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Musculoskeletal Disorders in Male Finnish Conscripts

Importance of physical fitness as a risk factor, and effectiveness of neuromuscular exercise and counseling in the prevention of acute injuries, and low back pain and disability

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ACADEMIC DISSERTATION
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This thesis is based on the following original publications, which are referred to in the text by the Roman numerals I-VI:

I Taanila H, Suni J, Pihlajamaki H, Mattila VM, Ohrankammen O, Vuorinen P, Parkkari J (2009): Musculoskeletal disorders in physically active conscripts: a one-year follow-up study in the Finnish Defence Forces. BMC Musculoskelet Disord 10:89.

II Taanila H, Suni J, Pihlajamaki H, Mattila VM, Ohrankammen O, Vuorinen P, Parkkari J (2010): Aetiology and risk factors of musculoskeletal disorders in physically active conscripts: a follow-up study in the Finnish Defence Forces. BMC Musculoskelet Disord 11:146.

III Taanila HP, Suni JH, Pihlajamaki HK, Mattila VM, Ohrankammen O, Vuorinen P, Parkkari JP (2012): Predictors of low back pain in physically active conscripts with special emphasis on muscular fitness. Spine J 12: 737–748.

IV Taanila H, Hemminki AJ, Suni JH, Pihlajamaki H, Parkkari J (2011): Low physical fitness is a strong predictor of health problems among young men: a follow-up study of 1411 male conscripts. BMC Public Health 11: 590.

V Parkkari J, Taanila H, Suni J, Mattila VM, Ohrankammen O, Vuorinen P, Kannus P, Pihlajamaki H (2011): Neuromuscular training with injury prevention counselling to decrease the risk of acute musculoskeletal injury in young men during military service: a population-based, randomised study. BMC Med 9: 35.

VI Suni JH, Taanila H, Mattila VM, Ohrankammen O, Vuorinen P, Pihlajamaki H, Parkkari J (2012): Neuromuscular exercise and counseling decrease absenteeism due to low back pain in young conscripts - a randomized, population-based primary prevention study. Spine (in press).

ABBREVIATIONS

AIT	advanced individual training (in U.S. Military)
BMI	body mass index
CI	confidence interval
HR	hazard ratio
ICD	International Classification of Diseases
ITT	intention to treat
LBP	low back pain
LR	likelihood ratio
MSD	musculoskeletal disorder
MSDI	incidence of musculoskeletal disorders
MTSS	medial tibial stress syndrome
NME	neuromuscular exercise
NNT	number needed to treat
NZ	neutral zone (of lumbar spine)
OR	odds-ratio
RCT	randomized controlled trial
RR	rate ratio, relative risk
SD	standard deviation
WC	waist circumference

ABSTRACT

The core of the Finnish Defence Forces is based on mandatory military service. Although the majority of European countries count on professional soldiers in their defence strategy, the Finnish conscription system has maintained its high coverage: approximately 80% of young men in Finland enter into military service. The purpose of this dissertation was to investigate the occurrence, nature, severity, injury mechanisms and risk factors of musculoskeletal disorders (MSDs) including low back pain (LBP) and medical discharge in physically active male Finnish conscripts, and examine whether a neuromuscular training with injury prevention counseling, designed to enhance body control, motor skills and knowledge of prevention methods, was effective in preventing acute musculoskeletal injuries and LBP in conscripts during military training.

First, the occurrence, anatomical location, severity and etiology including injury mechanisms and intrinsic risk factors for MSDs among conscripts were examined in studies I and II. Two successive cohorts of 18 to 28-year-old male conscripts (N = 944, median age 19) were followed for six months. MSDs, including overuse and acute injuries, treated at the garrison clinic were identified and analysed. Associations between MSDs and risk factors were examined by multivariate Cox's proportional hazard models.

Among 944 conscripts, there were 1629 MSDs and 2879 health clinic visits due to MSDs. The event-based incidence rate for MSD was 10.5 (95% confidence interval (CI): 10.0–11.1) per 1000 person-days. Most MSDs were in the lower extremities (65%) followed by the back (18%), upper extremities including shoulders (11%), head (2%) and other parts of the body (3%). Overuse-related MSDs (70%) were more than twice as prevalent as traumatic MSDs (30%). The majority (69%) of disorders were classified as minor leading to a maximum 3-day exemption from military training, while mild (4-7 off-duty days) MSDs accounted for 20%, moderate (8-28 off-duty days) for 8% and severe (>28 off-duty days) for 3% of all cases. Fractures, bone stress injuries, dislocations and internal knee injuries represented the most severe injuries.

Of the traumatic causes of acute MSDs, falling down (17%) and collision with an object (16%) were most commonly associated with MSDs. Marching and running (36%) were the most common activities associated with overuse-related MSDs,

followed by carrying and lifting loads (10%). Predictive associations between intrinsic risk factors and MSDs were examined using multivariate Cox's proportional hazard models. The strongest baseline factors associated with MSDs were poor result in the combined outcome of a 12-minute running test and back lift test (hazard ratio (HR) 2.9; 95% CI: 1.9–4.6). In addition, obesity measured as high waist circumference (WC) (HR 1.7; 95% CI: 1.3–2.2) or high body mass index (BMI) (HR 1.8; 95% CI: 1.3–2.4), earlier musculoskeletal symptoms (HR 1.7; 95% CI: 1.3–2.1) and poor school success (educational level and grades combined; HR 2.0; 95% CI: 1.3–3.0) were associated with MSDs.

Further and more specifically, the third study examined incidence, severity and predictors of LBP. Four successive cohorts of male conscripts without LBP before military entry (N = 982) were followed for 6 months. Conscripts who suffered from LBP were identified and treated at the garrison clinic.

The cumulative incidence of LBP was 16%. Of those 27% (n=42) had recurrent LBP, while the LBP incidence rate was 1.2 (95% CI: 1.0–1.4) per 1000 person-days. The majority (75%) of LBP was classified as minimal, leading to a maximum 3-day exemption from military training, while mild LBP accounted for 15%, moderate for 7%, and severe for 3% of all cases. Five previously symptomless conscripts were discharged prematurely due to LBP. Conscripts with low educational level had increased risk for incidence of LBP (HR 1.6, 95% CI: 1.1–2.3). Moreover, conscripts with low dynamic trunk muscle endurance and low aerobic endurance simultaneously (i.e. having co-impairment) at baseline had increased risk for incidence of LBP. The strongest risk factor was co-impairment of trunk muscular endurance in tests of back-lift and push-up (HR 2.8; 95% CI: 1.4–5.9).

The fourth study examining occurrence, reasons and risk factors of military discharge found that low physical fitness is a strong predictor of health problems leading to premature discharge from military service. Of 1411 participants, 9.4% (n=133) were discharged prematurely for medical reasons after the 2-week run-in period, mainly musculoskeletal (44%, n=59) and mental and behavioral (29%, n=39) disorders. Low levels of physical fitness assessed with a 12-min running test (HR 3.3; 95% CI: 1.7–6.4), poor school success (HR 4.6; 95% CI: 2.0-11.0), poor self-assessed health (HR 2.8; 95% CI: 1.6–5.2), and not belonging to a sports club (HR 4.9; 95% CI: 1.2–11.6) were most clearly associated with medical discharge in a graded manner.

The following two studies investigated the effect of neuromuscular exercise (NME) with injury prevention counseling to decrease the risk of acute musculoskeletal injuries (study V) and LBP (study VI) during military service. Participants were conscripts of four successive age cohorts (*N* = 1912). In the pre-study year, before adoption of the intervention, two successive cohorts of four companies (*N* = 944) were followed prospectively for 6 months to study the baseline incidence of acute injuries and LBP. Then the group randomization was carried out. In the intervention year, two new cohorts of the same companies (*N* = 968) were followed for 6 months: 501 conscripts participated in NME (intervention group: anti-tank and engineer companies) and 467 conscripts conducted their service as usual in the control group (signal and mortar companies).

A NME program and educational counseling were used to reduce acute extremity injuries, and LBP and disability. The NME program was aimed to enhance conscripts' motor and muscular performance with emphasis on the control of the lumbar neutral zone (NZ) and specifically avoiding full lumbar flexion. Counseling was based on the cognitive-behavior modeling. The aims were to increase awareness of military tasks that could lead to acute injuries or were potentially harmful to the lower back, and to enhance understanding and skills to perform them in a less risky manner.

In the intervention companies, the risk for acute ankle injury decreased significantly compared to the control companies (adjusted HR 0.34; 95% CI: 0.15–0.78, p=0.011). This risk decline was observed in conscripts with low, as well as moderate-to-high, baseline fitness. In the latter group of conscripts, the risk of upper extremity injuries also decreased significantly (adjusted HR 0.37; 95% CI 0.14–0.99, p=0.047). In addition, the intervention companies tended to have fewer time losses due to injuries (adjusted HR 0.55; 95% CI 0.29–1.04).

In the study VI, effectiveness of the NME and counseling for reducing the incidence of LBP and disability was investigated in conscripts with a healthy back, assessed by a questionnaire and routine medical screening by a physician at the beginning of military service. Altogether 472 (23%) conscripts were excluded from the analyses due to previous LBP. Total number of off-duty days due to LBP was significantly decreased in the intervention companies compared to the controls (adjusted HR 0.42; 95% CI 0.18–0.94, p = 0.035). The number of LBP cases, number of health clinic visits due to LBP, and number of the most severe cases showed a similar decreasing trend, but

without statistical significance. The findings indicated that exercise and education to improve control of the lumbar NZ had a prophylactic effect on LBP-related off-duty service days in the military environment, and may provide a target for the primary prevention of LBP.

The findings of this thesis indicate that MSDs, especially those involving lower extremities and low back, are common among a population-based sample of Finnish conscripts during physically demanding military service. However, a neuromuscular warm-up program with injury prevention counseling designed to enhance motor skills and body control especially considering lumbar NZ, and knowledge of prevention methods can clearly decrease the risk for acute ankle injuries and LBP. Hence, neuromuscular training programs can be recommended to be included in the weekly training schedules of conscripts. Injury prevention counseling especially at the beginning of military service would help to control the injury risk. A similar neuromuscular training as a warm-up or cool-down program for sports and physical exercise as well as in school sports lessons would offer means to reduce the burden of injuries and LBP, and consequently enhance the positive effects of regular physical activity on health.

TIIVISTELMÄ

Väitöskirja selvittää suomalaisten varusmiesten tuki- ja liikuntaelinvaivojen (tule-vaivojen; sisältäen tapaturma- ja rasitusperäiset vammat) yleisyyttä, syitä ja riskitekijöitä. Lisäksi tutkittiin, voidaanko alaselän neutraaliasennon hallintaa ja hermolihasjärjestelmää aktivoivan harjoitteluohjelman ja neuvonnan avulla vähentää äkillisiä tule-vammoja ja alaselkäkipua sekä näiden aiheuttamia poissaoloja varusmiespalveluksesta.

Väitöskirja rakentuu Varusmiesten selkävaivojen ja tapaturmien ehkäisytutkimuksen (VASTE) artikkeleihin. Tutkimus toteutettiin Pääesikunnan, Sotilaslääketieteen keskuksen, Porin Prikaatin ja UKK-instituutin yhteistyönä Porin Prikaatissa Säkylässä 24 kuukauden mittaisena prospektiivisena kohorttitutkimuksena, jossa neljää peräkkäistä saapumiserää vuosina 2006–2008 (N = 2057) seurattiin kuuden kuukauden ajan varusmiespalveluksen ensimmäisestä päivästä lähtien. Palveluksen alkuvaiheessa varusmiehille tehdyssä kyselyssä kartoitettiin alokkaiden sosioekonomista taustaa, terveyttä ja terveyskäyttäytymistä. Lisäksi varusmiehet suorittivat kuntotestit (12-minuutin Cooperin testin ja viisi eri lihaskuntotestiä). Tiedot tule-vaivoista ja palveluksen keskeytyksistä kerättiin varuskunnan potilasrekistereistä. Tutkimuksen interventio-osuudessa selvitettiin, vähentääkö varusmiespalveluksen alkuvaiheen intensiivinen lihaskuntoharjoittelu ja varusmiestehtäviin sidottu neuvontaprosessi selkävaivojen ja tapaturmien esiintyvyyttä kuuden kuukauden varusmiespalveluksen aikana. Tutkimuksen päärahoittajina olivat opetus- ja kulttuuriministeriö sekä Maanpuolustuksen tieteellinen neuvottelukunta (MATINE).

Kahdessa ensimmäisessä osatyössä selvitettiin tule-vaivojen ilmaantuvuutta, anatomista sijaintia, vakavuutta sekä tule-vaivojen syitä ja riskitekijöitä. Kahta peräkkäistä 18–28-vuotiaiden varusmiesten (N = 944, mediaani-ikä 19) saapumiserää seurattiin kuusi kuukautta asepalveluksen ensimmäisestä päivästä lähtien. Kuuden kuukauden palveluksen aikana 69 % varusmiehistä haki varuskunnan terveysasemalta apua tule-vaivaan. Vaivojen ilmaantuvuus oli 10,5 (95 % LV: 10,0–11,1) tuhatta henkilöpäivää kohden. Kahdella kolmasosalla hoitoa hakeneista varusmiehistä tule-vaivoja oli enemmän kuin yksi. Suurin osa tule-vaivoista kohdistui alaraajoihin (65 %) ja selkään (18 %). Vähemmän tule-vaivoja oli yläraajoissa (11 %) ja keskivartalossa (3 %). Rasitusvammat (70 %) olivat yleisempiä kuin äkilliset vammat (30 %). Yleisimmät

vammatyypit olivat alaraajan rasitusvammat, alaselkäkipu ja nivelten nyrjähdykset. Valtaosa (69 %) tule-vaivoista oli lieviä ja aiheutti korkeintaan kolmen päivän poissaolon asepalveluksesta. Vakavimmista vammoista yleisimpiä olivat äkilliset murtumat (n=15), rasitusmurtumat (n=15), luun sijoiltaan menot (n=22) ja polven sisäiset vammat (n=25). Ne aiheuttivat pitkiä poissaoloja palveluksesta tai varusmiespalveluksen keskeytymisen.

Kaatuminen (17 %) ja törmääminen (16 %) olivat yleisimmät syyt äkillisiin vammoihin. Rasitusvammojen taustalla oli useimmiten marssiminen tai juoksu (36 %) sekä taakkojen nostaminen ja kantaminen (10 %). Varusmiesten tule-vaivojen vahvin riskitekijä oli huono kestävyyskunto Cooperin testissä yhdistettynä huonoon lihaskuntoon selkälihastestissä (toistoja 1 min aikana), (HR 2,9; 95 % LV: 1,9–4,6). Lisääntynyttä varusmiehen vammariskiä ennustivat myös vyötärölihavuus (>102 cm), (HR 1.7; 95 % LV: 1.3–2.2) ja suuri painoindeksi (BMI>30), (HR 1,8; 95 % LV: 1,3–2,4) sekä huono koulumenestys (HR 2,0; 95 % LV: 1,3–3,0). Tutkimustulosten perusteella nykyistä paremmalla painon hallinnan ohjauksella voisi olla edullisia vaikutuksia vammariskiin varusmiespalveluksen aikana. Hyvä tulos (≥ 2600 m) 12 minuutin juoksutestissä on suotava harjoitusohjelman tavoite ennen asepalvelukseen astumista.

Kolmannessa osatyössä selvitettiin alaselkäkivun ilmaantumisen riskitekijöitä varusmiespalveluksen aikana aiemmin terveillä varusmiehillä. Ne varusmiehet, joilla oli esiintynyt alaselkäkipua jo ennen palvelukseen astumista, suljettiin pois analyyseistä. Kuuden kuukauden aikana 16 % varusmiehistä haki apua varuskunnan terveysasemalta alaselkäkivun vuoksi. Neljännes hoitoa hakeneista kärsi toistuvasta selkäkivusta. Selkäkivun ilmaantuvuus oli 1,2 (95 % LV: 1,0–1,4) tuhatta henkilöpäivää kohden. Viisi (0,5 %) aiemmin oireetonta varusmiestä keskeytti varusmiespalveluksen alaselkäkivun vuoksi. Huono koulumenestys (HR 1,6; 95 % LV: 1,1–2,3) oli yhteydessä alaselkäkivun ilmaantuvuuteen. Huono dynaaminen vartalonlihasten kestävyys yhdistettynä huonoon aerobiseen kuntoon (co-impairment) oli selkeästi yhteydessä alaselkäkivun ilmaantumiseen. Vahvin riskitekijä oli huono lihaskunto sekä punnerrus- että selkälihastestissä (HR 2,8; 95 % LV: 1,4–5,9).

Neljännessä osatyössä tutkittiin varusmiespalveluksen keskeytymisen syitä ja riskitekijöitä, koska aiempien tutkimusten perusteella varusmiespalveluksen keskeytyminen on yhteydessä sosioekonomiseen syrjäytymiseen ja suurempaan

sairastavuuteen sekä ennenaikaiseen kuolleisuuteen myöhemmällä iällä. Tutkimme, onko varusmiespalveluksen keskeytymisen taustalla samoja riskitekijöitä kuin lievempien tule-vaivojen ja alaselkäkivun kohdalla. Ensimmäisen kahden viikon aikana suoritetun lääkärintarkastusten perusteella tapahtuneita keskeytyksiä ei tutkimuksessa analysoitu, koska jo ennen palvelusta alkaneet tule-vaivat haluttiin sulkea pois. Kuuden kuukauden asepalveluksen aikana 133 (9,4 %) varusmiestä keskeytti palveluksen lääketieteellisistä syistä kahden ensimmäisen viikon jälkeen. Tule-vaivat sekä toisaalta mielenterveyden ongelmat olivat yleisimmät syyt keskeytymiseen. Huono fyysisen kunto (12 min juoksutesti < 2200m, HR 3,3; 95 % LV: 1,7–6,4) ja heikko koulumenestys (HR 4,6; 95 % LV: 2.0–11.0) olivat vahvimmin yhteydessä palveluksen keskeytymiseen. Lisäksi varusmiehen huono itsearvioitu terveys (HR 2,8; 95 % LV: 1,6–5,2), vyötärölihavuus (HR 2,4; 95 % LV: 1,3–4,6) ja urheiluseuraan kuulumattomuus (HR 4,9; 95 % LV: 1,2–11,6) olivat merkitsevästi yhteydessä palveluksen keskeytymiseen.

Kahdessa viimeisessä osatyössä tutkittiin hermolihasjärjestelmää aktivoivan lihaskuntoharjoitteiden ja neuvonnan vaikutusta varusmiesten vammariskiin. Mielenkiinnon kohteena viidennessä osatyössä olivat äkilliset tule-vammat ja kuudennessa osatyössä alaselkäkivun ilmaantuvuus ja sen aiheuttamat poissaolopäivät varusmiespalveluksesta. Tutkimukseen osallistui neljän tutkimukseen valitun yksikön 1912 miespuolista varusmiestä neljästä peräkkäisestä saapumiserästä Porin Prikaatissa. Tutkimus alkoi vuoden seurantajaksolla, jotta äkillisten tule-vammojen ja alaselkäkivun ilmaantuvuus lähtötilanteessa saatiin selvitetyksi. Interventiovuoden alkaessa yksiköt satunnaistettiin harjoitus- (panssarintorjunta- ja pioneerikomppania) ja kontrolliryhmään (viesti- ja kranaatinheitinkomppania) siten, että molempiin ryhmiin tuli kaksi yksikköä. Harjoitusryhmän varusmiehet osallistuivat interventioon, joka sisälsi liikehallintakykyä (tasapaino, koordinaatio, ketteryys) ja tuki- ja liikuntaelimistön kuntoa (notkeus, lihasvoima) kehittäviä harjoitteita. Niissä keskityttiin erityisesti alaselän neutraaliasennon hallintaan. Harjoitusryhmän varusmiehille annettiin lisäksi oppitunti yleisimmistä liikuntavammoista ja niiden ensiavusta sekä alaselän neutraaliasennon hallinnasta varusmiespalveluksen arkirutiineissa. Neuvontaa tuki varusmiehille jaettu opaskirjanen, jossa kuvien avulla neuvottiin neutraaliasennon hallinta palvelustehtävissä ja arkielämässä.

