Kawakami, N., Keren, A., Khoo, J. P., King, C. H., Knowlton, L. M., Kobusingye, O., Koranteng, A., Krishnamurthi, R., Laden, F., Lalloo, R., Laslett, L. L., Lathlean, T., Leasher, J. L., Lee, Y. Y., Leigh, J., Levinson, D., Lim, S. S., Limb, E., Lin, J. K., Lipnick, M., Lipshultz, S. E., Liu, W., Loane, M., Ohno, S. L., Lyons, R., Mabweijano, J., MacIntyre, M. F., Malekzadeh, R., Mallinger, L., Manivannan, S., Marcenes, W., March, L., Margolis, D. J., Marks, G. B., Marks, R., Matsumori, A., Matzopoulos, R., Mayosi, B. M., McAnulty, J. H., McDermott, M. M., McGill, N., McGrath, J., Medina-Mora, M. E., Meltzer, M., Mensah, G. A., Merriman, T. R., Meyer, A. C., Miglioli, V., Miller, M., Miller, T. R., Mitchell, P. B., Mock, C., Mocumbi, A. O., Moffitt, T. E., Mokdad, A. A., Monasta, L., Montico, M., Moradi-Lakeh, M., Moran, A., Morawska, L., Mori, R., Murdoch, M. E., Mwaniki, M. K., Naidoo, K., Nair, M. N., Naldi, L., Narayan, K. M., Nelson, P. K., Nelson, R. G., Nevitt, M. C., Newton, C. R., Nolte, S., Norman, P., Norman, R., O'Donnell, M., O'Hanlon, S., Olives, C., Omer, S. B., Ortblad, K., Osborne, R., Ozgediz, D., Page, A., Pahari, B., Pandian, J. D., Rivero, A. P., Patten, S. B., Pearce, N., Padilla, R. P., Perez-Ruiz, F., Perico, N., Pesudovs, K., Phillips, D., Phillips, M. R., Pierce, K., Pion, S., Polanczyk, G. V., Polinder, S., Pope, C. A., 3rd, Popova, S., Porrini, E., Pourmalek, F., Prince, M., Pullan, R. L., Ramaiah, K. D., Ranganathan, D., Razavi, H., Regan, M., Rehm, J. T., Rein, D. B., Remuzzi, G., Richardson, K., Rivara, F. P., Roberts, T., Robinson, C., De Leon, F. R., Ronfani, L., Room, R., Rosenfeld, L. C., Rushton, L., Sacco, R. L., Saha, S., Sampson, U., Sanchez-Riera, L., Sanman, E., Schwebel, D. C., Scott, J. G., Segui-Gomez, M., Shahraz, S., Shepard, D. S., Shin, H., Shivakoti, R., Singh, D., Singh, G. M., Singh, J. A., Singleton, J., Sleet, D. A., Sliwa, K., Smith, E., Smith, J. L., Stapelberg, N. J., Steer, A., Steiner, T., Stolk, W. A., Stovner, L. J., Sudfeld, C., Syed, S., Tamburlini, G., Tavakkoli, M., Taylor, H. R., Taylor, J. A., Taylor, W. J., Thomas, B., Thomson, W. M., Thurston, G. D., Tleyjeh, I. M., Tonelli, M., Towbin, J. A., Truelsen, T., Tsilimbaris, M. K., Ubeda, C., Undurraga, E. A., van der Werf, M. J., van Os, J., Vavilala, M. S., Venketasubramanian, N., Wang, M., Wang, W., Watt, K., Weatherall, D. J., Weinstock, M. A., Weintraub, R., Weisskopf, M. G., Weissman, M. M., White, R. A., Whiteford, H., Wiebe, N., Wiersma, S. T., Wilkinson, J. D., Williams, H. C., Williams, S. R., Witt, E., Wolfe, F., Woolf, A. D., Wulf, S., Yeh, P. H., Zaidi, A. K., Zheng, Z. J., Zonies, D., Lopez, A. D., AlMazroa, M. A. and Memish, Z. A. Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012;*380:* 2197-223.

Mykletun, A., Overland, S., Dahl, A. A., Krokstad, S., Bjerkeset, O., Glozier, N., Aaro, L. E. and Prince, M. A population-based cohort study of the effect of common mental disorders on disability pension awards. *Am J Psychiatry* 2006;*163:* 1412-8.

Mäntyniemi, A., Oksanen, T., Salo, P., Virtanen, M., Sjösten, N., Pentti, J., Kivimäki, M. and Vahtera, J. Job strain and the risk of disability pension due to musculoskeletal disorders, depression or coronary heart disease: a prospective cohort study of 69,842 employees. *Occup Environ Med* 2012;*69:* 574-81.

Nakamura, M., Nishiwaki, Y., Ushida, T. and Toyama, Y. Prevalence and characteristics of chronic musculoskeletal pain in Japan. *J Orthop Sci* 2011;*16:* 424-32.

Neovius, K., Johansson, K., Rossner, S. and Neovius, M. Disability pension, employment and obesity status: a systematic review. *Obes Rev* 2008;*9:* 572-81.

Neovius, K., Neovius, M. and Rasmussen, F. The combined effects of overweight and smoking in late adolescence on subsequent disability pension: a nationwide cohort study. *Int J Obes (Lond)* 2010;*34:* 75-82.

Neovius, M., Kark, M. and Rasmussen, F. Association between obesity status in young adulthood and disability pension. *Int J Obes (Lond)* 2008;*32:* 1319-26.

Ng, M., Fleming, T., Robinson, M., Thomson, B., Graetz, N., Margono, C., Mullany, E. C., Biryukov, S., Abbafati, C., Abera, S. F., Abraham, J. P., Abu-Rmeileh, N. M., Achoki, T., AlBuhairan, F. S., Alemu, Z. A., Alfonso, R., Ali, M. K., Ali, R., Guzman, N. A., Ammar, W., Anwari, P., Banerjee, A., Barquera, S., Basu, S., Bennett, D. A., Bhutta, Z., Blore, J., Cabral, N., Nonato, I. C., Chang, J. C., Chowdhury, R., Courville, K. J., Criqui, M. H., Cundiff, D. K., Dabhadkar, K. C., Dandona, L., Davis, A., Dayama, A., Dharmaratne, S. D., Ding, E. L., Durrani, A. M., Esteghamati, A., Farzadfar, F., Fay, D. F., Feigin, V. L., Flaxman, A., Forouzanfar, M. H., Goto, A., Green, M. A., Gupta, R., Hafezi-Nejad, N., Hankey, G. J., Harewood, H. C., Havmoeller, R., Hay, S., Hernandez, L., Husseini, A., Idrisov, B. T., Ikeda, N., Islami, F., Jahangir, E., Jassal, S. K., Jee, S. H., Jeffreys, M., Jonas, J. B., Kabagambe, E. K., Khalifa, S. E., Kengne, A. P., Khader, Y. S., Khang, Y. H., Kim, D., Kimokoti, R. W., Kinge, J. M., Kokubo, Y., Kosen, S., Kwan, G., Lai, T., Leinsalu, M., Li, Y., Liang, X., Liu, S., Logroscino, G., Lotufo, P. A., Lu, Y., Ma, J., Mainoo, N. K., Mensah, G. A., Merriman, T. R., Mokdad, A. H., Moschandreas, J., Naghavi, M., Naheed, A., Nand, D., Narayan, K. M., Nelson, E. L., Neuhouser, M. L., Nisar, M. I., Ohkubo, T., Oti, S. O., Pedroza, A., Prabhakaran, D., Roy, N., Sampson, U., Seo, H., Sepanlou, S. G., Shibuya, K., Shiri, R., Shiue, I., Singh, G. M., Singh, J. A., Skirbekk, V., Stapelberg, N. J., Sturua, L., Sykes, B. L., Tobias, M., Tran, B. X., Trasande, L., Toyoshima, H., van de Vijver, S., Vasankari, T. J., Veerman, J. L., Velasquez-Melendez, G., Vlassov, V. V., Vollset, S. E., Vos, T., Wang, C., Wang, X., Weiderpass, E., Werdecker, A., Wright, J. L., Yang, Y. C., Yatsuya, H., Yoon, J., Yoon, S. J., Zhao, Y., Zhou, M., Zhu, S., Lopez, A. D., Murray, C. J. and Gakidou, E. Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: a systematic analysis for the Global Burden of Disease Study 2013. *Lancet* 2014;*384:* 766-81.

Nguyen, U. S., Zhang, Y., Zhu, Y., Niu, J., Zhang, B. and Felson, D. T. Increasing prevalence of knee pain and symptomatic knee osteoarthritis: survey and cohort data. *Ann Intern Med* 2011;*155:* 725-32.

Nilsen, T. I., Holtermann, A. and Mork, P. J. Physical exercise, body mass index, and risk of chronic pain in the low back and neck/shoulders: longitudinal data from the Nord-Trondelag Health Study. *Am J Epidemiol* 2011;*174:* 267-73.

Nolet, P. S., Kristman, V. L., Cote, P., Carroll, L. J., Hincapie, C. A. and David Cassidy, J. The association between a lifetime history of work-related low back injury and future low back pain: a population-based cohort study. *Eur Spine J* 2016;*25:* 1242-50.

O'Connor, F. G. and Marlowe, S. S. Low back pain in military basic trainees. A pilot study. *Spine (Phila Pa 1976)* 1993;*18:* 1351-4.

O'Sullivan, P. B., Beales, D. J., Smith, A. J. and Straker, L. M. Low back pain in 17 year olds has substantial impact and represents an important public health disorder: a cross-sectional study. *BMC Public Health* 2012;*12:* 100.

OECD (Organisation for Economic Cooperation and Development). *Transforming disability into ability. Policies to promote work and income security,* OECD Publishing, Paris. 2003.

OECD (Organisation for Economic Cooperation and Development). *Sickness, disability and work: Breaking the barriers. A synthesis of findings across OECD countries.* OECD Publishing, Paris. 2010. Available: http://ec.europa.eu/health/mental_health/eu_compass/reports_studies/disability_synthesis_2010_en.pdf [Accessed 14.10.2015].

OECD (Organisation for Economic Cooperation and Development). *OECD Factbook 2014: Economic, environmental and social statistics.* OECD Publishing, 2014. Available: http://dx.doi.org/10.1787/factbook-2014-en [Accessed 14.8.2016].

OECD (Organisation for Economic Cooperation and Development). *Fit Mind, Fit Job: From Evidence to Practice in Mental Health and Work,* OECD Publishing, Paris. 2015.

Okifuji, A. and Hare, B. D. The association between chronic pain and obesity. *J Pain Res* 2015;*8:* 399-408.

Okorodudu, D. O., Jumean, M. F., Montori, V. M., Romero-Corral, A., Somers, V. K., Erwin, P. J. and Lopez-Jimenez, F. Diagnostic performance of body mass index to identify obesity as defined by body adiposity: a systematic review and meta-analysis. *Int J Obes (Lond)* 2010;*34:* 791-9.

Overland, S., Harvey, S. B., Knudsen, A. K., Mykletun, A. and Hotopf, M. Widespread pain and medically certified disability pension in the Hordaland Health Study. *Eur J Pain* 2012;*16:* 611-20.

Palmer, K. T., Walsh, K., Bendall, H., Cooper, C. and Coggon, D. Back pain in Britain: comparison of two prevalence surveys at an interval of 10 years. *BMJ* 2000;*320:* 1577-8.

Parkkola, K. Predicting failure in the compulsory conscript service: A follow-up study of the predictive value of the structured conscript interview and the conscript screen. [in Finnish, with English summary]. *Ann Med Mil Fenn* 1999;*74:* 125-127.