Interventio vähensi äkillisten nilkkavammojen riskiä merkitsevästi (HR 0,34; 95 % LV: 0,15–0,78, p=0,011). Lisäksi hyväkuntoisten varusmiesten ryhmässä äkilliset yläraajavammat vähenivät (HR 0,37; 95 % LV: 0,14–0,99, p=0,047) ja kokonaisuutena interventioryhmässä havaittiin laskeva trendi palveluksesta poissaoloissa äkillisten tule-vaivojen vuoksi (HR 0,55; 95 % LV: 0,29–1,04).

Kuudennessa osatyössä harjoitusohjelman ja neuvonnan vaikutusta alaselkäkivun ilmaantuvuuteen ja palveluksesta poissaoloihin tutkittiin aiemmin terveillä varusmiehillä. Kaikkiaan 472 (23 %) varusmiestä, joilla oli esiintynyt alaselkäkipua jo ennen palvelukseen astumista, suljettiin pois analyyseistä. Alaselkäkivusta aiheutuvien poissaolopäivien määrä väheni merkitsevästi interventioryhmässä verrattuna kontrolliryhmään (HR 0,42; 95 % LV: 0,18–0,94, p=0,035). Alaselkäkivun ilmaantuvuudessa, alaselkäkivun aiheuttaminen terveysasemakäyntien määrässä ja pitkäkestoisten alaselkäkipujen määrässä havaittiin myös laskeva trendi, kuitenkin ilman tilastollista merkitsevyyttä. Tutkimuksen havainnot osoittivat, että alaselän neutraaliasennon hallinnan parantamiseen tähtäävä lihaskuntoharjoittelu ja neuvonta vähentävät alaselkäkivusta aiheutuvia palveluksesta poissaoloja.

Väitöskirjatutkimuksen tulokset osoittavat, että alaraajojen ja alaselän vaivat ovat yleisiä nuorten suomalaisten varusmiesten keskuudessa. Vammoja voidaan kuitenkin huomattavasti vähentää, kun hermolihasjärjestelmän toimintaa aktivoiviin liikehallintakykyä ja erityisesti alaselän neutraaliasennon hallintaa kehittäviin lihaskuntoharjoitteisiin yhdistetään neuvonta, jolla pyritään vähentämään varusmiespalveluksen arkirutiinien aiheuttamaa alaselän kuormittumista. Lihaskuntoharjoittelua voidaankin suositella integroitavaksi osaksi viikoittaista varusmiespalvelusohjelmaa. Lisäksi tule-vaivojen ehkäisemiseen tähtäävä käytännönläheinen neuvonta kuvien avulla, erityisesti varusmiespalveluksen alussa, voi auttaa vammojen vähentämisessä. Vastaava harjoitusohjelma ja neuvonta oikein toteutettuna voivat olla toimiva keino äkillisten alaraajavammojen ja alaselkäkivun ennaltaehkäisyyn varusmiespalveluksen ulkopuolellakin, kuten kouluissa ja urheiluseuroissa, ja täten vahvistaa fyysisen aktiivisuuden myönteisiä vaikutuksia terveyteen.

1. INTRODUCTION

Musculoskeletal injuries and disorders are the main reasons for morbidity and temporary disability in military populations (Jones & Knapik 1999; Mattila et al. 2006; Yancosek et al. 2012). Health clinic visit rates are approximately equal for injuries and illnesses in the military environment, but the morbidity associated with injuries is over five times greater than that associated with illness (Jones & Knapik 1999; Kaufman et al. 2000; Knapik et al. 2004a). Moreover, musculoskeletal disorders (MSDs) are the second highest reason for premature discharge from military service in the Finnish Defence Forces, and their number increased clearly at the turn of the millennium (Sahi & Korpela 2002). In Finland, military service or alternative civil service is compulsory for all male citizens over 18 years of age, the duration varying from six to twelve months. Given that 80% of young men in Finland enter into military service, the high number of MSDs affects public health (Mattila et al. 2006).

The prevalence of LBP among adolescents and young adults in civil (Hakala et al. 2002; Hestbaek et al. 2006) and military populations (Heir & Glomsaker 1996; Hestbaek et al. 2005) is high, affecting approximately 50% of people by the age of 20 (Leboeuf-Yde & Kyvik 1998). Furthermore, hospitalization for LBP during military service causes significant morbidity in previously healthy Finnish conscripts (Mattila et al. 2009). Extensive evidence indicates that LBP during young adulthood predicts LBP later in life (Harreby et al. 1996; Hellsing & Bryngelsson 2000; Hestbaek et al. 2006), which is distressing and emphasizes the need to focus on the prevention of LBP in young populations.

Professional soldiers in the United States (US) have been the major target of injury research in the army environment (Gardner et al. 1988; Jones & Knapik 1999; Kaufman et al. 2000; Knapik et al. 2004a). Despite the large number of injuries, studies concerning the causes and risk factors for musculoskeletal injuries or disorders during conscription military service are sparse (Mattila et al. 2007a). The results from conscription army are not directly comparable with those of a professional army. The

number of conscripts, as well as practices and training schedules differ substantially from those in the professional army.

Not only are injuries the biggest health problem of the military services, they are also a complex problem. They may cause morbidity and disability in later life. Most commonly long-term consequences are in form of osteoarthritis and chronic LBP (Hellsing & Bryngelsson 2000; Ulaska et al. 2001; Patzkowski et al. 2012).

Before developing and initiating a preventive measure or program for MSDs in a specific environment, the epidemiology and etiology of injuries, including incidence, severity, risk factors and mechanisms, need to be identified (van Mechelen et al. 1992).

In this thesis, these steps in the sequence of sports injury prevention are followed. The aim is to introduce and examine the effect of neuromuscular exercise and educational counseling on the incidence of MSDs in Finnish conscripts during physically demanding military training.

2. REVIEW OF THE LITERATURE

2.1 Military training in Finland

Soldiers must develop and maintain high levels of physical fitness in preparation for the physically demanding tasks they perform; this training can be compared to athletes preparing for competition (Jones & Knapik 1999). The potential demands of combat missions require military forces to routinely engage in vigorous physical training (Jones & Knapik 1999).

In the beginning of military service, all Finnish conscripts perform 8 weeks of basic training consisting of varying physical activities including marching, running, cycling, skiing, orienteering, swimming, drill training and combat training. There is an average of 17 hours of military actions per week with a gradual increase in intensity. Most of this time is low-to-moderate intensity activity. The rest breaks are organized in such manner that conscripts manage to perform physical training regularly. During combat training and marching, the total weight of personal military equipment is approximately 26 kg to 36 kg. However, during the first weeks of service, the total weight of military equipment is lighter starting from 10 kg. The basic training period is followed by diverse training programs depending on the company and service duration. Over the following four months of service, however, the volume of moderate and high-intensity physical training is maintained approximately at the same level in the different companies. During the first 6 months of military service, conscripts are expected to complete approximately 450 hours of instructed physical training. These main structures of military training program have been similar since July 1998 when the volume of physical exercise was doubled in Finnish Defence Forces (Sahi & Korpela 2002). In addition to the compulsory supervised training, garrisons offer a variety of opportunities for physical activity during leisure time including jogging, weight training and lifting and team sports.

Conscript with poor physical fitness are not able to perform military tasks as required in combat field operations (Lindholm et al. 2008). In the Finnish Defence

Forces, the objective in physical training is to improve physical fitness of low-fit incoming conscripts during following 6 months of service. For the conscripts who have poor aerobic fitness in the beginning of the service, the training target is to achieve a test result of 2400-2600 metres in 12 min running before the end of the service according to the Physical Training Strategy of Finnish Defence Forces (2007). Considering aerobic fitness, the minimum level able to perform battle field activities is estimated to be about 42 ml/kg/min, which corresponds the 12 min running test result of about 2400 metres (Cooper 1968; Lindholm et al. 2008). Considering muscular fitness, the minimum objective is to achieve good muscular fitness level before the end of the military service. This level is estimated to correspond the minimum combat field requirements for muscular fitness. These requirements include ability to perform heavy lifting, digging and long marches on foot with 25-65 kg carriage (Santtila et al. 2006; Lindholm et al. 2008).

The physical training program of Finnish Defence Forces is effective in enhancing physical fitness measured by maximal oxygen uptake (Santtila et al. 2008) and improving cardiovascular risk factors (Cederberg et al. 2011). Increasing obesity has become one of the major challenges in conscript military training during last decades (Santtila et al. 2006) and the importance of gradual increase in physical load has been emphasized to prevent overuse-related MSDs (Sahi & Korpela 2002).

2.2 Epidemiology of musculoskeletal disorders (MSDs) in military training

2.2.1 Incidence, nature and severity

Despite the large number of injuries, studies concerning incidence, nature and severity of MSDs during compulsory military service are sparse. In the Finnish Defence Forces, in addition to hospital register studies (Mattila et al. 2006; Mattila et al. 2007a), some specific conditions in small target populations have been described such as patellar dislocations (Visuri & Maenpaa 2002), LBP (Ulaska et al. 2001), knee injuries (Kuikka et al. 2011), and stress fractures (Salminen et al. 2003; Niva 2006; Pihlajamaki et al. 2006; Ruohola 2007). In other Scandinavian conscription armies, some larger scale

epidemiological studies have examined MSDs, but the study populations have been rather small or follow-up time limited (Heir & Eide 1996; Heir & Eide 1997; Rosendal et al. 2003; Larsson et al. 2009).

In conscript training, Heir and Glomsaker (1996) monitored 6488 Army, Air Force and Navy conscripts during 6–10-wk period of military basic training in Norway and reported an incidence of approximately 4.2 per 1000 person-days for musculoskeletal injuries, including LBP. Heir and Eide (Heir & Eide 1996) followed 912 Norwegian male conscripts and reported a person-based incidence of 4.7 per 1000 person-days for musculoskeletal injuries. Rosendal et al. (2003) prospectively followed 330 Danish conscripts for 12 weeks in military basic training and reported an overall injury occurrence rate of 28% and a person-based incidence rate of approximately 3.5 per 1000 person-days. These findings cannot be generalised to Finnish Defence Forces, because in Norway less than 30%, in Denmark less than 8%, and in Sweden less than 6% of young men complete their military service (Appelqvist-Schmidlechner et al. 2010). Finland differs from all others Northern European countries considering coverage of the compulsory military service. In Finland 80% of young men enter into military and over 80% of them completed their service in late 2000s (Mattila et al. 2006; Appelqvist-Schmidlechner et al. 2010). In Finland, there are no previous peer-reviewed studies considering incidence and nature of MSDs leading to visit in garrison clinic. A study concerning all traumatic injury hospitalizations in Finnish Defence Forces reported an incidence of 94 per 1000 conscripts per year (Mattila et al. 2006).

In professional armies, person-based injury incidence rates during military training are usually slightly higher than in mandatory armies, ranging from 6 to 14 per 100 male recruits per month (2 to 5 per 1000 person-days) during basic training (Jones & Knapik 1999; Kaufman et al. 2000; Knapik et al. 2001b) to as high as 30 per 100 per month (10 per 1000 person-days) for Naval Special Warfare training in U.S. Army (Kaufman et al. 2000).

Several previous studies report that the majority of MSDs affects the lower limb in military recruits (Almeida et al. 1999b; Kaufman et al. 2000; Piantanida et al. 2000; Snedecor et al. 2000; Blacker et al. 2008) as well as conscripts in mandatory armies (Heir & Glomsaker 1996; Heir & Eide 1997; Rosendal et al. 2003; Mattila et al. 2006). Usually the proportion of MSDs affecting the lower extremity varies between 60-80% of all MSDs (Jones et al. 1993b; Heir & Glomsaker 1996; Rudzki 1997b; Almeida et

al. 1999b; Snedecor et al. 2000; Knapik et al. 2001b; Blacker et al. 2008). It seems that the military basic training exerts a load particularly on the lower limbs and especially at or below the knee level (Kaufman et al. 2000).

Overuse injuries are more common than acute injuries in military environment according to previous studies conducted both in professional (Jones et al. 1993b; Kaufman et al. 2000; Songer & LaPorte 2000; Knapik et al. 2001b) and mandatory armies (Heir & Glomsaker 1996; Heir & Eide 1997; Mattila et al. 2006). This differs substantially from the distribution seen in general population, in which only about 30% of physical activity-related injuries originate from overuse (Parkkari et al. 2004). There is not unanimous insight into the most common diagnoses encountered in military outpatient clinics probably due to different categorising methods. The definitions and classifications may vary between studies which complicates the comparison between studies considering overuse-related diagnoses (Kaufman et al. 2000). For overuse-related knee pain, for instance, there are several different diagnoses not easy to distinguish including iliotibial band syndrome, patellar tendinitis and patellofemoral syndrome.

Heir and Glomsaker (1996) reported that LBP, knee overuse injuries and Achilles tendinitis are the most common diagnoses in Norwegian conscripts. Of the acute injuries, several studies list ankle sprains and muscle strains the most common diagnoses (Jones et al. 1993b; Knapik et al. 1993; Heir & Glomsaker 1996; Almeida et al. 1999b; Piantanida et al. 2000; Billings 2004). Overall, it seems that basic military training especially exposes conscripts to overuse injuries and LBP (Jones et al. 1993a; Heir & Glomsaker 1996; Kaufman et al. 2000; Knapik et al. 2001b). In U.S. Military, an extensive study was organized by Department of Defense to develop a systematic, coordinated approach to injury prevention (Ruscio et al. 2010). In first step, the top five injuries ranked by the number of days of limited duty were identified in as: lower extremity overuse (pain, inflammation, and stress fractures), lower extremity fractures, upper extremity fractures, torso overuse (pain, inflammation, and stress fractures), and lower extremity sprains and strains. Altogether injuries accounted for 25 million days of limited duty in U.S. Military in 2004 (Ruscio et al. 2010).

Musculoskeletal injuries and disorders are the main reason for morbidity and temporary disability in military populations (Jones & Knapik 1999; Mattila et al. 2006; Ruscio et al. 2010). Health clinic visit rates are approximately equal for injuries and

illnesses in the military environment, but the morbidity associated with injuries is over five times greater than that associated with illness (Kaufman et al. 2000; Knapik et al. 2004a). That is, 80-90% of limited duty days for recruits and soldiers result from training injuries in U.S. Military (Jones & Knapik 1999). Moreover, training related injuries are the main reason for disability needing expensive treatment, long-term rehabilitation and leading to functional impairment and premature discharges from military service (Jones & Knapik 1999; Smith et al. 2000; Songer & LaPorte 2000; Yancosek et al. 2012). In the Finnish Defence Forces, MSDs are the second highest reason for premature discharge from military service, and their number has been increasing (Sahi & Korpela 2002).

2.2.2 Etiological circumstances and injury mechanisms

Previous studies from the U.S. Army have reported that the great majority of injuries are training-related (Jones & Knapik 1999; Ruscio et al. 2010). Among light infantry soldiers, 88% of the injuries were training-related conditions (Reynolds et al. 1994). Heir and Eide (1996) monitored 912 conscripts in Norway during 8-week basic training and reported that 74% of the injuries were training-related. Another study by the same authors (Heir & Eide 1997) mentioned that marching and infantry running were regarded as the causes of most injuries, but more specific information was not reported. Overall, studies concerning causes or inciting events of training-related injuries are sparse, especially in non-professional military environment. In addition, primarily only the causes of severe injuries leading to hospitalization have been studied (Mattila et al. 2006; Mattila et al. 2007a; Ruscio et al. 2010) to define the magnitude of the injury burden associated with each cause.

The leading causes for accidental injuries leading to injury hospitalizations reported in the U.S. Army included motor vehicles and sports as well as falls and combat training (Jones et al. 2000). Results concerning the U.S. Air Force were similar with the exception of more industrial mishaps and no combat injuries (Jones et al. 2000) (Table 1). In an extensive study, Ruscio et al. (2010) charted top ten causes leading to hospitalization in the U.S. Military in 2004. Falls were the leading cause in four of the five top hospitalized injuries (lower-extremity fractures, upper-extremity fractures, lower-extremity joint dislocations, and spine and back sprains and strains), accounting

for 29% of all hospitalizations. Sports and physical training were the leading cause of lower-extremity strains and sprains, accounting for 16% of all hospitalizations. Guns and explosives were the second leading cause of both lower- and upper-extremity fractures accounting for 13% of all hospitalizations. Non-military vehicles, twist, turn, run, or slip, and parachuting were the next most common causes for injury hospitalizations (Ruscio et al. 2010) (Table 1).

Table 1. Most important causes of acute injury hospitalizations during military training

Cause	% of total	Study	Design	n	Field of military service
Falls	29	(Ruscio et al. 2010)	Reg.	not reported	Army, Air Force, Navy, Marine
	11	(Jones et al. 2000)	Reg.	10003	Army
	8	(Jones et al. 2000)	Reg.	4934	Air Force
	32	(Mattila et al. 2006)	Reg.	213509 p-y*	Conscripts
	31	(Mattila et al. 2007a)	Reg.	135987	Conscripts
Sports and physical training	23	(Jones et al. 2000)	Reg.	4934	Air Force
	18	(Jones et al. 2000)	Reg.	10003	Army
	16	(Ruscio et al. 2010)	Reg.	not reported	Army, Air Force, Navy, Marine
Traffic accidents	16	(Jones et al. 2000)	Reg.	10003	Army
	13	(Ruscio et al. 2010)	Reg.	not reported	Army, Air Force, Navy, Marine
	10	(Jones et al. 2000)	Reg.	4934	Air Force
	5	(Mattila et al. 2006)	Reg.	213509 p-y*	Conscripts
	4	(Mattila et al. 2007a)	Reg.	135987	Conscripts
Inflicting by foreign objects	19	(Mattila et al. 2006)	Reg.	213509 p-y*	Conscripts
Guns and explosives	13	(Ruscio et al. 2010)	Reg.	not reported	Army, Air Force, Navy, Marine
Exposure to mechanical forces (twist, turn, run, slip)	9	(Mattila et al. 2007a)	Reg.	135987	Conscripts
	7	(Ruscio et al. 2010)	Reg.	not reported	Army, Air Force, Navy, Marine
Parachuting	7	(Ruscio et al. 2010)	Reg.	not reported	Army, Air Force, Navy, Marine
Overexertion	4	(Mattila et al. 2007a)	Reg.	135987	Conscripts
Tools and machinery	3	(Ruscio et al. 2010)	Reg.	not reported	Army, Air Force, Navy, Marine
Assault	2	(Mattila et al. 2006)	Reg.	213509 p-y*	Conscripts

Reg. = Register data
* p-y = person-years

In Finnish Defence Forces, the most common causes leading to hospitalization due to traumatic injuries were falls (32%) and injuries inflicted by foreign objects or

machinery (19%) (Mattila et al. 2006) (Table 1). In general, the problem in studies reporting causes in injuries is the large number of injuries with missing information. Usually the proportion of injuries with missing information of the cause has not been reported, but the study by Ruscio and co-workers (2010) reported that 8% of traumatic injuries had missing information.

In a study by Knapik and colleagues (2007), activities associated with injury included physical training 22% (especially running, 62% of those), mechanical work 12%, sports 11% (mostly basketball, football and softball), air-borne related activities 9% (mostly parachute landing problems affecting ankle ligaments) and road marching among 518 male U.S. Army Mechanics. Sherrard et al. (2004) reported similar causes for injuries among Australian Defence Forces. The major cause of injury was basic combat training followed by sports activity involving rugby, touch football and soccer. Falls and motor vehicle accidents were also common causes for injuries. Running, marching, physical training, and the obstacle course were the most frequent causes of injury in the study among 350 Australian Army recruits (Rudzki 1997b). A study comparing injury risk factors in infantry, artillery, construction engineers and special forces soldiers concluded that 88% of injuries in infantry soldiers were due to duty-related physical fitness training and marching with packs (Reynolds et al. 2009). On the other hand, among artillery and construction engineers, 30% of the injuries were related to occupational activities (e.g. carrying shells, constructing bridges, repairing vehicles) and about 50% were physical training-related. On the contrary, over 80% of injuries in special forces were related to physical training and sports, resulting over threefold number of limited duty days when compared to non-special battalions indicating more severe injuries among special forces (Reynolds et al. 2009). In these studies, the definition of injury included also overuse injuries not leading to a hospitalization as a major difference compared to injury hospitalization studies listed in Table 1.