Paulis, W. D., Silva, S., Koes, B. W. and van Middelkoop, M. Overweight and obesity are associated with musculoskeletal complaints as early as childhood: a systematic review. *Obes Rev* 2014;*15:* 52-67.

Peat, G., McCarney, R. and Croft, P. Knee pain and osteoarthritis in older adults: a review of community burden and current use of primary health care. *Ann Rheum Dis* 2001;*60:* 91-7.

Peitso, A. Keskeytyminen terveydellisistä syistä Pohjoisella Maanpuolustusalueella. [in Finnish]. *Sotilaslääketieteen laitoksen julkaisuja* 2002;*1:* 15-19.

Pereira, D., Peleteiro, B., Araujo, J., Branco, J., Santos, R. A. and Ramos, E. The effect of osteoarthritis definition on prevalence and incidence estimates: a systematic review. *Osteoarthritis Cartilage* 2011;*19:* 1270-85.

Picavet, H. S. and Schouten, J. S. Musculoskeletal pain in the Netherlands: prevalences, consequences and risk groups, the DMC(3)-study. *Pain* 2003;*102:* 167-78.

Pietikäinen, S., Silventoinen, K., Svedberg, P., Alexanderson, K., Huunan-Seppälä, A., Koskenvuo, K., Koskenvuo, M., Kaprio, J. and Ropponen, A. Health-related and sociodemographic risk factors for disability pension due to low back disorders: a 30-year prospective Finnish Twin Cohort Study. *J Occup Environ Med* 2011;*53:* 488-96.

Pietiläinen, O., Laaksonen, M., Rahkonen, O. and Lahelma, E. Self-rated health as a predictor of disability retirement--the contribution of ill-health and working conditions. *PLoS One* 2011;*6:* e25004.

Power, C., Frank, J., Hertzman, C., Schierhout, G. and Li, L. Predictors of low back pain onset in a prospective British study. *Am J Public Health* 2001;*91:* 1671-8.

Preacher, K. J. and Hayes, A. F. SPSS and SAS procedures for estimating indirect effects in simple mediation models. *Behav Res Methods Instrum Comput* 2004;*36:* 717-31.

Reunanen, A. Health examination. Measure point 1. in Heistaro, S., (ed.) *Methodology Report: Health 2000 Survey*. Publications of the National Public Health Institute. National Public Health Institute, 2008: 60-65. Available: http://urn.fi/URN:NBN:fi-fe201204193320 [Accessed 2.3.2016].

Reunanen, A. and Heliövaara, M. Health Examination. Clinical medical examination. in Heistaro, S., (ed.) *Methodology Report: Health 2000 Survey*. Publications of the National Public Health Institute. National Public Health Institute, Helsinki, 2008: 105-111. Available: http://urn.fi/URN:NBN:fi-fe201204193320 [Accessed 2.3.2016].

Richmond, S. A., Fukuchi, R. K., Ezzat, A., Schneider, K., Schneider, G. and Emery, C. A. Are joint injury, sport activity, physical activity, obesity, or occupational activities predictors for osteoarthritis? A systematic review. *J Orthop Sports Phys Ther* 2013;*43:* 515-B19.

Rissanen, A., Heliövaara, M., Knekt, P., Reunanen, A., Aromaa, A. and Maatela, J. Risk of disability and mortality due to overweight in a Finnish population. *BMJ* 1990;*301:* 835-7.

Rivinoja, A. E., Paananen, M. V., Taimela, S. P., Solovieva, S., Okuloff, A., Zitting, P., Järvelin, M. R., Leino-Arjas, P. and Karppinen, J. I. Sports, smoking, and overweight during adolescence as predictors of sciatica in adulthood: a 28-year follow-up study of a birth cohort. *Am J Epidemiol* 2011;*173:* 890-7.

Robroek, S. J., Reeuwijk, K. G., Hillier, F. C., Bambra, C. L., van Rijn, R. M. and Burdorf, A. The contribution of overweight, obesity, and lack of physical activity to exit from paid employment: a meta-analysis. *Scand J Work Environ Health* 2013;*39:* 233-40.

Robroek, S. J., Rongen, A., Arts, C. H., Otten, F. W., Burdorf, A. and Schuring, M. Educational Inequalities in Exit from Paid Employment among Dutch Workers: The Influence of Health, Lifestyle and Work. *PLoS One* 2015;*10:* e0134867.

Rohrer, M. H., Santos-Eggimann, B., Paccaud, F. and Haller-Maslov, E. Epidemiologic study of low back pain in 1398 Swiss conscripts between 1985 and 1992. *Eur Spine J* 1994;*3:* 2-7.

Ropponen, A., Korhonen, T., Svedberg, P., Koskenvuo, M., Silventoinen, K. and Kaprio, J. Persistent smoking as a predictor of disability pension due to musculoskeletal diagnoses: a 23 year prospective study of Finnish twins. *Prev Med* 2013a;*57:* 889-93.

Ropponen, A., Silventoinen, K., Hublin, C., Svedberg, P., Koskenvuo, M. and Kaprio, J. Sleep patterns as predictors for disability pension due to low back diagnoses: a 23-year longitudinal study of Finnish twins. *Sleep* 2013b;*36:* 891-7.

Ropponen, A., Svedberg, P., Kalso, E., Koskenvuo, M., Silventoinen, K. and Kaprio, J. A prospective twin cohort study of disability pensions due to musculoskeletal diagnoses in relation to stability and change in pain. *Pain* 2013c;*154:* 1966-72.

Ropponen, A., Svedberg, P., Koskenvuo, M., Silventoinen, K. and Kaprio, J. Physical work load and psychological stress of daily activities as predictors of disability pension due to musculoskeletal disorders. *Scand J Public Health* 2014;*42:* 370-6.

Rosenbaum, P. R. and Rubin, D. B. The Central Role of the Propensity Score in Observational Studies for Causal Effects. *Biometrika* 1983;*70:* 41-55.

Rosendal, L., Langberg, H., Skov-Jensen, A. and Kjaer, M. Incidence of injury and physical performance adaptations during military training. *Clin J Sport Med* 2003;*13:* 157-63.

Rothman, K. J. BMI-related errors in the measurement of obesity. *Int J Obes (Lond)* 2008;*32 Suppl 3:* S56-9.

Sa, K. N., Pereira Cde, M., Souza, R. C., Baptista, A. F. and Lessa, I. Knee pain prevalence and associated factors in a Brazilian population study. *Pain Med* 2011;*12:* 394-402.

Sahi, T. *Personal communication.* 2009.

Sahi, T. and Korpela, H. Varusmiespalveluksen keskeytyminen terveydellisistä syistä vuosina 1997–2000. [in Finnish]. *Sotilaslääketieteen laitoksen julkaisuja* 2002;*1:* 4-14.

Salminen, J. K., Saarijärvi, S. and Raitasalo, R. Depression and disability pension in Finland. *Acta Psychiatr Scand* 1997;*95:* 242-3.

Salonsalmi, A., Laaksonen, M., Lahelma, E. and Rahkonen, O. Drinking habits and disability retirement. *Addiction* 2012;*107:* 2128-36.

Samartzis, D., Karppinen, J., Cheung, J. P. and Lotz, J. Disk degeneration and low back pain: are they fat-related conditions? *Global Spine J* 2013;*3:* 133-44.

Samuelsson, A., Ropponen, A., Alexanderson, K. and Svedberg, P. A prospective cohort study of disability pension due to mental diagnoses: the importance of health factors and behaviors. *BMC Public Health* 2013;*13:* 621.

Sanford, B. A., Williams, J. L., Zucker-Levin, A. R. and Mihalko, W. M. Hip, Knee, and Ankle Joint Forces in Healthy Weight, Overweight, and Obese Individuals During Walking In Doyle, B., Miller, K., Wittek, A. and Nielsen, P. M. F., (eds.) *Computational Biomechanics for Medicine: Fundamental Science and Patient-specific Applications*, Springer-Verlag New York Inc. 101-111. 2014.

Santtila, M., Kyröläinen, H., Vasankari, T., Tiainen, S., Palvalin, K., Häkkinen, A. and Häkkinen, K. Physical fitness profiles in young Finnish men during the years 1975-2004. *Med Sci Sports Exerc* 2006;*38:* 1990-4.

Schneider, H. J., Friedrich, N., Klotsche, J., Pieper, L., Nauck, M., John, U., Dorr, M., Felix, S., Lehnert, H., Pittrow, D., Silber, S., Volzke, H., Stalla, G. K., Wallaschofski, H. and Wittchen, H. U. The predictive value of different measures of obesity for incident cardiovascular events and mortality. *J Clin Endocrinol Metab* 2010;*95:* 1777-85.

Shiri, R. and Falah-Hassani, K. The Effect of Smoking on the Risk of Sciatica: A Meta-analysis. *Am J Med* 2016;*129:* 64-73 e20.

Shiri, R., Falah-Hassani, K., Viikari-Juntura, E. and Coggon, D. Leisure-time physical activity and sciatica: A systematic review and meta-analysis. *Eur J Pain* 2016;*20:* 1563-1572.

Shiri, R., Kaila-Kangas, L., Ahola, K., Kivekäs, T., Viikari-Juntura, E., Heliövaara, M., Miranda, H. and Leino-Arjas, P. The relation of co-occurring musculoskeletal pain and depressive symptoms with work ability. *J Occup Environ Med* 2013a;*55:* 1281-5.

Shiri, R., Karppinen, J., Leino-Arjas, P., Solovieva, S., Varonen, H., Kalso, E., Ukkola, O. and Viikari-Juntura, E. Cardiovascular and lifestyle risk factors in lumbar radicular pain or clinically defined sciatica: a systematic review. *Eur Spine J* 2007;*16:* 2043-54.

Shiri, R., Karppinen, J., Leino-Arjas, P., Solovieva, S. and Viikari-Juntura, E. The association between obesity and low back pain: a meta-analysis. *Am J Epidemiol* 2010a;*171:* 135-54.

Shiri, R., Karppinen, J., Leino-Arjas, P., Solovieva, S. and Viikari-Juntura, E. The association between smoking and low back pain: a meta-analysis. *Am J Med* 2010b;*123:* 87 e7-35.

Shiri, R., Lallukka, T., Karppinen, J. and Viikari-Juntura, E. Obesity as a risk factor for sciatica: a meta-analysis. *Am J Epidemiol* 2014;*179:* 929-37.

Shiri, R., Solovieva, S., Husgafvel-Pursiainen, K., Telama, R., Yang, X., Viikari, J., Raitakari, O. T. and Viikari-Juntura, E. The role of obesity and physical activity in non-specific and radiating low back pain: the Young Finns study. *Seminars in arthritis and rheumatism* 2013b;*42:* 640-50.

Shiri, R., Solovieva, S., Husgafvel-Pursiainen, K., Viikari, J., Raitakari, O. T. and Viikari-Juntura, E. Incidence of nonspecific and radiating low back pain: followup of 24-39-year-old adults of the Young Finns Study. *Arthritis Care Res (Hoboken)* 2010c;*62:* 455-9.

Sidorchuk, A., Hemmingsson, T., Romelsjo, A. and Allebeck, P. Alcohol use in adolescence and risk of disability pension: a 39 year follow-up of a population-based conscription survey. *PLoS One* 2012;*7:* e42083.