2.2.3 Risk factors with emphasis on physical fitness

Sports injuries result from a complex interaction of multiple risk factors and events (Fig. 1). Risk factors may be categorized as either intrinsic or extrinsic in nature. Intrinsic factors relate to the individual characteristics such as anatomical, physical,

socio-economical and behavioral characteristics. Extrinsic factors relate to environmental variables containing for instance training duration, intensity and frequency, weather conditions, rules of sports and equipment factors (van Mechelen et al. 1992; Requa & Garrick 1996; Jones & Knapik 1999). The final element in the causation chain of injury is an inciting event related to injury mechanisms (Meeuwisse 1994).

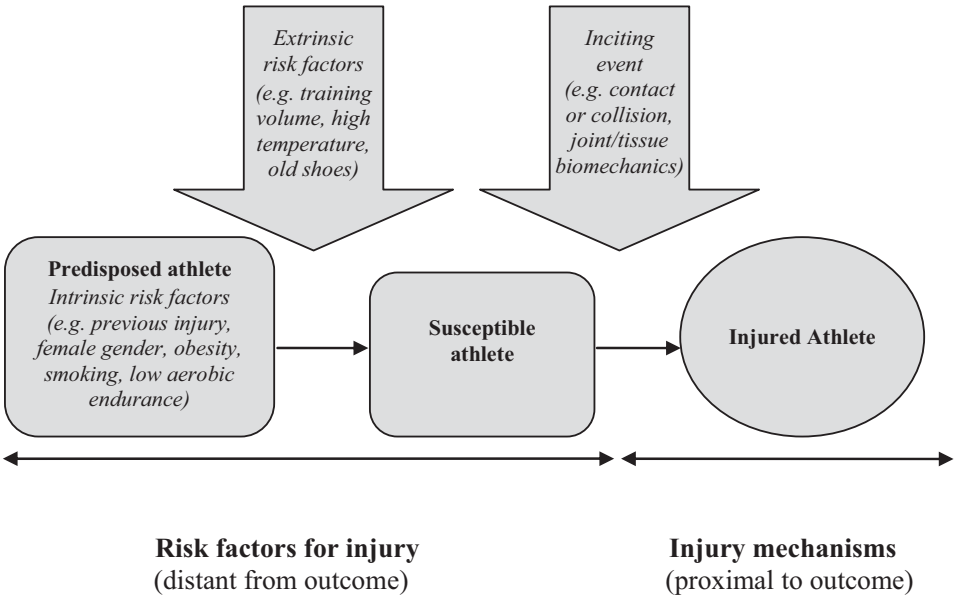


Figure 1. A multifactorial model of sports injury etiology (adapted from Meeuwisse 1994)

Older age

Several military studies have reported older age as a risk factor for stress fractures, bone stress injuries and musculoskeletal injuries (Table 2). The military studies indicate that older age may increase the risk of injury. Moreover, age should be adjusted for when other risk factors are being assessed.

In contrast to the majority of studies (Table 2), it has also been presented that younger age is associated with injuries (Knapik et al. 1993; Reynolds et al. 1999), whilst other studies indicate no association between injuries and age (Shaffer et al. 2006; Knapik et al. 2010). A study of 303 male Infantry basic trainees found that rates of lower extremity musculoskeletal injuries were over 4 times higher among trainees

aged 24 years or more when compared to younger persons (Jones et al. 1993b). In other military studies reporting older age as a risk factor for injuries, the age was a modest risk factor. Generally, the adjusted risk ratios were approximately two-fold for older age groups (Table 2). A large register study among 152095 Finnish conscripts reported hazard ratio of 2.1 (95% CI: 1.4-3.1) for bone stress injuries among conscripts aged 21 years or more when compared to 17-19 years old counterparts (Mattila et al. 2007b).

Female gender

Injury rates are approximately two-folded in women compared to men during basic military training (Bensel & Kish 1983; Jones et al. 1993a; Snedecor et al. 2000; Knapik et al. 2001b). Moreover, stress fracture incidences among women are 3-8 folded when compared to men (Protzman 1979; Jones et al. 1993a; Macleod et al. 1999; Mattila et al. 2007b). Almeida et al. (1999a) reported that the higher injury rates often found in female military trainees may be explained by gender differences in symptom reporting, women tending to report their symptoms more easily than men. This would result in more frequent registration of mild injuries among women than among men. Results from a Cadet study (Bijur et al. 1997) do not support this hypothesis. The findings suggest that women's injuries may be actually more severe than men's, rate of hospitalization being 3.9-folded (95% CI: 2.0-7.4) for women.

Women enter the military service less physically active and at a poorer level of conditioning than men (Jones et al. 1993b; Bijur et al. 1997; Bell et al. 2000). Men and women with the same running performance have quite similar rates of injuries (Protzman 1979; Bell et al. 2000; Blacker et al. 2008). These results suggest that by improving women’s aerobic fitness level through modified training programs before the onset of actual military training, injuries could be reduced (Jones & Knapik 1999; Rauh et al. 2006; Blacker et al. 2008). However, it seems that not all the differences in injury rates between men and women could be explained by physical fitness differences. Results from studies by Mattila et al. (2007a; 2007b) indicated that female gender was an independent risk factor for bone stress injuries and injury hospitalizations (Table 2).

The generally increased risk of injuries among women has been previously explained by anatomical differences (wide pelvis, coxa vara, genu valgum), neuromuscular and hormonal factors (Jones & Knapik 1999; Beck et al. 2000; Hewett

2000; Rauh et al. 2006; Shaffer et al. 2006; Mattila et al. 2007b). These factors affect bone characteristics (Teitz et al. 1997) explaining the clearly higher stress fracture incidences among women both in military (Protzman 1979; Jones et al. 1993a; Mattila et al. 2007b) and civilian athletes (Brunet et al. 1990). In addition, sex hormones affect ligament structures by increasing laxity and joint looseness, predisposing female athletes for knee and ankle ligament injuries (Hewett 2000; Beynnon et al. 2005). Moreover, women choose to undergo military service as volunteer recruits, as opposed to male conscripts. This may reflect higher motivation and more competitive temper, factors that may increase injury risk (Spain et al. 1997).

Race

A study of 3025 male Marine recruits followed during 12 weeks of basic training showed that the risk for stress fractures were 2.5 times higher among white recruits than non-white recruits when adjusted for previous physical activity (Gardner et al. 1988). A multivariate analysis of 861 Army basic trainees reported 2.1-fold risk for time-loss injuries in white recruits compared to blacks (Bell et al. 2000), whereas several studies reported no association between race and musculoskeletal injuries (Shaffer et al. 1999; Knapik et al. 2009). Overall, military studies suggest that white trainees may incur more musculoskeletal injuries compared to non-white persons. Because this has been documented especially considering stress fractures in recruits (Table 2) and civilian female collegiate distance runners (Barrow & Saha 1988), it can be assumed that black persons have higher bone mass than whites (Lappe et al. 2001).

It has been suggested that while age, race, and gender themselves are not modifiable risk factors, altering other risk factors, such as improving individuals' aerobic and muscular fitness, may reduce the risk for injury among these higher risk demographic groups (Jones & Knapik 1999; Rauh et al. 2006; Blacker et al. 2008).

Table 2. Risk factors for musculoskeletal injury during military service

Observed risk factor Risk estimate (95% CI)	(Authors, year), country	Outcome, Setting, Follow-up duration	n	Study design
Socioeconomic				
Older age				
RR 1.71 (0.92–3.21)	(Gardner et al. 1988), USA	SF†, Male Marine recruits, 12 wk	3025	→
OR 4.3 (2.0–9.2)	(Jones et al. 1993b), USA	LEMI‡, Male Infantry BMT, 12 wk	303	→
OR 2.33 (1.21–4.50)	(Heir & Eide 1997), Norway	MI*, Male conscripts, 10 wk	480	→
LR 7.1, p <0.001	(Pope et al. 2000), Australia	LEMI‡, Male army recruits, 12 wk	1538	→
RR 1.07 (1.05–1.1) [a]	(Lappe et al. 2001), USA	SF†, Female Army recruits, 8 wk	3758	→
HR 2.1 (1.4–3.1)	(Mattila et al. 2007b), Finland	BSI**, Conscr., 6–12 mo	152095	Reg.
HR 1.43 (1.11–1.83)	(Knapik et al. 2009), USA	MI*, Army BMT, 9 wk	3062	→
OR 1.7 (1.3–2.2)	(Kuikka et al. 2011), Finland	KI# hospitalization, Conscr., 6-12 mo	128584	Reg.
Younger age				
OR 0.88, p <0.01 [a]	(Reynolds et al. 1999), USA	Any injury, Male infantry soldiers, 161 km march lasting 5 days	218	→
p =0.09 ¤	(Knapik et al. 1993), USA	MI*, Male infantry soldiers, 6 mo	298	←
Female gender				
1% vs. 10% ¤	(Protzman 1979), USA	SF†, Cadet basic training, 8 wk	1485	←
23 % vs. 42 %, p <0.01 ¤	(Bensel & Kish 1983), USA	LEMI‡, Army BMT, 8 wk	2841	→
RR 2.1 (1.5–3.1) ¤	(Jones et al. 1993a), USA	LEMI‡, Army BMT , 8 wk	391	→
RR 5.1 (1.4–15.3) ¤	(Jones et al. 1993a), USA	SF†, Army BMT , 8 wk	391	→
p =0.02	(Bijur et al. 1997), USA	TLI††, Cadet basic training, 6 wk	558	→
3% vs. 11%, p <0.001 ¤	(Macleod et al. 1999), USA	SF†, Recruit basic training, -	4222	←
RR 2.2 (2.1–2.4) ¤	(Snedecor et al. 2000), USA	MI*, Air Force BMT, 6 wk	13910	←
RR 2.2, p <0.01 ¤	(Knapik et al. 2001b), USA	TLI††, Army BMT, 8 wk	1230	→
RR 2.03, p <0.05 ¤	(Yates & White 2004), USA	MTSS‡‡, Naval BMT, 10 wk	124	→
OR 2.66 (1.96–3.63)	(Billings 2004), USA	TRI§§, Cadet basic training, 6 wk	1210	←
OR 2.3 (1.9–2.7)	(Mattila et al. 2007a), Finland	Inj. hospitalization, Conscr., 6-12 mo	135987	Reg.
HR 8.2 (4.8–14.2)	(Mattila et al. 2007b), Finland	BSI**, Conscr., 6-12 mo	152095	Reg.
RR 1.74, p <0.01 ¤	(Grier et al. 2011), USA	TLI††, Army ordnance AIT, 8 wk	4255	→
Caucasian race				
RR 2.45 (1.06–5.68)	(Gardner et al. 1988), USA	SF†, Male Marine recruits, 12 wk	3025	→
RR 2.13 (1.37–3.32)	(Bell et al. 2000), USA	TLI††, Army basic training, 8 wk	861	→
RR 1.18 (1.07–1.31)	(Lappe et al. 2001), USA	SF†, Female Army recruits, 8 wk	3758	→
HR 1.4 (1.1–1.7)	(Blacker et al. 2008), UK	TRI§§, Army recruits, 12 wk	13417	←
Low intelligence level				
OR 4.2 (1.3–12.5)	(Hestbaek et al. 2005), Denmark	LBP discharge, Recruits, 3 mo	1711	→
Health				
Previous injury history				
10.6% fracture recurrence ¤	(Giladi et al. 1986), Israel	SF†, Infantry recruits, 1 yr	66	←
p <0.01 ¤	(Feldman et al. 1999), USA	LEMI‡, Army infantry training, -	-	→
OR 1.7 (0.9–3.2)	(Jones et al. 1993b), USA	LEMI‡, Male Infantry BMT, 12 wk	303	→
Previous injury without fully recovery or never injured				
RR 1.89 (1.05–3.44)	(Shaffer et al. 1999), USA	SF†, Male Marine recruits, 12 wk	1286	→
Back pain prior to service				
OR 5.9 (2.4–14.9)	(Hestbaek et al. 2005), Denmark	LBP discharge, Recruits, 3 mo	1711	→
High BMI				
RR 3.4 (1.3–9.4) ¤	(Jones et al. 1993a), USA	TLI††, Army BMT , 8 wk	391	→
OR 2.03 (1.41–2.93)	(Heir & Eide 1996), Norway	MI*, Male Air Force conscr., 8 wk	912	→
p < 0.05 ¤	(Reynolds et al. 2002), USA	S&S§, Professional soldiers, 1yr	313	→
OR 3.44 (1.94–6.09)	(Billings 2004), USA	TRI§§, Cadet basic training, 6 wk	1210	←
OR 1.4 (1.2–1.7)	(Mattila et al. 2007a), Finland	Inj. hospitalization, Conscr., 6–12 mo	135987	Reg.
OR 1.6 (1.03–2.5)	(Kuikka et al. 2011), Finland	KI# hospitalization, Conscr., 6-12 mo	128584	Reg.
High waist circumference				
p =0.093 ¤	(Taimela et al. 1990a), Finland	SF†, Male conscripts, 12 wk	108	→

Observed risk factor Risk estimate (95% CI)	(Authors, year), country	Outcome, Setting, Follow-up duration	n	Study design
Waist circumference < 75cm				
OR 1.17 (0.98–1.40)	(Moran et al. 2012), Israel	SF†, Male infantry conscr., 12 mo	57	→
Low BMI				
RR 2.8 (1.0–7.7), p =0.09 ¤	(Jones et al. 1993a), USA	TLI††, Army BMT, 8 wk	391	→
HR 1.5 (1.2–1.9)	(Blacker et al. 2008), UK	TRI§§, Army recruits, 12 wk	13417	←
Low body weight				
p <0.05	(Beck et al. 1996), USA	SF†, Male Marine recruits, 12 wk	626	→
RR 1.01 (1.004–1.02) [b]	(Lappe et al. 2001), USA	SF†, Female Army recruits, 8 wk	3758	→
Height				
p <0.05 ¤	(Kujala et al. 1986), Finland	KEI***, Male conscripts, 8 wk	62	→
p =0.051 ¤	(Taimela et al. 1990a), Finland	SF†, Male conscripts, 12 wk	108	→
Reduced mental health				
OR 4.04 (1.01–15.49)	(Heir & Eide 1996), Norway	TRI§§, Male Air Force conscr., 8wk	912	→
Psychological stress				
p <0.05 ¤	(Moran et al. 2011), Israel	SF†, Male infantry conscr., 11 wk	44	→
Low scores in achievement, dominance and exhibition				
p <0.04 ¤	(Taimela et al. 1990a), Finland	SF†, Male conscripts, 12 wk	108	→
Dysfuction of back or lower limb				
OR 1.79 (1.01–3.17)	(Heir & Eide 1996), Norway	MI*, Male Air Force conscr., 8wk	912	→
Leg length inequality				
p < 0.01 ¤	(Kujala et al. 1986), Finland	KEI***, Male conscripts, 8 wk	62	→
Genu valgus (knock knee)				
RR 1.9 (1.1–3.3) ¤	(Cowan et al. 1996), USA	OI†††, Male infantry trainees, 12 wk	294	→
Increased passive knee laxity				
p <0.05 ¤	(Kujala et al. 1986), Finland	KEI***, Male conscripts, 8 wk	62	→
Q-angle > 15 degrees				
RR 5.4, p =0.008 ¤	(Cowan et al. 1996), USA	SF†, Male infantry trainees, 12 wk	294	→
High or low foot arch				
RR 1.82–2.45 (0.63–6.70) ¤	(Kaufman et al. 1999), USA	SF†, Male Naval Special trainees, 2yr	449	→
High foot arch				
RR 6.1, p< 0.05 ¤	(Cowan et al. 1993), USA	LEMI‡, Army Infantry BMT, 12 wk	246	→
Pronated foot type				
RR 1.70, p <0.05 ¤	(Yates & White 2004), USA	MTSS‡‡, Naval basic training, 10 wk	124	→
Small femoral diaphyses of femur and tibia				
p <0.05	(Beck et al. 1996), USA	SF†, Male Marine recruits, 12 wk	626	→
Low hip bone mineral content				
p =0.044	(Valimaki et al. 2005), Finland	SF†, Male conscripts, 6-12 mo	179	→
Menstrual irregularity or amenorrhea				
OR 4.1 (1.5–10.9)	(Rauh et al. 2006), USA	SF†, Female Marine recruits, 13 wk	824	→
OR 3.79 (1.3–10.7)	(Shaffer et al. 2006), USA	SF†, Female Marine recruits, 13 wk	2962	→
Low serum vitamin-D level				
OR 3.6 (1.2–11.1)	(Ruohola et al. 2006), Finland	SF†, Conscripts, 90 days	756	→

Observed risk factor Risk estimate (95% CI)	(Authors, year), country	Outcome, Setting, Follow-up duration	n	Study design
Health behavior				
Smoking				
OR 1.9 (1.1–3.3)	(Jones et al. 1993b), USA	LEMI‡, Male Infantry BMT, 12 wk	303	→
OR 1.93, p <0.01	(Reynolds et al. 1999), USA	Any injury, Male infantry soldiers, 161 km march lasting 5 days	218	→
OR 1.5 (1.1–2.0)	(Altarac et al. 2000), USA	TRI§§, Army BMT , 8 wk	2002	→
HR 3.1 (1.6–5.9)	(Knapik et al. 2001b), USA	TLI††, Army BMT, 8 wk	1230	→
RR 1.34 (1.05–1.71)	(Lappe et al. 2001), USA	SF†, Female Army recruits, 8 wk	3758	→
HR 1.36 (1.16–1.59)	(Knapik et al. 2009), USA	MI*, Army BMT, 9 wk	3062	→
HR 1.28 (1.01–1.61)	(Knapik et al. 2010), USA	Any injury, Air Force BMT, 6 wk	2676	→
HR 1.87 (1.57–2.22)	(Grier et al. 2011), USA	TLI††, Army ordnance AIT, 8 wk	4255	→
Smokeless tobacco				
OR 2.44 (1.30–4.57)	(Heir & Eide 1997), Norway	MI*, Male conscripts, 10 wk	480	→
Use of alcohol				
RR 3.22 (1.82–5.69)	(Lappe et al. 2001), USA	SF†, Female Army recruits, 8 wk	3758	→
Low levels of previous physical activity				
RR 2.40 (1.26–4.58) ¤	(Gardner et al. 1988), USA	SF†, Male Marine recruits, 12 wk	3025	→
OR 0.19 (0.04–1.00) ¤	(Taimela et al. 1990a), Finland	SF†, Male conscripts, 12 wk	108	→
RR 12.4 (2.1–72.9) ¤	(Jones et al. 1993a), USA	TLI††, Army BMT , 8 wk	391	→
OR 2.2 (1.3–3.8)	(Jones et al. 1993b), USA	LEMI‡, Male Infantry BMT, 12 wk	303	→
RR 2.97 (1.32–6.73)	(Shaffer et al. 1999), USA	SF†, Male Marine recruits, 12 wk	1286	→
RR 1.5 (1.2–2.0)	(Lappe et al. 2001), USA	SF†, Female Army recruits, 8 wk	3758	→
HR 2.5 (1.1–9.0)	(Knapik et al. 2001b), USA	TLI††, Army BMT, 8 wk	1230	→
p < 0.001 ¤	(Rosendal et al. 2003), Denmark	LEOI‡‡‡, Male conscripts, 12 wk	330	→
HR 1.63 (1.16–2.30)	(Knapik et al. 2009), USA	MI*, Army BMT, 9 wk	3062	→
Less than 7 months weight training before military entry				
OR 4.5 (1.1–18.9)	(Rauh et al. 2006), USA	SF†, Female Marine recruits, 13 wk	824	→
Low levels of previous occupational activity				
OR 1.8 (1.0–3.2)	(Jones et al. 1993b), USA	LEMI‡, Male Infantry BMT, 12 wk	303	→
Being intercollegiate athlete				
OR 1.53 (1.18–1.98)	(Billings 2004), USA	TRI§§, Cadet basic training, 6 wk	1210	←
Physical fitness				
Low self-assessed fitness				
OR 3.33 (1.29–8.59)	(Heir & Eide 1997), Norway	MI*, Male conscripts, 10 wk	480	→
p < 0.0001 ¤	(Rosendal et al. 2003), Denmark	LEOI‡‡‡, Male conscripts, 12 wk	330	→
RR 1.7 (1.1–2.6)	(Rauh et al. 2006), USA	SF†, Female Marine recruits, 13 wk	824	→
Low muscular endurance				
RR 1.9, p =0.01 ¤	(Knapik et al. 1993), USA	MI*, Male infantry soldiers, 6 mo	298	←
p ≤0.05	(Bell et al. 2000), USA	TLI††, Army basic training, 8 wk	861	→
HR 1.8 (1.2–2.8) ¤	(Knapik et al. 2001b), USA	TLI††, Army BMT, 8 wk	1230	→
p <0.001 ¤	(Blacker et al. 2008), UK	TRI§§, Army recruits, 12 wk	13417	←
HR 1.23 (1.02–1.48)	(Grier et al. 2011), USA	TLI††, Army ordnance AIT, 8 wk	4255	→
High muscular strength				
OR 1.6 (1.2–2.4)	(Kuikka et al. 2011), Finland	KI# hospitalization, Conscr., 6-12 mo	128584	Reg.
Low aerobic endurance				
p =0.13 ¤	(Taimela et al. 1990a), Finland	SF†, Male conscripts, 12 wk	108	→
RR 1.6, p =0.10 ¤	(Knapik et al. 1993), USA	MI*, Male infantry soldiers, 6 mo	298	←
0 % vs.37 %, p =0.003 ¤	(Jones et al. 1993a), USA	TLI††, Army BMT , 8 wk	391	→
OR 1.83 (1.01–3.31)	(Heir & Eide 1997), Norway	MI*, Male conscripts, 10 wk	480	→
p < 0.01 ¤	(Bijur et al. 1997), USA	TLI††, Cadet basic training, 6 wk	558	→
RR 3.11 (1.26–7.66) ¤	(Shaffer et al. 1999), USA	SF†, Male Marine recruits, 12 wk	1286	→
LR 47.3, p <0.001	(Pope et al. 2000), Australia	LEMI‡, Male army recruits, 12 wk	1538	→