Siilasmaa, R., Ahtisaari, M., Ala-Pietilä, P., Junger, M., Komi, K., Ojajärvi, A., Parkkinen, M., Räty, A., Siimes, O. and Virtanen, V. *Finnish mandatory military service. A Report 2010.* Ministry of Defence, Helsinki, Finland, 2010. Available: http://www.defmin.fi/files/1648/Suomalainen_asevelvollisuus_plmv2_2010.pdf [Accessed 14.8.2015].

Sillanpää, P., Mattila, V. M., Iivonen, T., Visuri, T. and Pihlajamäki, H. Incidence and risk factors of acute traumatic primary patellar dislocation. *Med Sci Sports Exerc* 2008;*40:* 606-11.

Silverwood, V., Blagojevic-Bucknall, M., Jinks, C., Jordan, J. L., Protheroe, J. and Jordan, K. P. Current evidence on risk factors for knee osteoarthritis in older adults: a systematic review and meta-analysis. *Osteoarthritis Cartilage* 2015;*23:* 507-15.

Singh, D., Park, W., Hwang, D. and Levy, M. S. Severe obesity effect on low back biomechanical stress of manual load lifting. *Work* 2015;*51:* 337-48.

Sinokki, M., Hinkka, K., Ahola, K., Gould, R., Puukka, P., Lönnqvist, J. and Virtanen, M. Social support as a predictor of disability pension: the Finnish Health 2000 study. *J Occup Environ Med* 2010;*52:* 733-9.

Sitthipornvorakul, E., Janwantanakul, P., Purepong, N., Pensri, P. and van der Beek, A. J. The association between physical activity and neck and low back pain: a systematic review. *Eur Spine J* 2011;*20:* 677-89.

Sivertsen, B., Overland, S., Neckelmann, D., Glozier, N., Krokstad, S., Pallesen, S., Nordhus, I. H., Bjorvatn, B. and Mykletun, A. The long-term effect of insomnia on work disability: the HUNT-2 historical cohort study. *Am J Epidemiol* 2006;*163:* 1018-24.

Smith, S. M., Sumar, B. and Dixon, K. A. Musculoskeletal pain in overweight and obese children. *Int J Obes (Lond)* 2014;*38:* 11-5.

Snijder, M. B., van Dam, R. M., Visser, M. and Seidell, J. C. What aspects of body fat are particularly hazardous and how do we measure them? *Int J Epidemiol* 2006;*35:* 83-92.

Sotkanet. *SOTKAnet Statistics and Indicator Bank.* National Institute for Health and Welfare. 2015. Available: https://www.sotkanet.fi/sotkanet/en/index [Accessed 14.8.2015].

Sowers, M. R. and Karvonen-Gutierrez, C. A. The evolving role of obesity in knee osteoarthritis. *Curr Opin Rheumatol* 2010;*22:* 533-7.

Steffens, D., Maher, C. G., Pereira, L. S., Stevens, M. L., Oliveira, V. C., Chapple, M., Teixeira-Salmela, L. F. and Hancock, M. J. Prevention of Low Back Pain: A Systematic Review and Meta-analysis. *JAMA Intern Med* 2016;*176:* 199-208.

Sörberg, A., Lundin, A., Allebeck, P., Melin, B., Falkstedt, D. and Hemmingsson, T. Cognitive ability in late adolescence and disability pension in middle age: follow-up of a national cohort of Swedish males. *PLoS One* 2013;*8:* e78268.

Taanila, H., Suni, J., Pihlajamäki, H., Mattila, V. M., Ohrankammen, O., Vuorinen, P. and Parkkari, J. Musculoskeletal disorders in physically active conscripts: a one-year follow-up study in the Finnish Defence Forces. *BMC Musculoskelet Disord* 2009;*10:* 89.

Taanila, H., Suni, J., Pihlajamäki, H., Mattila, V. M., Ohrankammen, O., Vuorinen, P. and Parkkari, J. Aetiology and risk factors of musculoskeletal disorders in physically active conscripts: a follow-up study in the Finnish Defence Forces. *BMC Musculoskelet Disord* 2010;*11:* 146.

Taanila, H., Suni, J. H., Kannus, P., Pihlajamaki, H., Ruohola, J. P., Viskari, J. and Parkkari, J. Risk factors of acute and overuse musculoskeletal injuries among young conscripts: a population-based cohort study. *BMC Musculoskelet Disord* 2015;*16:* 104.

Taanila, H. P., Suni, J. H., Pihlajamäki, H. K., Mattila, V. M., Ohrankämmen, O., Vuorinen, P. and Parkkari, J. P. Predictors of low back pain in physically active conscripts with special emphasis on muscular fitness. *Spine J* 2012;*12:* 737-48.

Takatalo, J., Karppinen, J., Taimela, S., Niinimäki, J., Laitinen, J., Sequeiros, R. B., Samartzis, D., Korpelainen, R., Näyhä, S., Remes, J. and Tervonen, O. Association of abdominal obesity with lumbar disc degeneration--a magnetic resonance imaging study. *PLoS One* 2013;*8:* e56244.

Tanamas, S. K., Wluka, A. E., Davies-Tuck, M., Wang, Y., Strauss, B. J., Proietto, J., Dixon, J. B., Jones, G., Forbes, A. and Cicuttini, F. M. Association of weight gain with incident knee pain, stiffness, and functional difficulties: a longitudinal study. *Arthritis Care Res (Hoboken)* 2013;*65:* 34-43.

Taylor, J. B., Goode, A. P., George, S. Z. and Cook, C. E. Incidence and risk factors for first-time incident low back pain: a systematic review and meta-analysis. *Spine J* 2014;*14:* 2299-319.

Teichtahl, A. J., Wluka, A. E., Tanamas, S. K., Wang, Y., Strauss, B. J., Proietto, J., Dixon, J. B., Jones, G., Forbes, A. and Cicuttini, F. M. Weight change and change in tibial cartilage volume and symptoms in obese adults. *Ann Rheum Dis* 2015;*74:* 1024-9.

The Finnish Defence Forces. *Conscript 2016. A guide for you who are preparing to carry out your military service.* The Finnish Defence Forces, 2016. Available: http://puolustusvoimat.fi/documents/1948673/2258487/MAAVE_Varusmiesopas_2016_EN/1c0dc0d4-4a8a-41cc-b020-5150ed88171e [Accessed 12.08.2016].

Thiem, U., Lamsfuss, R., Gunther, S., Schumacher, J., Baker, C., Endres, H. G., Zacher, J., Burmester, G. R. and Pientka, L. Prevalence of self-reported pain, joint complaints and knee or hip complaints in adults aged >/= 40 years: a cross-sectional survey in Herne, Germany. *PLoS One* 2013;*8:* e60753.

Thompson, M. L., Myers, J. E. and Kriebel, D. Prevalence odds ratio or prevalence ratio in the analysis of cross sectional data: what is to be done? *Occup Environ Med* 1998;*55:* 272-7.

Thorstensson, C. A., Andersson, M. L., Jonsson, H., Saxne, T. and Petersson, I. F. Natural course of knee osteoarthritis in middle-aged subjects with knee pain: 12-year follow-up using clinical and radiographic criteria. *Ann Rheum Dis* 2009;*68:* 1890-3.

Toda, Y., Segal, N., Toda, T., Morimoto, T. and Ogawa, R. Lean body mass and body fat distribution in participants with chronic low back pain. *Arch Intern Med* 2000;*160:* 3265-9.

Tsang, A., Von Korff, M., Lee, S., Alonso, J., Karam, E., Angermeyer, M. C., Borges, G. L., Bromet, E. J., Demytteneare, K., de Girolamo, G., de Graaf, R., Gureje, O., Lepine, J. P., Haro, J. M., Levinson, D., Oakley Browne, M. A., Posada-Villa, J., Seedat, S. and Watanabe, M. Common chronic pain conditions in developed and developing countries: gender and age differences and comorbidity with depression-anxiety disorders. *J Pain* 2008;*9:* 883-91.

Tsiros, M. D., Coates, A. M., Howe, P. R., Grimshaw, P. N. and Buckley, J. D. Obesity: the new childhood disability? *Obes Rev* 2011;*12:* 26-36.

Upmark, M., Hemmingsson, T., Romelsjö, A., Lundberg, I. and Allebeck, P. Predictors of disability pension among young men: The role of alcohol and psychosocial factors. *Eur J Pub Health* 1997;*7:* 20-28.

Upmark, M., Lundberg, I., Sadigh, J., Allebeck, P. and Bigert, C. Psychosocial characteristics in young men as predictors of early disability pension with a psychiatric diagnosis. *Soc Psychiatry Psychiatr Epidemiol* 1999;*34:* 533-40.

Upmark, M., Lundberg, I., Sadigh, J. and Bigert, C. Conditions during childhood and adolescence as explanations of social class differences in disability pension among young men. *Scand J Public Health* 2001;*29:* 96-103.

Urquhart, D. M., Berry, P., Wluka, A. E., Strauss, B. J., Wang, Y., Proietto, J., Jones, G., Dixon, J. B. and Cicuttini, F. M. 2011 Young Investigator Award winner: Increased fat mass is associated with high levels of low back pain intensity and disability. *Spine (Phila Pa 1976)* 2011a;*36:* 1320-5.

Urquhart, D. M., Kurniadi, I., Triangto, K., Wang, Y., Wluka, A. E., O'Sullivan, R., Jones, G. and Cicuttini, F. M. Obesity is associated with reduced disc height in the lumbar spine but not at the lumbosacral junction. *Spine (Phila Pa 1976)* 2014;*39:* E962-6.

Urquhart, D. M., Tobing, J. F., Hanna, F. S., Berry, P., Wluka, A. E., Ding, C. and Cicuttini, F. M. What is the effect of physical activity on the knee joint? A systematic review. *Med Sci Sports Exerc* 2011b;*43:* 432-42.

Urwin, M., Symmons, D., Allison, T., Brammah, T., Busby, H., Roxby, M., Simmons, A. and Williams, G. Estimating the burden of musculoskeletal disorders in the community: the comparative prevalence of symptoms at different anatomical sites, and the relation to social deprivation. *Ann Rheum Dis* 1998;*57:* 649-55.

Waddel, G. and Burton, A. *Is work good for your health and well-being* Department for Work and Pensions, HM Government, London, 2006. Available: https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/214326/hwwb-is-work-good-for-you.pdf [Accessed 14.8.2016].

Wadsworth, M. E., Butterworth, S. L., Hardy, R. J., Kuh, D. J., Richards, M., Langenberg, C., Hilder, W. S. and Connor, M. The life course prospective design: an example of benefits and problems associated with study longevity. *Soc Sci Med* 2003;*57:* 2193-205.

Vague, J. La différenciation sexuelle; facteur déterminant des formes de l'obésité. *Presse Med* 1947;*55:* 339.

Valat, J. P., Genevay, S., Marty, M., Rozenberg, S. and Koes, B. Sciatica. *Best Pract Res Clin Rheumatol* 2010;*24:* 241-52.

Walker, B. F. The prevalence of low back pain: a systematic review of the literature from 1966 to 1998. *J Spinal Disord* 2000;*13:* 205-17.

van Rijn, R. M., Robroek, S. J., Brouwer, S. and Burdorf, A. Influence of poor health on exit from paid employment: a systematic review. *Occup Environ Med* 2014;*71:* 295-301.

Wang, Y., Simpson, J. A., Wluka, A. E., Teichtahl, A. J., English, D. R., Giles, G. G., Graves, S. and Cicuttini, F. M. Relationship between body adiposity measures and risk of primary knee and hip replacement for osteoarthritis: a prospective cohort study. *Arthritis Res Ther* 2009;*11:* R31.