Observed risk factor Risk estimate (95% CI)	(Authors, year), country	Outcome, Setting, Follow-up duration	n	Study design
RR 3.23 (1.59–6.58)	(Bell et al. 2000), USA	TRI§§, Army BMT, 8 wk	861	→
HR 2.2 (1.0–4.0), p =0.04	(Knapik et al. 2001b), USA	TLI††, Army BMT, 8 wk	1230	→
Not reported exactly ¤	(Rosendal et al. 2003), Denmark	LEOI‡‡‡, Male conscripts, 12 wk	330	→
OR 3.3 (1.4–8.1)	(Rauh et al. 2006), USA	SF†, Female Marine recruits, 13 wk	824	→
OR 3.54 (2.0–6.3)	(Shaffer et al. 2006), USA	SF†, Female Marine recruits, 13 wk	2962	→
HR 6.64 (4.92–8.97)	(Blacker et al. 2008), UK	TRI§§, Army recruits, 12 wk	13417	←
HR 1.42 (1.07–1.88)	(Knapik et al. 2009), USA	MI*, Army BMT, 9 wk	3062	→
HR 1.42 (1.05–1.93)	(Knapik et al. 2010), USA	Any injury, Air Force BMT, 6 wk	2676	→
HR 1.41 (1.18–1.69)	(Grier et al. 2011), USA	TLI††, Army ordance AIT, 8 wk	4255	→
Excellent aerobic fitness				
OR 1.3 (1.1–1.5)	(Mattila et al. 2007a), Finland	Inj. hospitalization, Conscr., 6-12 mo	135987	Reg.
High and low flexibility				
OR 3.3 (1.3–7.9)	(Jones et al. 1993b), USA	LEMI‡, Male Infantry BMT, 12 wk	303	→
HR 2.2 (1.0–4.8) ¤	(Knapik et al. 2001b), USA	TLI††, Army BMT, 8 wk	1230	→
Extrinsic factors				
High running mileage				
p <0.01 ¤	(Feldman et al. 1999), USA	LEMI‡, Army infantry training, -	-	→
OR 1.6 (0.9–2.7)	(Jones et al. 1993b), USA	LEMI‡, Male Infantry BMT, 12 wk	303	→
High total distance ambulated				
16.4% greater, p <0.01 ¤	(Moran et al. 2011), Israel	SF†, Male infantry conscripts, 11 wk	44	→
Aerobic training duration > 40min				
OR 1.66 (1.02–2.70) ¤	(Moran et al. 2012), Israel	SF†, Male infantry conscripts, 12 mo	57	→
Aerobic training frequency < 2 times /week				
OR 4.5 (1.7–12.2) ¤	(Moran et al. 2012), Israel	SF†, Male infantry conscripts, 12 mo	57	→
High volume of weekly vigorous physical training				
p =0.018–0.027	(Almeida et al. 1999b), USA	MI*, Male Marine recruits, 12 wk	1296	→
Increased age of shoes				
p <0.056 ¤	(Gardner et al. 1988), USA	SF†, Male Marine recruits, 12 wk	3025	→
High environmental temperature				
RR 2.4 (1.9–3.0)	(Knapik et al. 2002), USA	TLI††, Army BMT, 8 wk	2568	←

→ Prospective study design
← Retrospective study design
Reg. Register data
HR hazard ratio
OR odds-ratio
LR likelihood ratio
RR relative risk
AIT advanced individual training
If the results were stratified for gender, relative risk for men is mentioned
¤ Result is unadjusted to other significant variables
* MI= Musculoskeletal injury
‡ LEMI= Lower extremity musculoskeletal injury
** BSI= Bone stress injury
† SF= Stress fracture
†† TLI= Time-loss injury with ≥ 1 days of limited duty
‡‡ MTSS= medial tibial stress syndrome
§§ TRI= Training related injury including acute and overuse injuries
§ S&S= Sprains and strains
††† OI= Overuse injury
‡‡‡ LEOI= Lower extremity overuse injury with ≥ 1 days of limited duty
*** KEI= Knee exertion injury
# KI= Knee injury
[a] for each year increase in age
[b] for each pound decrease in weight

Previous injury history

It is well established that previous injury history (Giladi et al. 1986; Jones et al. 1993b; Feldman et al. 1999) especially without fully recovery (Shaffer et al. 1999) is associated with a higher risk of injury during basic military training (Table 2). Conscripts or recruits entering military service have a medical check-up before military entry. Usually conscripts have to recover fully from previous injuries before military entry and hence the effect of previous injuries as a risk factor for current injury has not been studied more thoroughly in army environment. In civilian studies, previous injury is identified clearly as a risk factor for a new injury (Macera et al. 1989; Macera 1992; Hagglund et al. 2006). Shaffer et al. (1999) reported interestingly that recruits who had never experienced an injury were at higher risk than those with fully recovery from injury. It was speculated that a past training injury is a marker of past physical activity before military entry and probably also a marker of awareness of the possible trauma, thus accounting a lower risk for injuries during military training (Shaffer et al. 1999).

Musculoskeletal symptoms charted by a questionnaire indicating symptoms which do not prevent a recruit from entering into military are not usually reported in previous studies, because recruits entering military are expected to be fully healthy. In conscription armies, on the other hand, only few studies have examined the association between musculoskeletal symptoms and injury risk. Heir and Eide (1996) reported that dysfunctions of the back and lower limbs were associated with 1.8-fold risk (95% CI: 1.01-3.17) for musculoskeletal injuries in Norwegian conscripts during 8-week basic training. Long-lasting LBP prior to service increased the risk of leg pain, LBP and exemption from duty during service among 1711 Danish conscripts (Hestbaek et al. 2005) indicating that questionnaires are useful in predicting problems during service, and results considering other risk factors should be adjusted to symptom reporting. Overall, previous studies indicate that the association of past injuries with the risk for new injury is not simple and it may be confounded by other factors such as levels of prior activity and adequacy of recovery (Jones et al. 2002).

Low levels of previous physical activity

Several military studies have reported an association between low levels of previous physical activity (sedentary lifestyle) and musculoskeletal injuries (Table 2). A

multivariate analysis of 1230 recruits during 8 weeks of Army basic combat training reported 2.5 times higher risk (95% CI: 1.1–9.0) for time-loss injury in recruits who exercised sports less than once a week, compared to persons engaged in sports at least two times per week during the last month before military entry (Knapik et al. 2001b). Other previous military studies have charted previous physical activity with similar methods by using a questionnaire enquiring physical activity before entry to military on a 5-point scale. A study of 1286 Marine recruits showed 3 times higher rates of stress fractures among those who reported never or only occasionally sweating exercise when compared to those who exercised most often and added that less running before military entry was also associated with stress fractures (Shaffer et al. 1999).

The observed risk estimates vary depending on the selected reference group and number of compared physical activity levels (Table 2), but the majority of studies indicate that persons who engage in more physical activity have minor risk for musculoskeletal injuries when beginning a physically demanding training program (Jones et al. 2002). Similar findings have been reported also in conscription armies (Taimela et al. 1990a; Rosendal et al. 2003), but these results have been unadjusted for other variables. Despite the benefits of previous physical activity before military entry, excessive physical activity *during* military training predisposes to musculoskeletal injuries and disorders (Almeida et al. 1999b). Similar findings have been reported among civilian athletes (Pollock et al. 1977; Macera 1992; Ristolainen 2012).

Overweight

In earlier studies, higher BMI was linked to an increased risk of injury during military service (Table 2), although contradictory results indicating no association between BMI and injuries (Pope et al. 2000), and an association of lower BMI with injuries (Beck et al. 1996; Blacker et al. 2008) were also reported. Summarizing the results from different studies, it could be suggested that there is a bimodal relationship between BMI and injuries, as described previously (Jones et al. 1993a). The association between underweight and musculoskeletal injuries is not as widely documented as overweight as a predisposing factor, but it seems to be valid especially when considering lower limb overuse injuries and stress fractures during intensive military training (Table 2). Speculations whether over- and underweight are independent risk factors or just markers of other underlying predictors like poor physical fitness or older

age have been made (Niebuhr et al. 2009). Recruits with a higher BMI are able to cope better with load carriage tasks (Knapik et al. 2004b; Vanderburgh 2008). However, increasing obesity has become more common both in conscription (Santtila et al. 2006) and professional armies (Knapik et al. 2006b) during last decades. Obesity is associated with decrease in physical fitness, which leads to problems to meet military service standards (Knapik et al. 2001b; Santtila et al. 2006). According to a recent Australian study, high BMI in the military increases healthcare usage, but does not lead to increased number of off-duty days or military discharge (Peake et al. 2012).

Smoking

Smoking has been identified as a risk factor for MSDs generally in previous studies (Table 2). A number of studies reported risk for injuries among smokers to be about 50% higher compared to non-smokers after adjustments for other variables (Table 2). Altarac and colleagues (2000) followed over 2000 U.S. Army basic trainees eight weeks and reported an adjusted 1.5-folded odds-ratio for injuries among smokers compared to non-smokers. A dose-response relationship, in which risk increases with the number of cigarettes smoked per day, further strengthens the association (Knapik et al. 2001b; Grier et al. 2011). A study among Norwegian infantry conscripts indicated that smokeless tobacco users are even at higher risk for musculoskeletal injuries compared to non-smokeless tobacco users (Heir & Eide 1997), but usually the association between smokeless tobacco and MSDs has not been studied.

Physical fitness

Previous studies have represented that subjects whose initial fitness level is below average, enhance most their aerobic capacity and endurance during basic military training (Gordon et al. 1986; Rosendal et al. 2003). Despite these positive improvements, there are risks associated with physical activity, especially when the increase in activity is too abrupt (Almeida et al. 1999b). Low aerobic endurance is one of the best documented risk factors for musculoskeletal injuries (Kaufman et al. 2000; Pope et al. 2000; Knapik et al. 2001b; Knapik et al. 2010) probably because less fit persons fatigue more easily (Jones & Knapik 1999) and fatigue reduces coordination and dynamic muscular control (Wojtys et al. 1996; Thorlund et al. 2008). The adjusted

risk ratios usually vary from 1.5 to 6 depending on outcome definitions, sample size and characteristics and how the compared fitness categories are defined (Table 2). Conflicting results were reported in Finnish studies of injury hospitalizations reporting excellent aerobic fitness (Mattila et al. 2007a) and high muscular strength (Kuikka et al. 2011) as risk factors for lower limb and knee injury hospitalizations. In Finland, only about 6% of conscripts achieve excellent aerobic fitness test result (Santtila et al. 2006). Those with better muscular strength and aerobic fitness are likely to engage in vigorous physical training more often (Kannus & Jarvinen 1989) probably also on leisure time during military service. Thus, the higher exposure time predisposes high-fit conscripts to injuries because it is a well-established fact that as activity increases, injury risk increases (Pollock et al. 1977; van Mechelen et al. 1992; Parkkari et al. 2004; Knapik et al. 2011; Ristolainen 2012). In addition, conscripts with better physical fitness may be required to perform more physically challenging tasks predisposing to injuries (Kuikka et al. 2011).

Poor muscular strength and endurance have also been reported to be risk factors for injuries during military training but these results have usually been unadjusted to other significant variables (Table 2). Interestingly, according to a large register study in 435445 Swedish conscripts, low aerobic capacity and muscle strength in military tests were associated with an increased risk of low-energy fractures later in life, while a low-energy fracture was associated with an increased risk of death already in middle-aged men (Nordstrom et al. 2012). Low self-assessed physical fitness is a good indicator of elevated risk for MSDs according to studies conducted both in professional and conscription armies (Table 2). In the majority of the studies, however, the effect of self-perceived physical fitness has not been investigated.

Neuromuscular deficiencies including poor muscular strength, delayed muscle firing, defective muscular activation order and muscular imbalances are associated with elevated injury risk among civilians (Ekstrand & Gillquist 1983; Baumhauer et al. 1995; Hewett et al. 1999; Leetun et al. 2004; Zazulak et al. 2007; Pasanen et al. 2008b; Zebis et al. 2009). Neuromuscular deficits have a direct influence on neuromuscular control during physical activities. Failures of motor control and inabilities to control the position and motion of the body during movements associate with increased risk of injury (Leetun et al. 2004; Hewett et al. 2005; Kibler et al. 2006; Zazulak et al. 2007; Myer et al. 2011)

Extrinsic risk factors

The research of risk factors in the military has mainly focused on intrinsic risk factors because it has been assumed that military environment provides highly standardized conditions for investigating the effect of individual risk factors (Bennell et al. 1999; Knapik et al. 2001b). When athletes, who train on a voluntary basis, are compared to inducted soldiers, who do not have much choice to consider the contents of training, it is natural that the focus of risk factor research has been on individual characteristics in the military. In civilian studies, the research has focused more on extrinsic risk factors because of the higher variety in duration, frequency, intensity and contents of training as well as equipment factors. However, recent research found by using pedometers that individual variance in the recruits' ambulation was almost 50% during the same basic training program in Israeli Defense Forces (Moran et al. 2011). The group of recruits who ambulated more had also more stress fractures, and questions on how uniform physical fitness training in the military actually is, were raised. Recently, Knapik et al. (2011) confirmed this finding by measuring objectively physical activity in 2072 basic military recruits who worn pedometers daily during the 9-week training cycle. The authors reported 1.9 (95% CI: 1.5-2.6) times higher injury risk for highest active tertile compared with the lowest active tertile.

Among young civilians, high exposure to competitive sports participation is associated with a higher risk of injuries (Mattila et al. 2004; Parkkari et al. 2004; Rose et al. 2008). In previous military studies, however, participation in competitive sports was not associated with MSDs (Jones et al. 1993a; Heir & Eide 1997). High running mileage is an evident risk factor for injuries based on several military (Almeida et al. 1999b; Jones & Knapik 1999; Kaufman et al. 2000; Knapik et al. 2003; Finestone & Milgrom 2008) and civilian studies (Pollock et al. 1977; Macera et al. 1989; Colbert et al. 2000), indicating that as the total training volume increases, the injuries decrease first, until a point is reached at which injuries increase disproportionately with changes in physical fitness (Pollock et al. 1977). Among civilian endurance athletes, excessive training, defined as more than 700 hours/year, and recovery time of less than two days a week in the training season seems to predispose to overuse injury (Ristolainen 2012).

High environmental temperature was clearly associated with injuries during the U.S. Army basic combat training, when recruits of the different arrivals were followed for 8

weeks (Knapik et al. 2002). The authors suggested that environmental temperature might provide a partial explanation for the finding.

Equipment related factors, especially shoes, may affect the risk for MSDs and particularly for lower limb injuries. Increased age of shoes was noticed as a risk factor for stress fractures in 1988 among 3025 male marine recruits, but the result was slightly statistically insignificant and unadjusted to other significant variables (Gardner et al. 1988).

Risk factors of LBP

The literature of risk indicators of LBP during military training is sparse although LBP is the leading cause of musculoskeletal disability discharge in conscription (Sahi & Korpela 2002) and professional armies (Feuerstein et al. 1997; Lincoln et al. 2002). In addition, LBP is the second most common reason to seek healthcare according to U.S. Armed Forces report (2003) causing a loss of billions of dollars annually (Songer & LaPorte 2000). Hestbaek et al. (2005) reported results among 1711 Danish recruits after 3-month military service and concluded that the strongest predictor for LBP during military training was long-lasting LBP during previous year before military entry. It was also found that high intelligence level decreased the risk for severe LBP. However, it was added that parents' high education increased the risk of non-severe LBP. The majority of U.S. Military LBP studies have focused on military personnel in special occupational groups (Feuerstein et al. 1999; Lincoln et al. 2002) and hence their results are not comparable with compulsory military service.

Among young civilians, on the contrary, several risk factor studies have been conducted. Wedderkopp et al. (2009) reported that high levels of physical activity in childhood protect against LBP in early adolescence, but this is controversial (Burton et al. 1996; Balague et al. 1999; Feldman et al. 2001; Auvinen et al. 2008). On the other hand, participation in competitive sports seems to predispose to LBP (Balague et al. 1994; Burton et al. 1996; Kujala et al. 1996; Harreby et al. 1999), particularly young females (Mattila et al. 2008). Thus, there appears to be a U-shaped association between physical activity and risk of LBP (Jones & Macfarlane 2005; Auvinen et al. 2008). Physical activity prior to entering the military may not lower the risk for LBP during military service (O'Connor & Marlowe 1993; Milgrom et al. 2005), but findings are conflicting (Karvonen et al. 1980).

A consistent, although weak, link exists between smoking and LBP (Deyo & Bass 1989; Leboeuf-Yde et al. 1998; Feldman et al. 2001; Shiri et al. 2010a), whereas alcohol intake does not seem to be associated with LBP (Leboeuf-Yde 2000). Among body characteristics, obesity was modestly associated particularly with chronic LBP and seeking care for LBP in a recent systematic meta-analysis (Shiri et al. 2010b).

In a study among university athletes investigating LBP as a risk factor for recurrent low back injuries, researchers found that athletes who reported a previous low back injury were at a 3 times greater risk, and athletes who reported current LBP were at a 6 times greater risk of sustaining a low back injury during a 1-year follow-up period (Greene et al. 2001). The consequences of debilitating LBP are long-term according to Swedish study conducted twenty years after the military enlistments (Hellsing & Bryngelsson 2000). The odds-ratio for frequent back or neck pain at age of 40 was over 8-fold for those men who had reporting back pain debilitating everyday life and reducing physical activity at the age of 18 (Hellsing & Bryngelsson 2000). Thus, LBP during young adulthood clearly predicts LBP later in life (Harreby et al. 1996; Hestbaek et al. 2006).

The major question considering the relation between physical fitness and the risk of LBP in population level (Alaranta et al. 1995; Adams et al. 1999; Hamberg-van Reenen et al. 2007) as well as in occupational (Skovron 1992; Dempsey et al. 1997; Takala & Viikari-Juntura 2000; Stroyer & Jensen 2008) and military settings (Karvonen et al. 1980; O'Connor & Marlowe 1993; Feuerstein et al. 1999; Feuerstein et al. 2001; Daniels et al. 2005; Milgrom et al. 2005) is unclear. Longitudinal population studies on fitness were systematically reviewed for the first time by Hamberg-van Reenen et al. (2007). The major question was whether poor fitness in muscular endurance and strength, or reduced spinal mobility (i.e. flexibility) were predictors of LBP. The results from best evidence analyses were inconclusive considering the association between all evaluated fitness factors and the risk for LBP.

Risk factors of untimely medical discharge

In addition to Finnish studies (Parkkola 1999; Multimaki et al. 2005; Salo 2008; Appelqvist-Schmidlechner et al. 2010), only one peer-reviewed study has investigated risk factors for premature discharge in a conscription army. In Sweden, Larsson et al. (2009) found a strong association between musculoskeletal injuries or complaints

especially considering LBP or knee pain and discharge. However, the group of conscripts were selected because less than 6% of young men completed their military service in Sweden in late 2000s (Appelqvist-Schmidlechner et al. 2010).

It is important for military forces to identify persons unsuitable for service as early as possible (Booth-Kewley et al. 2002; Larson et al. 2002), preferably at call-up before entering the service (Multimaki et al. 2005). Early discharge from military service is a major drain of financial resources and time (Knapik et al. 2001a; Reis et al. 2007). Moreover, severe injuries may result in functional impairment that leads to disabilities requiring long-term rehabilitation (Patzkowski et al. 2012).

Knapik and colleagues (2001a) reported that lower performance in army physical fitness tests, lower educational level, and injuries accounting for time lost from service are risk factors for discharge in United States Army recruits, consistent with findings from other studies (Snoddy & Henderson 1994; Pope et al. 1999; Blacker et al. 2008; Niebuhr et al. 2008; Salo 2008; Swedler et al. 2011). Other risk factors for discharge identified foremost in professional armies include: female sex (Talcott et al. 1999; Knapik et al. 2001a; Booth-Kewley et al. 2002; Swedler et al. 2011), older age (Talcott et al. 1999; Reis et al. 2007), Caucasian race (Knapik et al. 2001a; Blacker et al. 2008), tobacco smoking (Van Hoof et al. 1992; Snoddy & Henderson 1994; Talcott et al. 1999; Klesges et al. 2001; Larson et al. 2002; Larsson et al. 2009; Swedler et al. 2011), high alcohol consumption (Van Hoof et al. 1992), no history of competitive exercise (Reis et al. 2007), recurrent back pain prior to entering the service (Booth-Kewley et al. 2002), history of depression (Cigrang et al. 1998; Parkkola 1999; Booth-Kewley et al. 2002), misconduct (Talcott et al. 1999; Larson et al. 2002; Salo 2008), lack of motivation (Cigrang et al. 1998; Niebuhr et al. 2008; Salo 2008), pre-service injuries (Cox et al. 2000; Niebuhr et al. 2006) especially those with incomplete recovery (Reis et al. 2007; Larsson et al. 2009), poor self-rated physical fitness on arrival (Reis et al. 2007; Larsson et al. 2009), and low pre-service physical activity (Van Hoof et al. 1992; Talcott et al. 1999; Larsson et al. 2009; Swedler et al. 2011).

Salo found in his thesis (2008) that discharge from the Finnish compulsory military service was associated with the conscript's intent to quit, low educational level and poor school success, poor expected adjustment, criminal background, poor physical health, low quality of civilian relationships and conscript's and his friends attitudes towards military service. Physical and mental problems often overlap, leading to

premature discharge from military service (Talcott et al. 1999; Niebuhr et al. 2006; Salo 2008). Moreover, some researchers have suggested that it is better to focus on overall discharge including both physical and mental reasons when examining the value of screening methods (Booth-Kewley et al. 2002; Larson et al. 2002).

For the young individual, discharge during military service can cause financial, emotional, and physical harm (Multimaki et al. 2005; Blacker et al. 2008). Discharged conscripts are at risk of being marginalised in society at a time when they are at the threshold of adulthood (Multimaki et al. 2005; Appelqvist-Schmidlechner et al. 2010). Especially mental health reasons leading to discharge were associated with poor income, retirement, divorced or single status, and a criminal record (Otto 1973; Upmark et al. 1999) in a follow-up of 10 to 23 years after compulsory military service.

2.3 Prevention of MSDs

Sports injury research and prevention has been recommended to follow a four-step model (van Mechelen et al. 1992) (Fig. 2). Firstly, the extent of the sports injury problem must be identified and described in terms of incidence and severity. Secondly, the risk factors and injury mechanisms related to the occurrence of sports injuries have to be established. By using this information of risk factors and injury mechanisms, the third step is to introduce measures that are likely to reduce the future risk or severity of sports injuries. Finally the effect of the measures must be evaluated by repeating the first step.

In summary, it is essential to know whether injuries create a problem in certain sport activity. The next question is, whether there are factors that can be altered or modified to control the problem. There are several extrinsic and intrinsic risk factors that are modifiable. Of the extrinsic factors contents and volume of training, sports equipment and rules of sports are largely alterable. Personal skills and physical fitness are examples of modifiable intrinsic risk factors. Nonetheless, there are predisposing factors, such as age, gender, anatomic abnormalities, previous injuries, weather conditions, and type of playing surface which are more difficult to modify or even completely unchangeable.

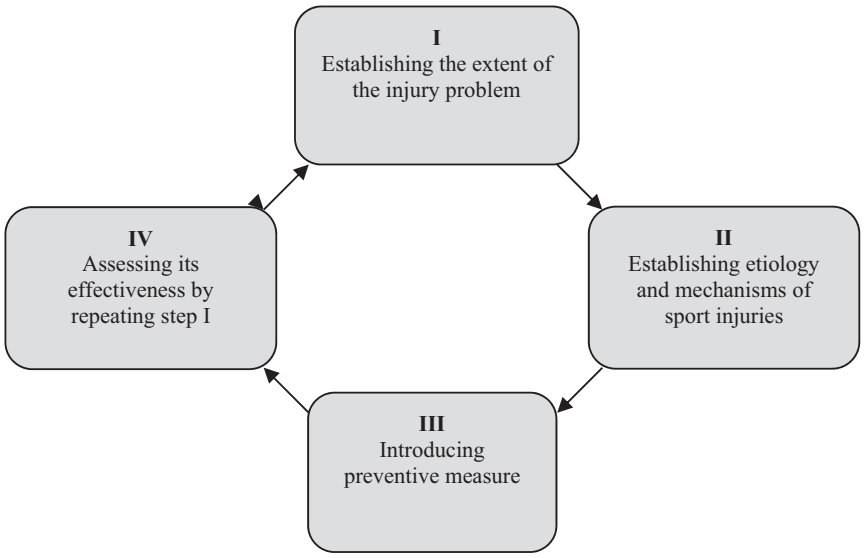


Figure 2. The sequence of prevention of sports injuries (adapted from van Mechelen et al. (1992))

Modification of training programs

The results of both civilian (Yeung & Yeung 2001) and military (Rudzki 1997a; Almeida et al. 1999b; Kaufman et al. 2000; Knapik et al. 2001b; Jones et al. 2002; Finestone & Milgrom 2008) studies indicate that modification of running distance, frequency, and duration is probably effective in preventing lower extremity overuse injuries.

Finestone and Milgrom (2008) reported a remarkable 60% decrease in stress fractures by reducing cumulative marching and by assuring a minimum sleep regimen in the Israeli army. Similar findings were reported in a previous study among soldiers in the U.S. Army (Knapik et al. 2004a). Both studies confirmed that these changes in military training did not lower soldiers' combat readiness or their performance in physical fitness tests. However, these studies were nonrandomized and suffer from design limitations.

A key element in military weight-bearing training to avoid overuse related injuries is a gradual increase in the distance, frequency, and duration of training (Almeida et al. 1999b; Kaufman et al. 2000; Jones et al. 2002; Rosendal et al. 2003). A nonrandomized study from the Singaporean army, however, demonstrated that a formal pre-training conditioning program reduced attrition more effectively than training with

a gradual pace increase extending basic military training by one month (Lee et al. 1997). Similar findings from the U.S. Army favoured pre-conditioning of low-fit recruits resulting in lower number of discharges and a tendency towards lower injury risk (Knapik et al. 2006a). In the Finnish Defence Forces, as well as in other mandatory armies in the Nordic countries, the proportion of incoming conscripts with low physical fitness and obesity has increased dramatically over recent decades. This forces the military training programs to adapt themselves to these new challenges (Sahi & Korpela 2002; Santtila et al. 2006; Mattila et al. 2007c). Therefore, it has been suggested that the time frame for physical adjustment and development should be the whole duration of service. More progressive individual training programs, coaching and goals could alleviate the problem of low-fit incoming conscripts (Salo 2008).

Stretching

Stretching is a specific method to improve the extensibility of muscle-tendon units (Weppler & Magnusson 2010), and thus to increase flexibility of healthy joints. It is recommended by American College of Sports Medicine (1998) to stretch muscles prior to physical activity to reduce the risk of injury. However, there is moderate to strong evidence that routine application of static stretching does not reduce overall injury rates (van Mechelen et al. 1992; Pope et al. 1998; Shrier 1999; Pope et al. 2000; Thacker et al. 2004; Small et al. 2008; Bullock et al. 2010; Jamtvedt et al. 2010). On the other hand, recent studies report preliminary evidence that static stretching may reduce musculotendinous injuries especially in lower extremities (Small et al. 2008; Jamtvedt et al. 2010; McHugh & Cosgrave 2010). A military setting study among Japanese recruits (Amako et al. 2003) evaluating the effect of static stretching before and after every physical training session reported similar conclusions: the total injury rate did not vary between the stretching and control groups but the incidences of musculotendinous injuries and LBP were favoring the stretching group ($p < 0.05$). Similar findings were found also among 298 U.S. Army recruits during 13-week basic military training (Hartig & Henderson 1999). Increased hamstring flexibility was achieved due to 3 hamstring stretching sessions per day lasting 30 seconds per leg and reduced number of lower extremity overuse injuries was observed ($p=0.02$). Majority of studies have examined the role of stretching as a part of warm-up program hampering to evaluate the individual effect of stretching. Epidemiologic military (Jones

et al. 1993b; Knapik et al. 2001b) and civilian data (Taimela et al. 1990b) suggest that both too high and too low joint flexibility are associated with injuries. Different sports require different amounts of flexibility in specific joints. Hence it is important to ensure adequate extensibility of the corresponding muscle groups specific to that sport. By focusing on individuals with limited flexibility, future prospective randomized studies could determine whether stretching can decrease passive resistance, indication of increased muscle-tendon length, and reduce musculotendinous injuries among the least flexible individuals (McHugh & Cosgrave 2010).

The role of shock absorption and other methods in injury prevention

According to a meta-analysis study, the best way to prevent lower limb fatigue fractures is to use shoes incorporating a proper shock absorbing cushion (Gillespie & Grant 2000). However, data concerning the use of custom-made or prefabricated insoles for reducing lower limb injuries in military recruits is conflicting (Milgrom et al. 1985; Gardner et al. 1988; Schwellnus et al. 1990; Jones & Knapik 1999; Kaufman et al. 2000; Larsen et al. 2002; Finestone et al. 2004; Aaltonen et al. 2007). Main conclusion in two good quality military studies was that routine use of orthotic insoles does not prevent physical-stress-related lower limb injuries in healthy young male adults (Withnall et al. 2006; Mattila et al. 2011). However, Baxter et al. (2011) reported recently that by orthotic footwear incidence of stress fractures of shin, foot and low back as well as chronic knee pain and LBP pain could be reduced over 50% among New Zealand Army recruits. Frankyn-Miller et. al (Franklyn-Miller et al. 2011) reported similar findings considering lower limb injuries with an absolute risk reduction of 0.49 and NNT 2 from use of the customized foot orthoses in Britannia Royal Naval trainees during 7-week military basic training.

Other methods proven to prevent physical activity-related injuries in randomized controlled trials include the use of external joint supports and protectors, controlled use of protective equipment, careful rehabilitation of injuries and gradual increase of physical exercise (Kaufman et al. 2000; Parkkari et al. 2001; Parkkari et al. 2003; McGuine & Keene 2006; Aaltonen et al. 2007). Of the military findings, Amoroso and co-workers (1998) found that among 745 military paratrooper students inversion ankle sprains during parachute training can be significantly reduced (50%) by using outside-the-boot ankle braces. Sitler and colleagues (1990) found that among 1396 cadets while

playing American football the use of prophylactic knee braces significantly reduced the frequency of knee injuries including medial collateral ligament injuries, but the number of ACL injuries or knee injury severity was not reduced. Similarly, semirigid ankle stabilizers (Sitler et al. 1994) significantly reduced (69%) the frequency of ankle injuries among 1601 cadets while playing basketball but injury severity was not reduced.

Neuromuscular exercise (NME) programs

Table 3 lists **s**ports injury prevention studies using NME programs with emphasis on challenging proprioceptive sensation. Humans use proprioceptive feedback (i.e. sensation of position-movement and strength of effort being employed) to provide information about body mechanics in the identification of the preferred pattern of movement (Dean 2013).

Outside military environment, several studies focusing on the injury prevention have been made among athletes since 1980s when Ekstrand et al. (1983) did the pioneer study among soccer players. In their study, 12 teams (180 male players) were randomized to control and intervention group and followed up for 6 months. The multiform program including warm-up, stretching, use of leg guards, ankle taping, and systematic rehabilitation reduced the injury rate 75%. Especially, the risk for acute injuries of knee and ankle were reduced through the intervention. The individual effect of neuromuscular training decreasing the injury risk was not speculated in the article.

After the pioneer study (Tropp et al. 1985) using balance boards, more than a decade passed by before more studies of preventive effects of proprioceptive neuromuscular training were published. However, the knowledge has increased rapidly during last decade when several research groups have investigated if it is possible to prevent sports injuries using specific training programs including different types of neuromuscular training, e.g. balance board, strengthening, sports-specific agility drills, landing techniques and plyometric exercises (Table 3). Majority of the studies are conducted among female athletes (Wedderkopp et al. 1999; Pasanen et al. 2008b; Soligard et al. 2008; Steffen et al. 2008; LaBella et al. 2011) probably due to their higher risk of injury occurrence. The conclusion of these studies is that neuromuscular, exercise including proprioceptive training, can be effective and reduce 20-80% the incidence of specific types of sports injuries affecting lower limbs among adolescents

and young adult athletes. This is demonstrated especially among young females during pivoting sports (Table 3). Studies finding no preventative effect on lower limb injuries, compliance rates were poor (<75%) or unreported (Gabbe et al. 2006; Engebretsen et al. 2008; Steffen et al. 2008; Collard et al. 2010), lacked adequate power (Hewett et al. 1999; Soderman et al. 2000; Pfeiffer et al. 2006; Gilchrist et al. 2008), training volume was low (Junge et al. 2002) (Table 3), or exercises were performed without proper supervision (Brushoj et al. 2008).

The multi-intervention training programs for injury prevention have been designed to enhance motor (balance, movement control, coordination) and muscular performance capacity. Furthermore, through improving biomechanics (e.g. by improving agility and balance using dynamic balance training and agility drills) and reducing damaging forces to lower limb for example by learning to avoid landing on extended knees and use of flexed knees instead the injury incidence would be reduced. However, only few studies have also measured the training effects on athletes' performance. These studies have shown that neuromuscular training, designed to prevent injuries, affects positively on musculoskeletal performance, for example balance, muscular activation patterns and power (Soderman et al. 2000; Askling et al. 2003; Emery et al. 2005; Brushoj et al. 2008; Chappell & Limpisvasti 2008; Panics et al. 2008; Pasanen et al. 2009; Barendrecht et al. 2011).

Despite of the positive results of NME training programs, the implementation of evidence-based practice into the injury prevention of everyday life is complicated. Young athletes, their parents and coaches often do not view acute injuries as preventable and appropriate prevention strategies are unknown (Orr et al. 2011). The studies show a large variety of different exercises and multi-intervention programs use combinations of balance, weight, plyometric, agility and sport-specific exercises (Hubscher et al. 2010). Hence, it is still unknown which exercises actually are effective and how different training programs are generalized to other sport, age, and gender groups. Moreover, the methodological quality is inconsistent and lacks often the report of randomization method, allocation concealment, blinding and compliance (Hubscher et al. 2010). One problem in the implementation of neuromuscular training strategies is the need of special equipment (e.g. balance boards) which lowers the practicality to incorporate these exercises to current routines in each sport session (Herman et al. 2012).

To our knowledge, the first RCT-study to investigate the preventive effect of concurrent neuromuscular exercise program on overuse injuries in the military environment was completed in Danish army conscripts (Brushoj et al. 2008). The study revealed that an exercise program enhancing muscular strength, coordination, and flexibility based on intrinsic risk factors identified in previous studies was not effective in reducing the incidence of lower extremity overuse injury. The intervention was speculated to be more effective in situations with a more gradual increase in load. In addition, the compliance was low (< 75%) and performed without proper supervision. However, the program enhanced aerobic endurance of the conscripts measured in a 12-minute running test (Brushoj et al. 2008).

More recently, Coppack and colleagues (2011) completed a RCT-study of 1502 male and female recruits in UK. They reported that a 14-week training program consisting of 4 warm-up exercises and 4 warm-down static stretches completed 7 times per week (total 105 minutes per week) was effective in reducing overuse anterior knee pain. There was a 75% reduction in anterior knee pain risk in the intervention group (adjusted HR 0.25; 95% CI: 0.13–0.49). The authors speculated that it was not possible to determine whether the lower limb strengthening exercises or lower limb static stretches were responsible for the observed reduction of overuse anterior knee pain. The main limitation in the study was that other MSDs were not recorded and assessors were not fully blinded. However, there were no reported adverse effects of the intervention exercises and also a reduction of medical discharges was perceived in the intervention group (0.4% vs. 3.4%) (Table 3).

Table 3. Sports injury prevention studies using neuromuscular training programs

Study and Design	Sport or activity	Intervention	Duration & Details	Participants & Training compliance	Outcomes	OR/RR (95% CI)
Proprioceptive neuromuscular training programs						
(Tropp et al. 1985) Cluster RCT	Soccer	Balance board training	6 mo, 5 x 10 min/wk for 10 wks, then 3 x 5 min/wk	315 (all male), age NR*, dropout = 17%, compliance = NR*	Ankle sprains Recurrent sprains	**OR 0.24 (0.10–0.57)** **OR 0.14 (0.04–0.51)**
(Wester et al. 1996) RCT	Athletes	Wobble board training during a 12-week recovery period beginning 1 week after ankle sprain	8 mo, 15 min each day for 12 weeks	61 (60% male), age 25 (mean), dropout = 21%, compliance = NR*	Recurrent ankle sprains	**OR 0.28 (0.08–0.96)**
(Soderman et al. 2000) Cluster RCT	Soccer	Home-based balance board training	7 mo, 10-15 min each day for 1 mo, then 3 x 10-15 min / wk for 6 mo	221 (all female), age 15-25, dropout = 37%, compliance = 62%	Lower limb injuries	OR 1.25 (0.62–2.52)
(Verhagen et al. 2004) Prospective intervention study	Volleyball	Balance board training as warm-up exercises	36 wk, 5 min before each training session	1127 (43% males), age 21-27, dropout = 39%, compliance = NR*	New ankle sprains Recurrent sprains	RR 0.8 (0.3–2.2) **RR 0.4 (0.2–0.8)**
(Emery et al. 2005) Cluster RCT	Students	Home-based balance board training	6 mo, 7 x 20 min /wk for 6 weeks, then 1 x 20 min /wk	127 (50% male), age 14-19, dropout = 10%, compliance = NR*	All sports injuries Ankle sprains	**RR 0.2 (0.05–0.88)** RR 0.14 (0.18–1.13)
(McGuine & Keene 2006) Cluster RCT	Basketball and soccer	Balance exercises on floor and balance disc	1 season, 3 x 10 min / wk	765 (32% male), age 17 (mean), dropout = 19%, compliance = NR*	All ankle sprains New sprains	**RR 0.56 (0.33–0.95)** RR 0.54 (0.28–1.08)
(Emery et al. 2007) Cluster RCT	Basketball	Balance training warm-up exercises (sport-specific, wobble board) before training sessions	12 mo, 5 x 5 min / wk and home exercises 20 min	920 (50% male), age 12-18, dropout = 1%, compliance = 60%	Acute injuries Sports injuries Ankle sprains	**RR 0.71 (0.50–0.99)** RR 0.80 (0.57–1.11) RR 0.71 (0.45–1.13)