Wellens, R. I., Roche, A. F., Khamis, H. J., Jackson, A. S., Pollock, M. L. and Siervogel, R. M. Relationships between the Body Mass Index and body composition. *Obes Res* 1996;*4:* 35-44.

WHO (World Health Organization). *Physical status: the use and interpretation of antropometry, Report of a WHO expert comittee.* Technical report Series, No 854, Geneva, 1995. Available: http://apps.who.int/iris/bitstream/10665/37003/1/WHO_TRS_854.pdf [Accessed 8.4.2016].

WHO (World Health Organization). *Obesity: preventing and managing the global epidemic. Report of a WHO Consultation on Obesity.*, Geneva, 2000. Available: http://www.who.int/nutrition/publications/obesity/WHO_TRS_894/en/ [Accessed 20.4.2016].

WHO (World Health Organization). *Waist Circumference and Waist–Hip Ratio: Report of a WHO Expert Consultation Geneva, 8–11 December 2008* Geneva, 2011. Available: http://apps.who.int/iris/bitstream/10665/44583/1/9789241501491_eng.pdf [Accessed 8.3.2016].

WHO (World Health Organization). *Obesity and overweight, Fact sheet No. 311. 2015.* Available: http://www.who.int/mediacentre/factsheets/fs311/en/ [Accessed 15.9.2015].

WHO (World Health Organization) and International Longevity Centre - UK. *The implications for training of embracing: a life course approach to Health.* World Health Organization, Geneva, 2000. Available: [Accessed 14.8.2016].

Vincent, H. K., Heywood, K., Connelly, J. and Hurley, R. W. Obesity and weight loss in the treatment and prevention of osteoarthritis. *PM R* 2012;*4:* S59-67.

Wittchen, H. U., Jacobi, F., Rehm, J., Gustavsson, A., Svensson, M., Jonsson, B., Olesen, J., Allgulander, C., Alonso, J., Faravelli, C., Fratiglioni, L., Jennum, P., Lieb, R., Maercker, A., van Os, J., Preisig, M., Salvador-Carulla, L., Simon, R. and Steinhausen, H. C. The size and burden of mental disorders and other disorders of the brain in Europe 2010. *Eur Neuropsychopharmacol* 2011;*21:* 655-79.

von Bondorff, M. B., Tormäkangas, T., Salonen, M., von Bonsdorff, M. E., Osmond, C., Kajantie, E. and Eriksson, J. G. Early life origins of all-cause and cause-specific disability pension: findings from the Helsinki Birth Cohort Study. *PLoS One* 2015;*10:* e0122134.

Woolf, A. D., Vos, T. and March, L. How to measure the impact of musculoskeletal conditions. *Best Pract Res Clin Rheumatol* 2010;*24:* 723-32.

Vos, T., Flaxman, A. D., Naghavi, M., Lozano, R., Michaud, C., Ezzati, M., Shibuya, K., Salomon, J. A., Abdalla, S., Aboyans, V., Abraham, J., Ackerman, I., Aggarwal, R., Ahn, S. Y., Ali, M. K., Alvarado, M., Anderson, H. R., Anderson, L. M., Andrews, K. G., Atkinson, C., Baddour, L. M., Bahalim, A. N., Barker-Collo, S., Barrero, L. H., Bartels, D. H., Basanez, M. G., Baxter, A., Bell, M. L., Benjamin, E. J., Bennett, D., Bernabe, E., Bhalla, K., Bhandari, B., Bikbov, B., Bin Abdulhak, A., Birbeck, G., Black, J. A., Blencowe, H., Blore, J. D., Blyth, F., Bolliger, I., Bonaventure, A., Boufous, S., Bourne, R., Boussinesq, M., Braithwaite, T., Brayne, C., Bridgett, L., Brooker, S., Brooks, P., Brugha, T. S., Bryan-Hancock, C., Bucello, C., Buchbinder, R., Buckle, G., Budke, C. M., Burch, M., Burney, P., Burstein, R., Calabria, B., Campbell, B., Canter, C. E., Carabin, H., Carapetis, J., Carmona, L., Cella, C., Charlson, F., Chen, H., Cheng, A. T., Chou, D., Chugh, S. S., Coffeng, L. E., Colan, S. D., Colquhoun, S., Colson, K. E., Condon, J., Connor, M. D., Cooper, L. T., Corriere, M., Cortinovis, M., de Vaccaro, K. C., Couser, W., Cowie, B. C., Criqui, M. H., Cross, M., Dabhadkar, K. C., Dahiya, M., Dahodwala, N., Damsere-Derry, J., Danaei, G., Davis, A., De Leo, D., Degenhardt, L., Dellavalle, R., Delossantos, A., Denenberg, J., Derrett, S., Des Jarlais, D. C., Dharmaratne, S. D., Dherani, M., Diaz-Torne, C., Dolk, H., Dorsey, E. R., Driscoll, T., Duber, H., Ebel, B., Edmond, K., Elbaz, A., Ali, S. E., Erskine, H., Erwin, P. J., Espindola, P., Ewoigbokhan, S. E., Farzadfar, F., Feigin, V., Felson, D. T., Ferrari, A., Ferri, C. P., Fevre, E. M., Finucane, M. M., Flaxman, S., Flood, L., Foreman, K., Forouzanfar, M. H., Fowkes, F. G., Franklin, R., Fransen, M., Freeman, M. K., Gabbe, B. J., Gabriel, S. E., Gakidou, E., Ganatra, H. A., Garcia, B., Gaspari, F., Gillum, R. F., Gmel, G., Gosselin, R., Grainger, R., Groeger, J., Guillemin, F., Gunnell, D., Gupta, R., Haagsma, J., Hagan, H., Halasa, Y. A., Hall, W., Haring, D., Haro, J. M., Harrison, J. E., Havmoeller, R., Hay, R. J., Higashi, H., Hill, C., Hoen, B., Hoffman, H., Hotez, P. J., Hoy, D., Huang, J. J., Ibeanusi, S. E., Jacobsen, K. H., James, S. L., Jarvis, D., Jasrasaria, R., Jayaraman, S., Johns, N., Jonas, J. B., Karthikeyan, G., Kassebaum, N., Kawakami, N., Keren, A., Khoo, J. P., King, C. H., Knowlton, L. M., Kobusingye, O., Koranteng, A., Krishnamurthi, R., Lalloo, R., Laslett, L. L., Lathlean, T., Leasher, J. L., Lee, Y. Y., Leigh, J., Lim, S. S., Limb, E., Lin, J. K., Lipnick, M., Lipshultz, S. E., Liu, W., Loane, M., Ohno, S. L., Lyons, R., Ma, J., Mabweijano, J., MacIntyre, M. F., Malekzadeh, R., Mallinger, L., Manivannan, S., Marcenes, W., March, L., Margolis, D. J., Marks, G. B., Marks, R., Matsumori, A., Matzopoulos, R., Mayosi, B. M., McAnulty, J. H., McDermott, M. M., McGill, N., McGrath, J., Medina-Mora, M. E., Meltzer, M., Mensah, G. A., Merriman, T. R., Meyer, A. C., Miglioli, V., Miller, M., Miller, T. R., Mitchell, P. B., Mocumbi, A. O., Moffitt, T. E., Mokdad, A. A., Monasta, L., Montico, M., Moradi-Lakeh, M., Moran, A., Morawska, L., Mori, R., Murdoch, M. E., Mwaniki, M. K., Naidoo, K., Nair, M. N., Naldi, L., Narayan, K. M., Nelson, P. K., Nelson, R. G., Nevitt, M. C., Newton, C. R., Nolte, S., Norman, P., Norman, R., O'Donnell, M., O'Hanlon, S., Olives, C., Omer, S. B., Ortblad, K., Osborne, R., Ozgediz, D., Page, A., Pahari, B., Pandian, J. D., Rivero, A. P., Patten, S. B., Pearce, N., Padilla, R. P., Perez-Ruiz, F., Perico, N., Pesudovs, K., Phillips, D., Phillips, M. R., Pierce, K., Pion, S., Polanczyk, G. V., Polinder, S., Pope, C. A., 3rd, Popova, S., Porrini, E., Pourmalek, F., Prince, M., Pullan, R. L., Ramaiah, K. D., Ranganathan, D., Razavi, H., Regan, M., Rehm, J. T., Rein, D. B., Remuzzi, G., Richardson, K., Rivara, F. P., Roberts, T., Robinson, C., De Leon, F. R., Ronfani, L., Room, R., Rosenfeld, L. C., Rushton, L., Sacco, R. L., Saha, S., Sampson, U., Sanchez-Riera, L.,

Sanman, E., Schwebel, D. C., Scott, J. G., Segui-Gomez, M., Shahraz, S., Shepard, D. S., Shin, H., Shivakoti, R., Singh, D., Singh, G. M., Singh, J. A., Singleton, J., Sleet, D. A., Sliwa, K., Smith, E., Smith, J. L., Stapelberg, N. J., Steer, A., Steiner, T., Stolk, W. A., Stovner, L. J., Sudfeld, C., Syed, S., Tamburlini, G., Tavakkoli, M., Taylor, H. R., Taylor, J. A., Taylor, W. J., Thomas, B., Thomson, W. M., Thurston, G. D., Tleyjeh, I. M., Tonelli, M., Towbin, J. A., Truelsen, T., Tsilimbaris, M. K., Ubeda, C., Undurraga, E. A., van der Werf, M. J., van Os, J., Vavilala, M. S., Venketasubramanian, N., Wang, M., Wang, W., Watt, K., Weatherall, D. J., Weinstock, M. A., Weintraub, R., Weisskopf, M. G., Weissman, M. M., White, R. A., Whiteford, H., Wiersma, S. T., Wilkinson, J. D., Williams, H. C., Williams, S. R., Witt, E., Wolfe, F., Woolf, A. D., Wulf, S., Yeh, P. H., Zaidi, A. K., Zheng, Z. J., Zonies, D., Lopez, A. D., Murray, C. J., AlMazroa, M. A. and Memish, Z. A. Years lived with disability (YLDs) for 1160 sequelae of 289 diseases and injuries 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet* 2012;*380:* 2163-96.

Vuolteenaho, K., Koskinen, A. and Moilanen, E. Leptin - a link between obesity and osteoarthritis. applications for prevention and treatment. *Basic Clin Pharmacol Toxicol* 2014;*114:* 103-8.

Yip, Y. B., Ho, S. C. and Chan, S. G. Tall stature, overweight and the prevalence of low back pain in Chinese middle-aged women. *Int J Obes Relat Metab Disord* 2001;*25:* 887-92.

Yu, S. Editor's choice: The life-course approach to health. *Am J Public Health* 2006;768.

Zhang, W., Doherty, M., Peat, G., Bierma-Zeinstra, M. A., Arden, N. K., Bresnihan, B., Herrero-Beaumont, G., Kirschner, S., Leeb, B. F., Lohmander, L. S., Mazieres, B., Pavelka, K., Punzi, L., So, A. K., Tuncer, T., Watt, I. and Bijlsma, J. W. EULAR evidence-based recommendations for the diagnosis of knee osteoarthritis. *Ann Rheum Dis* 2010;*69:* 483-9.

Zheng, H. and Chen, C. Body mass index and risk of knee osteoarthritis: systematic review and meta-analysis of prospective studies. *BMJ Open* 2015;*5:* e007568.

Zhou, Z. Y., Liu, Y. K., Chen, H. L. and Liu, F. Body mass index and knee osteoarthritis risk: a dose-response meta-analysis. *Obesity (Silver Spring)* 2014;*22:* 2180-5.

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