Study and Design	Sport or activity	Intervention	Duration & Details	Participants & Training compliance	Outcomes	OR/RR (95% CI)
(Mohammadi 2007) RCT	Soccer	Balance board (BB) versus strengthening (isometric and dynamic) of evertor muscles (S) versus control (C)	1 season, 20 – 30 min each day for 1 season	80 (all male), age 25 (mean), dropout = 0%, compliance = NR*	Recurrent ankle sprains BB vs. C S vs. C	 **RR 0.13 (0.0–0.9)** RR 0.5 (0.11–1.87)
(Hupperets et al. 2009) Cluster RCT	Athletes	Unsupervised home based neuromuscular training on balance boards as warm-up exercise after usual care for an ankle sprain	1 year, 3 x 30 min /wk for 8 weeks	522 (52% male), age 12-70 (mean 28), dropout = 14%, compliance = 65%	Recurrent ankle sprains Recurrent severe ankle sprains	**RR 0.63 (0.45–0.88)** **RR 0.25 (0.12–0.50)**
(Eils et al. 2010) Cluster RCT	Basketball	Multistation proprioceptive exercise program as warm-up: six exercises lasting 45 seconds were performed twice at the beginning of normal training	1 season, 20 min once /wk for one season	232 (59% male), age 14-43 (mean 24), dropout = 19%, compliance = NR*	Ankle injuries	**OR 0.35 (0.15–0.84)**
Multi-intervention training programs						
(Ekstrand et al. 1983) Cluster RCT	Soccer	Prophylatic training program: warm-up, stretching, use of leg guards, ankle taping, counseling and systematic rehabilitation	6 mo, 20 min warm-up and 5 min cool-down	180 (all male), age 17-37, dropout = NR*, compliance = NR*	Sports injuries	**75% reduction, p<0.001**
(Wedderkopp et al. 1999) Cluster RCT	Handball	Balance board training and functional exercises	10 mo, 10-15 min in every training session	237 (all female), age 16-18, dropout = NR*, compliance = NR*	Sports injuries	**OR 0.20 (0.10–0.41)**
(Hewett et al. 1999) Prospective intervention study	Basketball volleyball and soccer	Preseason training (6-wk): plyometric, landing technique, strengthening, and flexibility exercises	1 year follow-up, 3 x 60-90min / wk for 6 weeks	1263, (34% male as a control group), HSA** dropout = 6%, compliance = 70%	Serious knee injuries	RR 0.25 (0.06–1.15)
(Heidt et al. 2000) RCT	Soccer	Preseason training (7-wk): endurance, strength, plyometric, and flexibility exercises	1 year, 2-3 sessions / wk for 7 weeks	300 (all female, only 42 in intervention group), age 14-18, dropout = NR*, compliance = NR*	Sports injuries	**RR 0.42 (0.2–0.9)**

Study and Design	Sport or activity	Intervention	Duration & Details	Participants & Training compliance	Outcomes	OR/RR (95% CI)
(Junge et al. 2002) Prospective intervention study	Soccer	Multi-intervention: warm-up, cool-down, rehabilitation, taping, fair play, and strength, endurance, coordination, stability, and flexibility exercises	1 year, 1 training session / wk organized by physiotherapist	194 (all male), age 14-19, dropout = 26% compliance = NR*	Sports injuries	RR 0.79, p> 0.05
(Askling et al. 2003) RCT		Hamstring exercises during pre-season as concentric and eccentric actions performed on flywheel ergometer after 15 min warm-up	10 mo, 4x8 repetitions 1-2 times/wk for 10 wks	30 (all male), age 25 (mean), dropout = 0%, compliance = 100%	Hamstring injuries	**OR 0.13 (0.02–0.66)**
(Wedderkopp et al. 2003) Cluster RCT	Handball	Balance board training and functional strength exercises versus functional strength exercises alone	9 mo, 10-15 min in every training session	163 (all female), age 14-16, dropout = NR*, compliance = NR*	Acute sports injuries	**OR 0.37 (0.14–1.00)**
(Mandelbaum et al. 2005), Prospective intervention study	Soccer	Warm-up program: running, stretching, strengthening, plyometrics, and soccer specific agility exercises (videotape and supportive literature guidance)	2 year, 20 min before each training session throughout 1 season	*Year 1:* 2946 (all female), *Year 2:* 2755 (all female), age 14-18, dropout = NR*, compliance = NR*	Non-contact ACL injuries	*Year 1:* **RR 0.11 (0.03–0.48)** *Year 2:* **RR 0.26 (0.09–0.73)**
(Olsen et al. 2005) Cluster RCT	Handball	Structured warm-up program: technique, strengthening, balance, and plyometric exercises	8 mo, 15 x before each training session, then 1 x 15-20 min /wk	1837 (14% male), age 15-17, dropout = 6%, compliance = 87%	Acute ankle and knee injuries Upper limb injuries	**RR 0.53 (0.35–0.81)** **RR 0.37 (0.20–0.69)**
(Pfeiffer et al. 2006) Prospective intervention study	Basketball, volleyball and soccer	Multi-intervention program as warm-up or warm-down: jump-landing, running-deceleration, directional changes, plyometric exercises	2 seasons, 2 x 20 min/ wk for 9 weeks per season	1439 (all female), dropout = NR*, compliance = 56%	Non-contact ACL injuries	OR 2.05, p >0.05
(Gabbe et al. 2006) Cluster RCT	Australian Football	Eccentric hamstring exercises at the end of the training before cool-down: 12 sets of 6 repetitions with 10s rest between repetitions and 2-3 min rest between sets	12 weeks 1 x / 2 wk for 6 weeks, then 1 x / 3 wk for 6 weeks	220 (all male), age 17-36 (median 24), dropout = 30%, compliance < 35%	Hamstring injury *Compliant players* †: Hamstring injury	RR 1.2 (0.5–2.8) RR 0.3 (0.1–1.4)

Study and Design	Sport or activity	Intervention	Duration & Details	Participants & Training compliance	Outcomes	OR/RR (95% CI)
(Engebretsen et al. 2008) Cluster RCT	Soccer	Injury-prevention program for athletes at increased injury risk: Specific programs for each risk group including balance, strengthening and plyometric exercises	1 season, 3 x /wk for 10 weeks, then 1 x /wk for rest of the season	508 (all male), age NR*, dropout = 3%, compliance = 28%	All Sports injuries Ankle injuries Knee injuries Hamstring injuries Groin injuries	RR 0.93 (0.71–1.21) RR 0.64 (0.32–1.29) RR 0.96 (0.35–2.64) RR 1.55 (0.83–2.90) RR 1.18 (0.55–2.54)
(Gilchrist et al. 2008) Cluster RCT	Soccer	Multi-intervention warm-up: strengthening, running, stretching, plyometrics, agilities and to avoid risky positions depicted on video	3 mo, 3 x 20 min /wk for 12 weeks	1435 (all female), age 20 (mean), dropout = 12%, compliance = 72%	Non-contact ACL knee injury	RR 0.30, p =0.066
(Soligard et al. 2008) Cluster RCT	Soccer	Structured warm-up program: running, strengthening, plyometric and balance exercises	8 mo, 20 min before each training session	1892 (all female), age 13-17, dropout = 26% compliance = 77%	Lower limb injuries All injuries Overuse injuries Severe injuries	RR 0.71 (0.49–1.03) **RR 0.68 (0.48–0.98)** **RR 0.47 (0.26–0.85)** **RR 0.55 (0.36–0.83)**
(Steffen et al. 2008) Cluster RCT	Soccer	Multi-intervention: core stability, balance, strengthening, and plyometric exercises	8 mo, 15 x before each training session, then 1 x 15-20 min /wk	2092 (all female), age 13-17, dropout = 2%, compliance = 52%	Sports injuries	RR 1.0 (0.8–1.2)
(Brushoj et al. 2008) Cluster RCT	Conscripts	Multi-intervention: strengthening, balance and quadriceps stretching exercises	3 mo, 3 x 15 min/wk for 3 mo, concurrent with basic military training	1020 (all male), age 19-26 (mean 21), dropout = 5%, compliance = 75%	Lower limb overuse injuries Overuse knee injury Overuse shin pain	RR 1.05 (0.98–1.11) RR 1.19, p=0.55 RR 0.93, p=0.78
(Pasanen et al. 2008b) Cluster RCT	Floorball	Multi-intervention warm-up: running techniques, balance, plyometric, strengthening, and stretching exercises	6 mo, 1-3 x 20-30 min / wk before training session	457 (all female), age 24 (mean), dropout = 5%, compliance = 74%	Non-contact acute leg injuries All leg injuries	**RR 0.34 (0.20-0.57)** **RR 0.70 (0.52–0.93)**
(Emery & Meeuwisse 2010) Cluster RCT	Soccer	Multi-intervention: dynamic stretching, eccentric strength, agility, jumping and balance (including home-based wobble board training)	1 year, 15 min before training sessions for 20 wks	744 (45% male), age 13-18, dropout = 16%, compliance = NR*	Sports injuries Acute injuries Ankle sprains Knee sprains	**RR 0.62 (0.39–0.99)** **RR 0.57 (0.35–0.91)** RR 0.50 (0.24–1.04) RR 0.38 (0.08–1.75)

Study and Design	Sport or activity	Intervention	Duration & Details	Participants & Training compliance	Outcomes	OR/RR (95% CI)
(Petersen et al. 2011) Cluster RCT	Soccer	Progressive training program of Nordic hamstring exercise as partner exercise during the training session but not before a proper warm-up program	1 season (mean 318 d), 2-3 x 5-12 repetitions 1-3 x /wk for 10 wks, then 1 x/ wk	942 (all male), age (mean 23), dropout = 8%, compliance = 91%	Acute hamstring injury New hamstring injury Recurrent hamstring injury	**RR 0.29 (0.15–0.57)** **RR 0.41 (0.18–0.93)** **RR 0.14 (0.04–0.51)**
(Coppack et al. 2011) Cluster RCT	Army recruits	Multi-intervention: 3 sets of 4 strengthening and 4 stretching exercises focusing on lower limbs	14 weeks, 7 x 15 min /wk for 14 wks	1502 (73% male), age 20 (mean), dropout = 0%, compliance = 91%	Overuse anterior knee pain Medical discharge	**HR 0.25 (0.13–0.49)** **OR 0.12 (0.04–0.39)**
(LaBella et al. 2011) Cluster RCT	Soccer and basketball	Multi-intervention warm-up training: progressive strengthening, plyometric, balance and agility exercises including awareness to avoid dynamic knee valgus and to learn proper jump landing technique	1 season, 3 x 20 min / wk for 13 (mean) wks	1558 (all female), age 16 (mean), dropout = 5%, compliance = 80%	Lower limb NC overuse injury Lower limb acute NC injury NC ankle sprain NC knee sprain NC ACL injury	RR 0.48 (0.18–1.26) **RR 0.33 (0.17–0.61)** **RR 0.38 (0.15–0.98)** **RR 0.30 (0.10–0.86)** **RR 0.20 (0.04–0.95)**
(Longo et al. 2012) Cluster RCT	Basketball	Multi-intervention: The FIFA 11+ warm-up program including running, strengthening, plyometrics, balance and awareness of core stability and proper knee alignment	9 mo, 3-4 x 20 min /wk for one season	121 (all male), age 11-24 (mean 14), dropout =0%, compliance = 100%	Any injury Lower limb injury Acute injury Overuse injury Ankle injury Knee injury	**OR 0.32 (0.17–0.60)** **OR 0.40 (0.19–0.84)** **OR 0.21 (0.10–0.44)** OR 1.21 (0.36–4.11) OR 0.79 (0.21–3.04) OR 1.21 (0.36–4.11)
(van Beijsterveldt et al. 2012) Cluster RCT	Soccer	Multi-intervention: The FIFA 11+ warm-up program including running, strengthening, plyometrics, balance and awareness of core stability and proper knee alignment	9 mo, 2 x 10-15 min /wk	456 (all male), age 18-40 (mean 25), dropout = 6%, compliance = 71%	All sports injuries Knee injuries	OR 1.04 (0.71–1.51) OR 0.58 (0.34–1.00)

Study and Design	Sport or activity	Intervention	Duration & Details	Participants & Training compliance	Outcomes	OR/RR (95% CI)
(Walden et al. 2012) Cluster RCT	Soccer	Multi-intervention: neuromuscular warm-up program including 6 exercises targeting core stability, balance, and proper knee alignment	7 mo, 15 min two times /wk for one season (7 mo)	4564 (all female), age 12-17 (mean 14), dropout = 21%, compliance = NR*	Any acute knee injury Severe knee injury ACL injury Non-contact ACL	RR 0.92 (0.61–1.40) RR 0.70 (0.42–1.18) **RR 0.36 (0.15–0.85)** RR 0.40 (0.13–1.18)
					*Compliant players****: Any acute knee injury Severe knee injury ACL injury Non-contact ACL	 **RR 0.53 (0.30–0.94)** **RR 0.18 (0.07–0.45)** **RR 0.17 (0.05–0.57)** **RR 0.26 (0.07–0.99)**

* NR = not registered
NC = noncontact
ACL = anterior cruciate ligament
† attending at least the first two training sessions
** HSA = high school athletes
*** attending minimum 50% of intervention exercises

3. AIMS OF THE STUDY

The aims of this thesis were

1. to describe the incidence, nature, severity and etiological circumstances of MSDs among young men during conscript military training in Finland (I and II)

2. to examine associations between various risk factors and MSDs with special attention to the physical fitness of the conscripts during six-month military training (II)

3. to study the predictive associations of various intrinsic risk factors in young conscripts for LBP and disability during military training (III)

4. to evaluate predictive associations between untimely medical discharge of the conscripts and various intrinsic risk factors including socio-economic, health, health behavior, and physical fitness outcomes (IV)

5. to investigate whether a neuromuscular exercise program with injury prevention counseling is effective in preventing acute musculoskeletal injuries during military service of young men (V)

6. to investigate effectiveness of neuromuscular exercise program with injury prevention counseling in preventing LBP and disability during military service of young men (VI)

7. to evaluate the public health implications of the findings (I-VI)

4. MATERIALS AND METHODS

4.1 Study design and subjects

This study (The VASTE Study) was designed as collaboration between Tampere Research Centre of Sports Medicine, the UKK Institute, General Headquarters of Finnish Defence Forces, Centre for Military Medicine and Pori Brigade. The participants of this study were male conscripts from one brigade (Pori Brigade, Säkylä) in the Finnish Defence Forces. The Pori Brigade is a typical Finnish garrison and the chosen companies formed a representative sample of conscripts. During the study period, four arrivals of conscripts entered military service in the Pori Brigade: 359 in July 2006, 619 in January 2007, 522 in July 2007 and 557 in January 2008 (total 2057). All companies without special qualification requirements in the Pori Brigade were enrolled in the study including anti-tank, signal, mortar, and engineer companies. Annually, the conscripts of each age-cohort were randomly assigned into the study companies. This assignment was conducted without seeing the conscripts by the office secretary who works outside the brigade in the headquarters of the Finnish Defence Forces before military entrance. In Finland, military service or alternative civil service is compulsory for all male citizens over 18 years of age and annually about 80% of 19-year-old men enter into the service. The service period varies from 6 to 12 months.

4.1.1. Epidemiologic studies (studies I-IV)

Subjects in studies I and II

The participants of the studies I and II consisted conscripts of two arrivals starting service during the first year of VASTE study, in July 2006 or in January 2007. The group of participants was nearly the same in studies I and II. The inclusion criteria considering missing data in the pre-information questionnaire were stricter in study II leading to an exclusion of 11 conscripts who participated in the study I. Some of the

conscripts changed their company during basic training period leading to six companies enrolled into the study II: the anti-tank company, the signal company, the mortar company, the engineer company, the infantry company and the logistic company. There were no qualification requirements for any of the study companies.

Subjects in study III

During the study period, four consecutive cohorts of conscripts began service in the brigade. Companies participating in the intervention program during the last two cohorts were excluded from the data. First two cohorts of conscripts were presented earlier in studies I and II, but the inclusion criteria were stricter considering earlier LBP in study III. The flow of conscripts through the study III is presented in Figure 3.

LBP during the month before military entry was assessed based on the answers to four questions included in a pre-information questionnaire. The questions charted period prevalence of LBP with or without radiation to lower extremity and its ill effects on everyday life at baseline. Data for conscripts who reported at least 1 day of LBP or disability in everyday activities due to LBP (n=396) during the month before military entry were excluded from the analyses to ensure that previous LBP did not bias the results. In addition, 33 conscripts who did not respond to the pre-information questionnaire were excluded (Fig. 3).

Subjects in study IV

During the study period, four consecutive cohorts of conscripts began service in the brigade. The initial sample including 1513 conscripts was the same as in study III, but there were no inclusion criteria considering previous LBP in study IV leading to 1411 conscripts included in the study analysis. Companies participating in the intervention program during the last two cohorts were naturally excluded from the data in study IV.

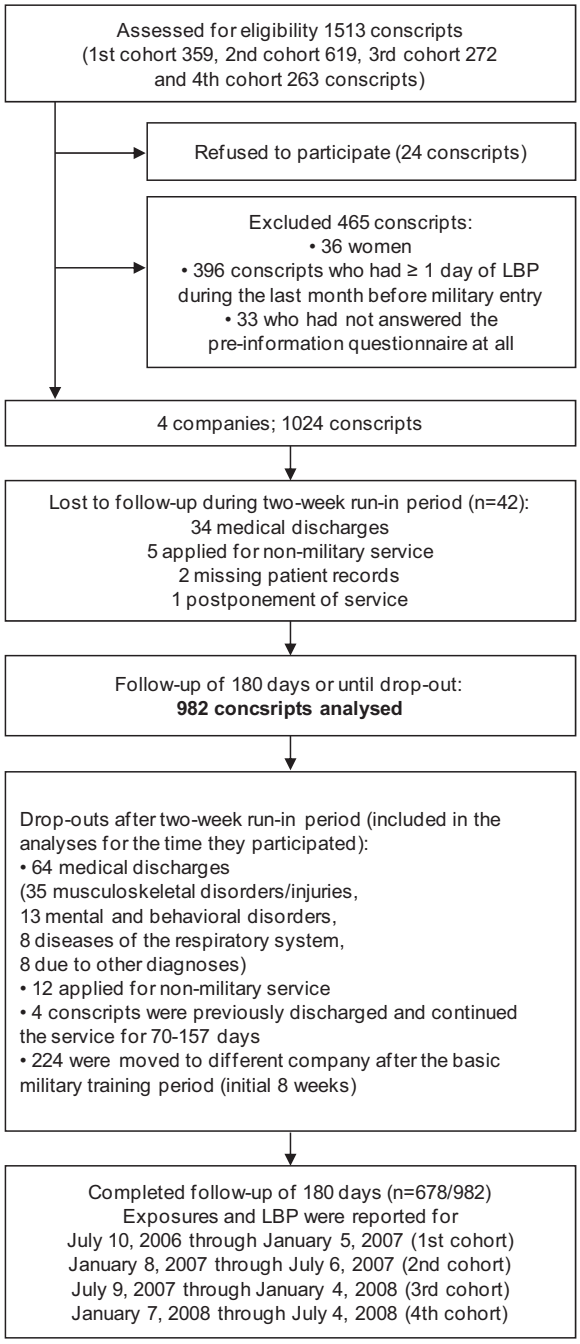


Figure 3. Flow of conscripts through study III (Taanila et al. 2012)

4.1.2. Intervention studies for prevention (studies V-VI)

Sample size

Based on previous studies of physical activity-related injuries (Pasanen et al. 2008a; Tiirikainen et al. 2008), the incidence of acute lower limb injury was estimated to be 0.6 injuries per person year. The power calculations were based on negative binomial model with the assumption of overdispersion parameter of 1.50. Thus, a minimum of 33% reduction in the incidence of lower limb injury, from 0.6 injuries per person year in the control group to 0.4 injuries per person year in the intervention group would be detected with the sample size of 500 persons per group. The statistical power was set to 0.80 and the significance level to 0.05.

Participants and randomization

The participants of the intervention studies comprised male conscripts from four companies. During the intervention studies V and VI, four cohorts of conscripts started service in the brigade: 359 in July 2006, 619 in January 2007, 522 in July 2007 and 557 in January 2008 (total 2057). The first two successive cohorts were followed prospectively for one term (6 months) to assess the baseline incidence of injuries (pre-study period) and to find out possible difference in the risk of acute injury in the participating companies. After this, the four companies were randomized into two groups (2 intervention companies: anti-tank, engineer and 2 control companies: signal, mortar) and their two new successive cohorts were followed prospectively for one term comprising the data for the intervention (intervention period). The subjects of each incoming cohort were different.

Eighteen (3 in anti-tank/engineer companies and 15 in signal/mortar companies) conscripts during pre-study period and 14 (8 in anti-tank/engineer companies and 6 in signal/mortar companies) during study period refused to participate in the study, respectively. Therefore, 2025 (98%) conscripts agreed to participate and provided their informed consent prior to initiation of the study. Details of the flow of participants during the randomized intervention studies V and VI are shown in Figures 4 and 5 (Fig. 5 includes whole study period including pre-study and intervention periods).

In the study V, during the intervention period, there were 501 and 467 conscripts in the intervention and control groups, respectively, eligible for analyses (Fig. 4). Corresponding figures for the pre-study period were 508 and 436. There were some statistically significant differences between the companies (Table 4), and thus, these variables were adjusted in statistical models. The initial sample including 2057 conscripts was the same in studies V and VI, but there were no inclusion criteria considering previous LBP in study V leading to higher number of conscripts included in analyses in study V.

In the study VI, during the intervention period, there were 356 and 334 conscripts in the intervention and control groups, respectively, eligible for analyses. Corresponding figures for the pre-study period were 390 and 329. In the intervention year, altogether 389 of 1079 conscripts were excluded; 258 due to previous LBP, 14 for refusal to participate, 13 for missing data considering previous LBP, 28 for female gender and seven had excluding back pain diagnosis: M41 (scoliosis, n=5), M40.3 (flatback syndrome, n=1), and M51.9 (intervertebral disc disorder, n=1). Following the medical screening during the two-week run-in period, an additional 69 men lost (Fig. 4, 5).

In the pre-study period, altogether 259 of 978 conscripts were excluded. Main reason for exclusion was prior LBP (n=214) followed by refusal to participate (n=18), missing data considering previous LBP (n=10) and female gender (n=8). During the run-in period, an additional eight conscripts were lost to follow-up and one had excluding back pain diagnosis: M41 (scoliosis) (Fig. 5).

Using the company as the unit of randomization and a computer-generated randomization program, an independent statistician who had no information about the study subjects performed the randomization of companies into the intervention and control groups for the July 2007 and January 2008 cohorts. Companies allocated to the intervention group were informed about the upcoming program for preventing injuries. Companies in the control group followed the usual regimen of the Finnish army.

All subjects were followed for 6 months starting from the first day of service. If a conscript changed his company during the study, he was followed until the change and this was taken into account when calculating exposure times.

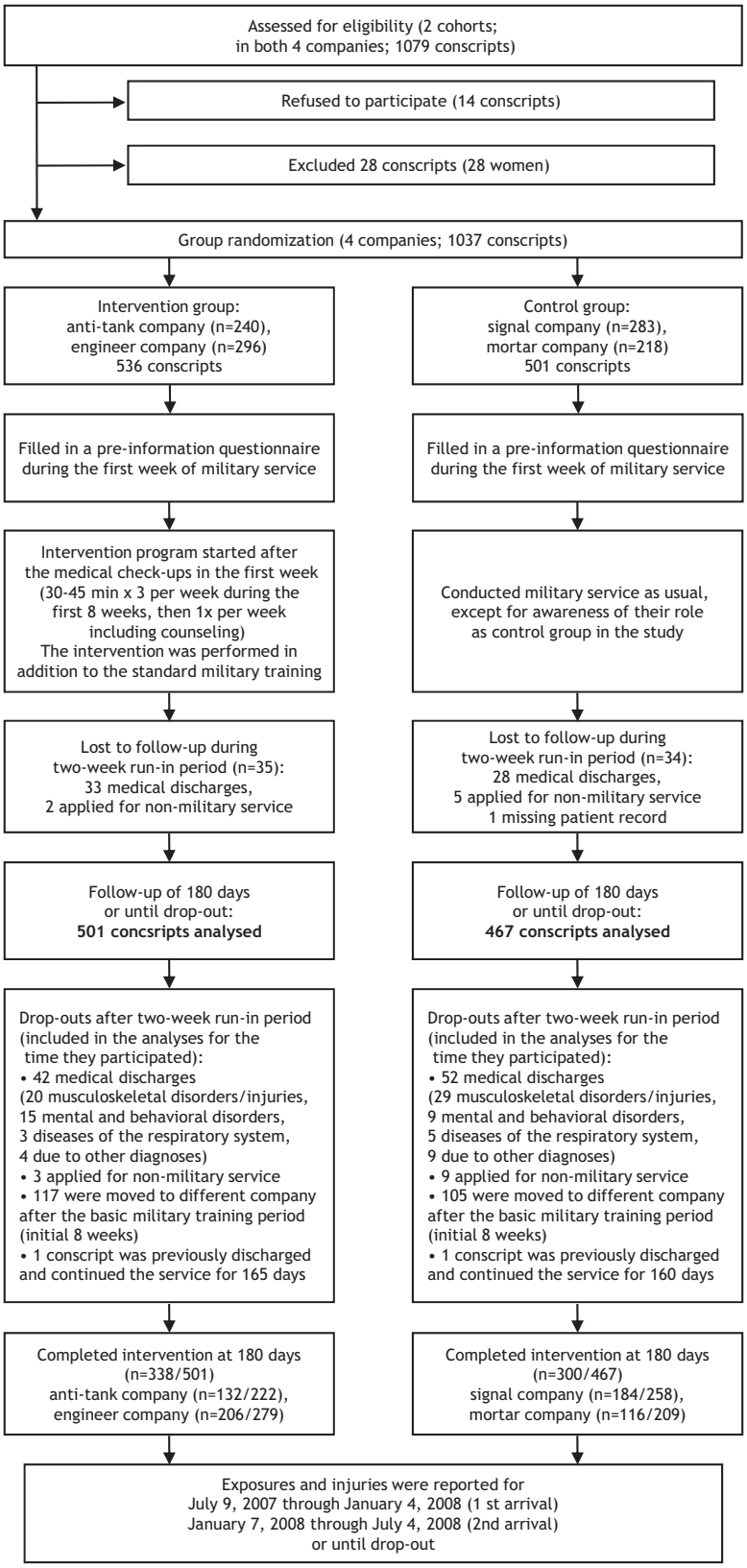


Figure 4. Flow of participants through the study V (adapted from Parkkari et al. (2011))

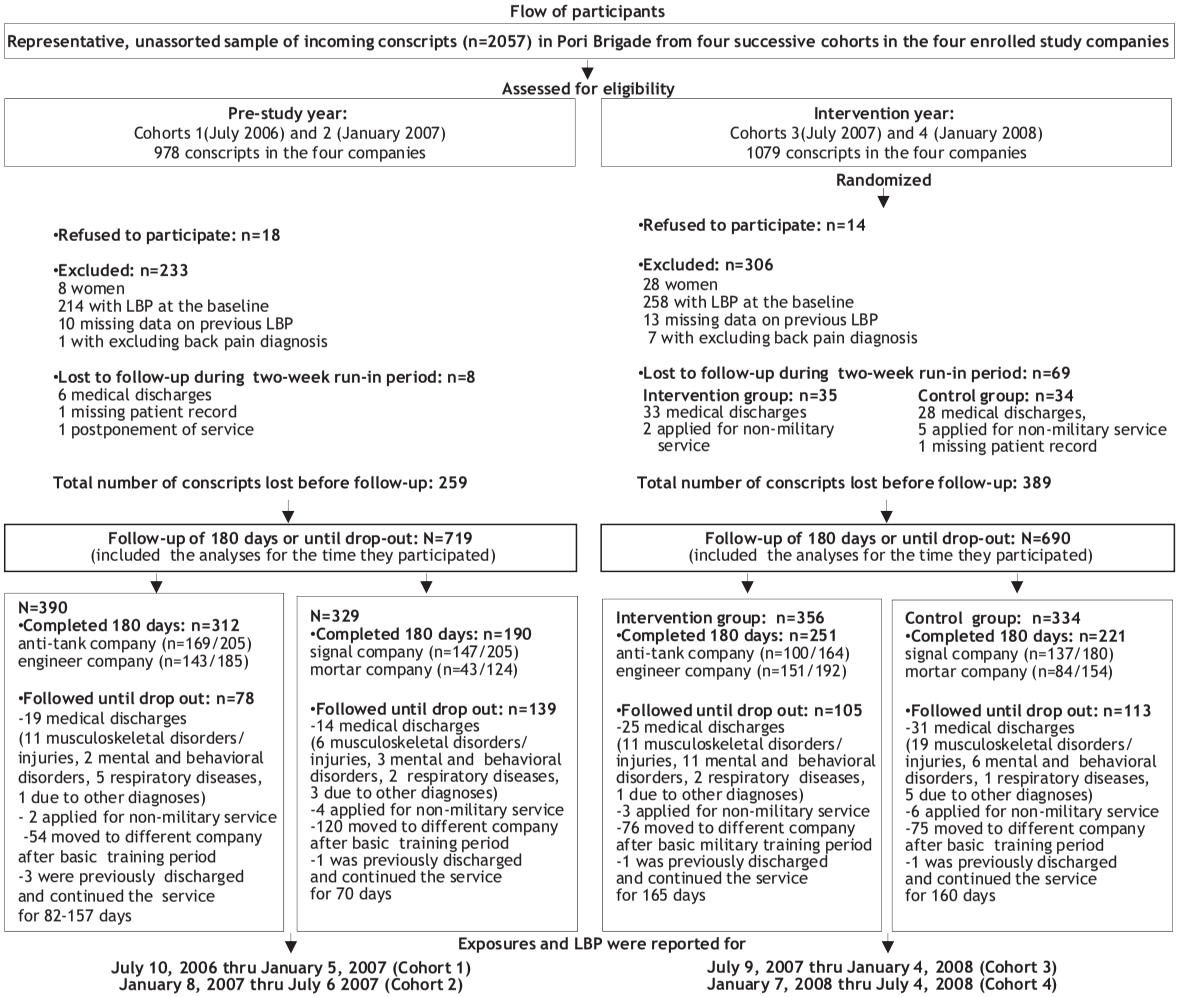


Figure 5. Flow of participants through the study VI (Suni et al. 2012)

Table 4. Baseline characteristics of 1912 male conscripts by company and study period (adapted from Parkkari et al. (2011))

Variable	Pre-study period				Study period intervention group		Study period control group		Missing data	*P* value[a]
	Anti-tank company	Engineer company	Signal company	Mortar company	Anti-tank company	Engineer company	Signal company	Mortar company		
Number of conscripts	263	245	282	154	222	279	258	209	0 (0%)	-
Median age, yr	19	19	19	19	19	19	19	19	0 (0%)	0.116[b*]
Median body mass index, kg/m^2	23.4	23.6	22.5	22.7	23.6	23.3	22.8	23.7	175 (9%)	0.107[b*]
Median waist circumference, cm	87.0	87.0	85.0	84.5	85.0	86.0	84.0	86.1	139 (7%)	0.729[b*]
Median 12-minute running test result, m	2,310	2,400	2,340	2,515	2,350	2,420	2,300	2,470	51 (3%)	0.081[b*]
Median muscle fitness index[c], points	7	7	7	8	7	6	6	10	37 (2%)	0.107[b*]
Median conscript physical fitness index (CPFI)[d], points	15.05	15.50	15.03	16.75	15.75	15.25	14.60	17.05	58 (3%)	0.095[b*]
High level of education[e], %	48	35	36	50	46	24	41	49	23 (1%)	0.001[b]
Father's occupation non-physical, %	36	33	37	33	38	33	38	41	112 (6%)	0.475[b]
Conscript's hometown population ≥10,000, %	59	57	64	54	66	57	68	63	25 (1%)	0.142[b]
High level of preceding physical activity[f], %	31	36	26	32	24	26	21	49	24 (1%)	0.006[b]
Good self-assessed health[g], %	57	51	54	50	54	53	41	70	23 (1%)	0.998[b]
Chronic impairment or disability, %	17	17	11	17	11	18	19	16	30 (2%)	0.293[b]
Past orthopaedic surgery, %	8	9	7	9	9	10	11	7	25 (1%)	0.826[b]
Clear musculoskeletal symptoms[h], %	28	27	32	28	34	34	31	25	25 (1%)	0.070[b]
Previous or current regular smoker, %	43	57	47	40	53	58	47	46	27 (1%)	0.004[b]
Use of alcohol at least three times per week, %	16	20	15	16	24	23	23	14	24 (1%)	0.077[b]

[a]*P*-value for difference between intervention and control companies [b]*P* value was calculated by using χ^2 statistics for significant differences, continuous* variables were categorized and cut-off points to describe overweight and obesity for body mass index and waist circumference were set according to the WHO. Cut-off points to describe physical fitness were set according to Finnish Defence Forces; [c]Muscle fitness index is the sum of individual muscle fitness test results comprising push-ups, sit-ups, pull-ups, the standing long jump and the back-lift test (excellent = 13 to 15 points, good = 9 to 12 points, fair to good = 5 to 8 points, and poor = 0 to 4 points); [d]CPFI = (12-minute running test result (measured in meters) + 100 × muscle fitness index) ÷ 200; scoring was excellent = CPFI ≥21.00), good = 17.00 ≤ CPFI < 21.00, fair to good = 13.00 ≤ CPFI < 17.00, and poor = CPFI < 13.00; [e]graduted or studies in higher education institution; [f]sweating exercise at least three times per week during the past month before entry into the military; [g]compared to age cohort; [h]symptoms lasting more than 7 days in at least one anatomical region during the past month before entering the military.

4.2 Measurements (studies I-VI)

4.2.1 Procedures and baseline characteristics including health screening

To ensure that conscripts entering military service were healthy and fit for service, all conscripts had a medical check-up by a clinician before call-up into the military. The health status of the conscripts was rechecked at baseline during the first two weeks of service using routine medical screenings performed by a physician. To exclude injuries and illnesses originating before the onset of military service, conscripts discharged from the service at the medical screenings during the two-week run-in period were excluded from the analyses. Because less than 3% of conscripts were women, they were excluded from the data. The age of the conscripts ranged from 18 to 28 years (median 19). All subjects were planned to be followed for 6 months beginning on the first day of service, but some dropped-out from the military or changed company and this was taken into account when calculating exposure times.

4.2.2 Assessment of common risk factors of MSDs

Pre-information questionnaire

Subjects were administered a pre-information questionnaire during the first week of military service. A same questionnaire was used in all studies of this thesis to chart conscripts' socio-economic factors, health, and health behavior at the baseline of the study. The socio-economic factors included education, urbanization level of the place of residence, school success (educational level and grades), and father's occupational group. Health factors included previous sports injuries and orthopaedic surgeries, medication, chronic disease (e.g. asthma, atopy), chronic impairment or disability, self-assessed health compared to age mates, and musculoskeletal pain in seven anatomical regions during the last month. Health behavior was assessed with questions on the use of alcohol and tobacco, frequency of drunkenness, volume of physical exercise, prior sporting activities, belonging to a sports club, participation in competitive sports,

highest level achieved in school sports, self-assessed physical fitness, and opinion about the physical demands of a soldier.

4.2.3 Assessment of physical fitness

Assessment of baseline physical fitness

A Cooper's test (12-minute running test) and muscular fitness tests were performed by most (97%) conscripts at the beginning of military service. A minority of conscripts (3%) were unable to complete their physical fitness tests due to minor health problems, such as infection or overuse injury. Muscular fitness tests and the 12-minute run test were performed on different days. Because excellent results in the Cooper's test were sparse (< 4%), the two highest levels, good and excellent, were combined to obtain a group of equal size for comparison between different fitness categories.

Muscular fitness tests included push-ups, sit-ups, pull-ups, the standing long jump, and a back-lift test (Santtila et al. 2006). Instructors of the companies supervised so that each test was performed technically correctly. The recovery time between each muscular fitness test was at least five minutes. The purpose, test method and outcome definition of each muscular fitness test is presented in Figures 6, 7, 8, 9 and 10. Individual muscular fitness test results were combined into a single variable to explore whether the combined fitness variable, representing co-impairment, is more strongly associated with outcome. Co-impairment was defined as a poor result in both measured fitness tests according to the standard result categories (Santtila & Tiainen 2004).

PULL-UP TEST

Purpose: To measure dynamic endurance of flexor muscles in arm and shoulder.

Method: The conscript is required to raise his chin over a bar and then return to the starting point with elbows fully extended.

Outcome: Repeats without time limit. Repeats have to be consecutive and intermission in the starting point is not allowed. Result categories: Excellent (≥14), Good (≥10), Fair good (≥6) and Poor (<6) [repeats].


Starting position


Top position

Figure 6. Description of pull-up test (Taanila et al. 2010)

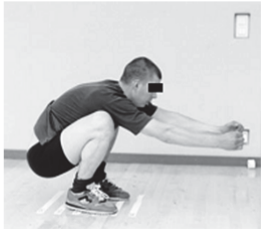
STANDING LONG-JUMP TEST

Purpose: To measure explosive force production of the lower limb extensor muscles as well as motor control.

Method: The jump starts with legs close to each other and bilateral takeoff is assisted by swinging of the upper body and arms. The landing is bilateral and shortest distance expressed in metres from the landing to the starting point was measured.

Outcome: The conscript has two attempts and the best result is registered. Result categories: Excellent (≥2,40 m), Good (≥2,20 m), Fair good (≥2,00 m) and Poor (<2,00 m).

Starting position



Landing position

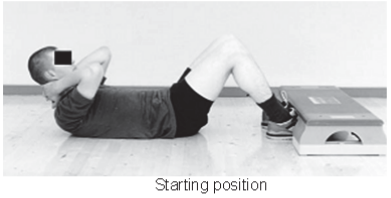
Figure 7. Description of standing long jump test (Taanila et al. 2010)

SIT-UP TEST

Purpose: To measure dynamic endurance of abdominal and hip-flexor muscles.

Method: The conscript is lying on the floor supine with hands behind the neck. The knees are flexed at an angle of 90°, and an assistant supports the ankles (contrary to the picture). The conscript raises upper body until his elbows touches the knees and then returns to the starting position where both scapulas touches the floor.

Outcome: Number of consecutive repeats completed in 60 seconds. Result categories: Excellent (≥48), Good (≥40), Fair good (≥32) and Poor (<32) [repeats].



Starting position

Top position

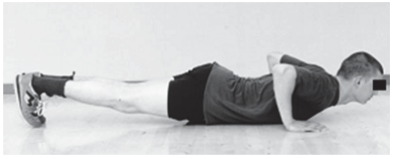
Figure 8. Description of sit-up test (Taanila et al. 2010)

PUSH-UP TEST

Purpose: To assess dynamic strength of the upper body and the ability to stabilise the trunk.

Method: The conscript starts from the lowest face-down position and hands are kept shoulder-wide level. During the push-up, a conscript was first required to fully extend his arms while keeping the body straight with tensed trunk muscles. In the second phase, the body was lowered to the down position with an elbow angle of 90°.

Outcome: Number of consecutive repeats completed in 60 seconds. Result categories: Excellent (≥38), Good (≥30), Fair good (≥22) and Poor (<22) [repeats].



Starting position

Top position

Figure 9. Description of push-up test (Taanila et al. 2010)

BACK LIFT TEST

Purpose: To measure dynamic endurance of back and hip-extensor muscles.

Method: The conscript lies prone on the floor with hands behind the neck in the starting position. An assistant supports the legs (contrary to the picture). During the movement, the upper body is lifted until the scapulas are approximately 30 cm higher than in the starting point. Thereafter, the upper body is lowered down back to the starting position.

Outcome: Number of consecutive repeats completed in 60 seconds. Result categories: Excellent (≥60), Good (≥50), Fair good (≥40) and Poor (<40) [repeats].

Starting position

Top position

Figure 10. Description of back lift test (Taanila et al. 2010)

A conscript's physical fitness index (CPFI) was calculated using the following formula: (12 min running test result [metres] + 100 x Muscular fitness index) / 200. The formula is based on practice in the Finnish Defence Forces since 1982 (Santtila & Tiainen 2004). In addition, height, weight, and waist circumference (WC) were measured during the first service weeks. Body mass index (BMI) was calculated by dividing weight (kilograms) by the square of height (metres). WC, as a mark of abdominal obesity and excessive visceral fat (Shen et al. 2006), was measured with a tape at the midway between the lowest rib and iliac crest after normal exhalation. The cut-off points to describe overweight and obesity for BMI and WC were set according to the World Health Organisation (2000).

Basic physical training program

Conscripts performed 8 weeks of basic physical training program which is routine in the Finnish Defence Forces. There was an average of 17 hours of military actions per week with a gradual increase in intensity including marching, cycling, skiing, orienteering, swimming, drill training and combat training. The two month basic training period was followed by a specific military training program depending on the company and service duration. During this 4-month period of service, the volume and intensity of physical training was maintained at approximately the same level in different companies. Military tasks practiced in the four companies were partly different after the 2-month basic training period due to different soldiery assignment objectives depending of the

company. After this, however, the core of the military physical training was still based on the same military actions as in the beginning of the service.

4.2.4 Assessment and monitoring of MSDs

Injury definition and data collection

Injury (MSD, LBP, acute injury) was defined as an event that resulted in physical damage or pain for which the conscript sought medical care from the garrison clinic. During military service, all conscripts had to use the services of the military healthcare units. The date, anatomical location, type, etiological circumstances, severity and diagnosis were registered in electronic patient records in studies II-VI. Because the conscripts may have sought medical care several times due to the same event, the total number of health clinic visits exceeded the number of diagnoses. The health clinic visits were considered to be for the same injury when the conscript had sustained an injury of the same type and location during the preceding two weeks or if a physician had marked on the patient files that the reason for the visit was related to the previous injury.

In the study I, a questionnaire (appendix 1) was used instead of electronic patient records. At the clinic, assisted by the healthcare personnel, a conscript filled out a disorder questionnaire eliciting the type, anatomical location, severity, associated activities and cause of MSD. All answers were checked by a nurse or physician and any unanswered question was filled if possible. The disorder questionnaire included 26 different defined MSD types and an open question for undefined MSD. The MSD was considered recurrent when the conscript had previously sustained an MSD of the same type and in the same location. To ensure that all MSDs were registered, data were collected from electronic patient records in studies II-VI.

MSDs that occurred during the conscript's leisure time or on the way to vacation or back to garrison were also included in the analyses. After careful clinical examination, necessary diagnostic tests and radiological graphs, the most accurate diagnosis was selected by a physician according to the 10th Revision of the International Classification of Diseases and Related Health Problems (ICD-10). The anatomical location of the MSD was reported according to the diagnosis in studies II-VI. The type of injury was categorized as acute if it had a sudden onset involving known trauma

(Requa & Garrick 1996; Pasanen et al. 2008b; Soligard et al. 2008). For example, sprains, strains, ligament ruptures, and joint dislocations were categorized as acute injuries. Overuse-related MSDs had a gradual onset without known trauma (Requa & Garrick 1996; Soligard et al. 2008) and they were described as a pain syndrome of the musculoskeletal system, where symptoms appeared during physical activities at previously symptomless body part (Orava 1980).

The severity of the outcomes (MSD, LBP, acute injury) was categorized according to the number of days of limited duty: 0–3 days denoting minor, 4–7 days mild, 8–28 days moderate, and > 28 days severe (Ekstrand & Gillquist 1983; Pasanen et al. 2008b; Soligard et al. 2008). Limited duty involved a physical restriction that prevented the conscript from fully participating in military training events. Discharge from military service was indicated when a physician determined a conscript unable to continue military training. Discharges from military service due to musculoskeletal injury were registered as severe injuries.

4.3 Aims and description of the neuromuscular exercise and counseling intervention (studies V-VI)

Intervention program

The intervention program started after the initial medical check-ups in the first week and was performed in addition to the standard military training program. The intervention included neuromuscular training and injury prevention counseling with cognitive-behavioral learning goals. The main aims were to decrease the number of acute musculoskeletal injuries and LBP during the military service. Implementation of the intervention was planned together with the personnel of the brigade as well as conscripts with leading positions. Two educated female instructors outside the brigade, one of whom had completed military service, were responsible for conducting the implementation of the intervention.

Neuromuscular training. The neuromuscular exercise (NME) program was designed to enhance conscripts' movement control and agility, as well as to increase the stability of the trunk, knee, and ankle. In order to reduce the incidence of LBP, NME was aimed to improve the control of the lumbar NZ and specifically avoiding full lumbar flexion

(Warming et al. 2008). All exercises (Fig. 11 and Table 5) required control of the NZ (Cholewicki et al. 1997). The focus of each of the 9 exercises (see Fig. 11) was on the use of proper technique, such as good posture, maintenance of core stability or positioning of the hip, knee, and ankle, especially "knee-over-toe" position. Conscripts worked in pairs and were instructed to evaluate each other's technique and to provide feedback during training. The exercises and their dosage are listed in Table 5, with the order of the exercise corresponding to the number (1-9). Two exercises (1,2) improved balance and posture, one (4) improved coordination and agility, three (2,4,8) improved control of the lumbar NZ, two (3,5) improved core (trunk) stability and endurance of the trunk muscles, one (7) improved eccentric muscular work of hamstring muscles, two (6,8) improved extensibility of lower extremity muscles, and one (9) improved mobility of thoracic spine (9). All exercises performed in upright positions (1,2,4,6,8) followed the exercise principle of a closed kinetic chain (Irish et al. 2010).

During the first 8 weeks of basic service, neuromuscular training was conducted 3 times a week as part of normal compulsory service in the intervention companies. The conscripts trained inside in small groups (~40 men per group), led by the above noted two instructors. One exercise session lasted from 30 to 45 minutes and included the above-described 9 exercises at moderate intensity. At the beginning of the training, the emphasis was on correct performance of the technique, and later the challenge for balance and coordination, numbers of repetitions, and load were increased. Each conscript in intervention companies was provided with a training book named "TULTA" (appendix 2), which included the rational of each exercise and pictured performance instructions for maintaining the correct technique. A training log was attached to the book.

During the specialising military training period (weeks 9–17) and the team training period (weeks 18–26), conscripts in the intervention companies were instructed to continue to exercise on their own at least once a week. To support this, instructed training sessions were provided in the evenings during the conscripts' leisure time. The conscripts were commanded to meet the exercise instructors once a week to have their exercise logs checked and to receive individual guidance on how to correctly perform the exercises when needed. Neuromuscular exercises were also guided by conscripts with leading positions as a part of compulsory physical training 2–4 times per month

during this training period. Selected exercises were also performed during the field service outdoors.

Injury prevention counseling. Educational counseling was used to increase knowledge and awareness of musculoskeletal injuries during various training situations. Counseling was based on the cognitive-behavior modeling (Linton & Nordin 2006). Each conscript in the intervention companies received a guidance booklet named "OPAS" (appendix 3) with information on situations and duties that were supposed to pose a high risk for injury. These included the training on uneven surfaces, landing from the vehicles and lifting heavy materials. Furthermore, information on how to manage acute injuries was provided. In order to prevent LBP, the aims were to increase conscript awareness of tasks during daily military life potentially harmful for the lower back, and to increase personal knowledge, understanding, and skills regarding performance of these tasks in a less harmful manner, and thus reduce the fear of pain (Leeuw et al. 2007). A 1-hour lecture on these potentially hazardous training and combat actions was provided by one of the instructors in the middle of the basic training period. Furthermore, the leaders of the companies and the exercise instructors addressed the potential hazards in field service when appropriate. Conscripts in the control companies conducted their service as usual, except for their awareness of their role as control group in the study. In addition, they filled in all the study questionnaires and participated in the baseline fitness test battery.

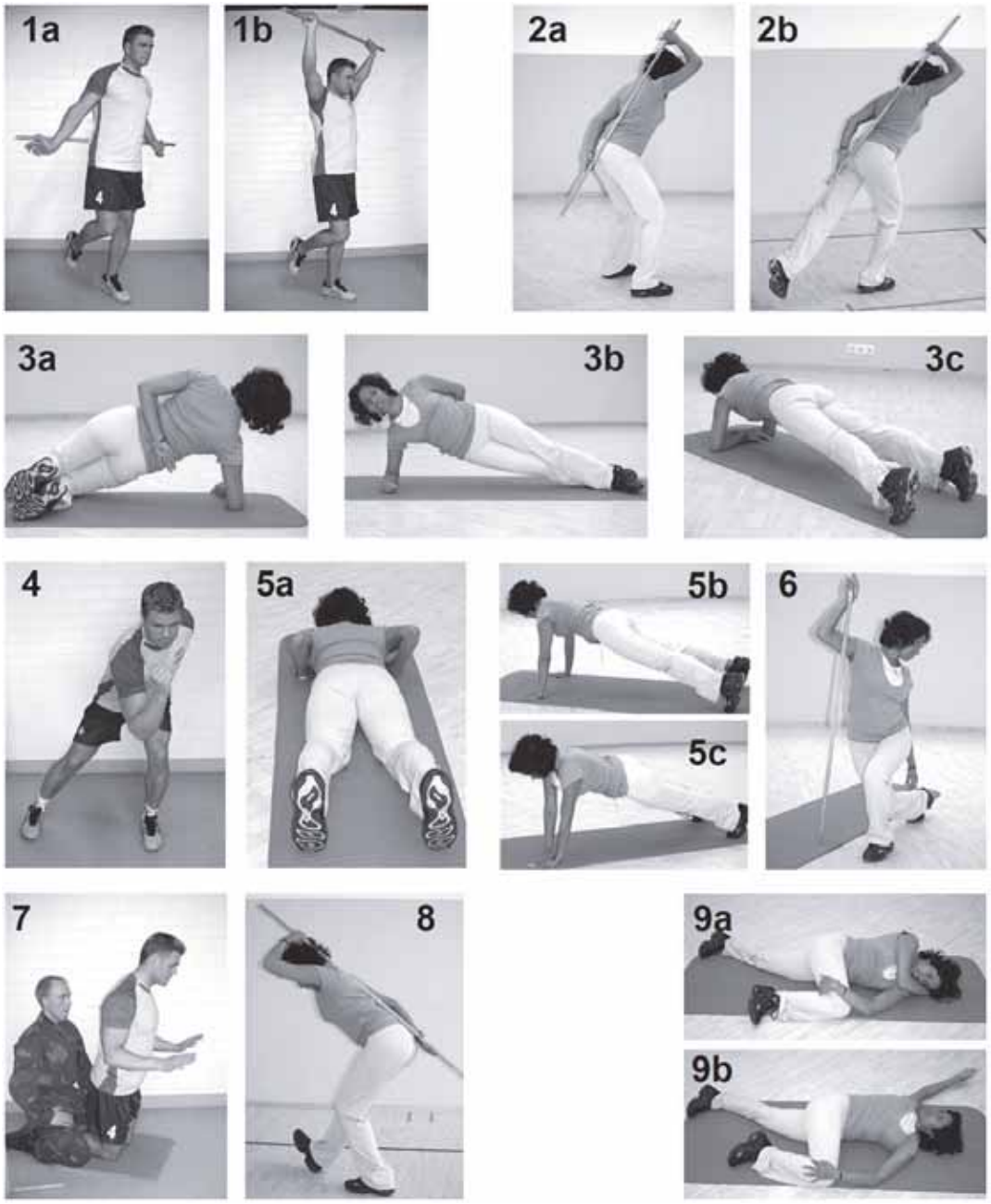


Figure 11. Neuromuscular training exercises performed by the intervention group.
Exercises 1 through 9 and their specific aims are described in Table 5 (Parkkari et al. 2011).

Table 5. Dosage and aims of the neuromuscular training program (Parkkari et al. 2011)

Exercise and dosage	Aimed to enhance/improve
1. One-leg standing with a stick 20 repetitions (10+10) with alternating legs	•balance and coordination •shoulder-neck posture and mobility
2. Squat exercise with a stick on two and one leg 16 repetitions (rep.) on two legs, 16 rep. (8+8) with alternating legs	•balance and control of lumbar neutral zone (NZ) •lower extremity muscular strength
3. Horizontal side-support Stage one (flexed knees): 5 rep. with 5 s static holding (5+5) with alternating side Stage two (straight knees): 5 circles of "side-belly-side" with 5 s hold for each	•co-contraction of trunk muscles and back stability •trunk muscular endurance
4. Jumping from side to side Rhythm: 4 slow jumps + 8 fast jumps; exercise time 60 s	•coordination and agility; control of lumbar NZ •lower extremity muscular endurance
5. Modified push-up Repetitions as many as possible; exercise time 60 s	•upper extremity extensor strength •co-contraction of trunk muscles and back stability
6. Stretching exercise for hip flexor muscles 5 x 10 s stretch with alternating side	•extensibility of hip flexor and side muscles •lower extremity muscular strength
7. Hamstring exercise on knees; repetitions 8-12	•eccentric capacity of hamstring muscles •trunk motor control
8. Stretching exercise with a stick for hamstring muscles 3 x 20 s stretch with alternating legs	•extensibility of hamstring and calf muscles •control of lumbar NZ
9. Upper body rotation while side-lying, "yoga stretch" 1 x 60 s for both sides	•rotational mobility of thoracic spine •extensibility of pectoral muscles

4.4 Outcome measures

4.4.1. Descriptive outcomes of MSDs and untimely medical discharge (study I and IV)

MSD registration and outcome definition in study I

The data was collected between July 10th, 2006 and July 6th, 2007. A major difference between the study I and studies II-VI was the use of questionnaire form instead of using computerized patient records. A MSD (including overuse and acute injuries and LBP) was defined as an event that resulted in physical damage to the body and for which the conscript sought medical care from the garrison clinic. At the clinic, assisted by the healthcare personnel, a conscript filled out a disorder questionnaire eliciting the type, anatomical location, severity, associated activities and cause of MSD.

Discharge registration and outcome definition in study IV

The data were collected from July 10th 2006 to July 4th 2008 considering all four arrivals of the VASTE study. Data regarding medical discharge were charted from computerized patient records. In addition, separate discharge statistics were received from the Pori Brigade and this data were cross-checked with the patient records to ensure that the data were complete. Discharges were divided into four main categories according to International Statistical Classification of Diseases and Related Health Problems (10th Revision): musculoskeletal disorders and injuries (M- and S-diagnoses), mental and behavioral disorders (F-diagnoses), respiratory diseases (J-diagnoses), and other diagnoses. Untimely medical discharge from military service was indicated when a physician determined a conscript unable to continue military training.

4.4.2 Acute and overuse musculoskeletal injuries (study II)

MSD registration and definition in study II

The data were collected from July 10th 2006 to July 6th 2007. A MSD (including overuse and acute injuries and LBP) was defined as an event that resulted in physical damage to the body for which the conscript sought medical care from the garrison clinic. Heat or cold injuries were not included in the analysis. Only those wounds that were direct consequences of musculoskeletal contusions were considered MSDs.

4.4.3 Low back pain (LBP) and disability (III)

LBP registration and definition in study III

The data were collected from July 10, 2006 to July 4, 2008 covering all four incoming cohorts of conscripts of the VASTE study (Fig. 3). LBP included the following ICD-10 diagnoses: M54 (dorsalgia), M54.5 (LBP), M41 (scoliosis), M54.9 (dorsalgia, unspecified), and M54.3 (sciatica). The anatomical location of the afflicted body part was confirmed by the study physician (HT) based on computerized patient records. Upper back pain was excluded from the outcome definition.

4.4.4 Intervention studies (V-VI)

Acute injury definition in study V

The data were collected from July 10th 2006 to July 4th 2008 including 6-month follow-up of all four incoming cohorts of conscripts in both intervention studies. In study V, injury was defined as an acute event that resulted in physical damage to the body for which the conscript sought medical care from the garrison clinic. Overuse, heat or cold injuries were not included in the analysis. The primary outcome measure was an acute lower- or upper-limb injury that occurred during the 6-month military service. The severity of injuries was a secondary outcome measure of the study.

LBP definition in study VI

In study VI, LBP included the following ICD-10 diagnoses: M54 (dorsalgia), M54.5 (LBP), M54.9 (dorsalgia, unspecified), and M54.3 (sciatica). Exclusion diagnoses are shown in Figure 5. The anatomical location of the afflicted body part was confirmed by the study physician (HT) based on computerized patient records. Upper back pain was excluded from the outcome definition. The outcome measures were the number and incidence of LBP, total number of healthcare visits due to LBP, total number of off-duty days, and at least five off-duty days due to LBP. Off-duty included any physical restriction that prevented full participation in military training.

4.5 Statistical analyses

SPSS versions 16.0, 17.0 and 18.0 for Windows software (SPSS Inc., Chicago, IL) were used for statistical analyses. In studies I, II and III, outcome (MSD, LBP) incidence was calculated by dividing the number of conscripts treated in the garrison clinic (numerator) for outcome by the total number of conscripts (denominator) and expressed as a percentage. Person-based incidence rate was calculated by dividing the number of conscripts treated in the garrison clinic by the exposure time. Exposure time for person-based incidence rate was calculated until onset of the conscript's first injury (MSD, LBP). Event-based incidence rate was calculated by dividing the total number of MSDs by the exposure time. Exposure time for event-based incidence rate was calculated until the end of follow-up. Time loss due to MSD was allowed for when calculating the exposure time for the event-based incidence rate. In study IV, medical discharge incidence was calculated by dividing the number of discharged conscripts by the total number of conscripts and expressed as a percentage. Incidence rate was calculated by dividing the number of discharged conscripts by the exposure time. Exposure time was calculated until the end of the follow-up. In all studies, the incidences with 95% confidence intervals (CI) were expressed per 1000 person-days.

In the study I, descriptive statistics were used to analyse the data. Cross-tabulations and chi-square test were used to analyse categorical variables. To examine differences in the occurrence rate of MSDs between the two arrivals of conscripts and between the service stages, the χ^2 statistics was used to test the hypothesis of no difference.

In the studies II-IV, Cox's proportional hazard models were applied to study the prospective associations between baseline characteristics and outcome. In the study II, the primary outcome was defined as an incidence of any type of MSD (MSDI). The secondary outcome was defined as an incidence of time loss of at least 10 active service days due to one or several MSDs (referred to as a long-term MSDI). In the study III, primary outcome was defined as an incidence of LBP treated at the garrison clinic. Secondary outcome was defined as at least 3 health clinic visits due to LBP or time loss of at least 5 active service days due to LBP (hereafter referred to as a recurrent LBP). In the study IV, the outcome was defined as an incidence of premature discharge due to medical reasons. In all risk factor studies (II-IV), continuous variables relating to physical fitness and body characteristics were converted to categorical variables to examine associations between risk factors and outcomes when the relationship was not linear. In the first phase of the Cox regression, each independent variable was analysed one at a time (univariate). Results were expressed as hazard ratios (HR) and calculated with 95% CIs with age at baseline forced into the model. A multivariate Cox regression was used to identify independent risk factors for outcome and to examine interactions between risk factors. Only possibly significant variables (P <0.20) in the initial univariate-models were included in the multivariate model. A P value of < 0.05 was considered statistically significant when interpreting the results from Cox's proportional hazard models.

Multivariate adjustments in Cox regression model in study II

Company, father's occupational group, urbanisation level of the place of residence, self-assessed health, opinion about physical demands for a soldier, last degree achieved in school sports, belonging to a sports club and self-assessed physical fitness were included in the multivariate model as possible confounders. Smoking status (previous or current regular smoker), poor baseline medical condition (sports injury during the last month before military entry, chronic impairment or disability due to prior musculoskeletal injury, earlier musculoskeletal symptoms, chronic disease), not participating in individual aerobic sports and low physical activity during the previous three months before military entry were entered into the multivariate model as known risk factors. Poor school success (educational level and grades combined), participation in competitive sports, height and high frequency of drunkenness before military service

were considered as possible risk factors after univariate modelling and entered these variables into the multivariate model although the literature considering these variables as risk factors of MSDs during military training is sparse. In addition, high WC and older age were considered possible risk factors and were therefore included in the multivariate model although results from previous studies are to some extent conflicting.

Multivariate adjustments in Cox regression model in Study III

Older age, smoking status, poor baseline medical condition (sports injury during the last month before entering the military, chronic impairment or disability due to prior musculoskeletal injury, previous orthopaedic surgeries, sum factor of musculoskeletal symptoms in anatomical regions other than the back during the last month before entering the military, chronic disease, regular medication), low educational level, and low school degrees were entered into the multivariate model as known or possible risk factors. Participation in individual aerobic sports, company and father's occupational group were considered as effect modifiers and entered these variables into the multivariate model.

Multivariate adjustments in Cox regression model in study IV

In the data analysis, based on the previous literature, conceptually compatible and logical risk factors were chosen for multivariate-models. Higher age, company, smoking status (previous or current regular smoker), high alcohol intake, poor baseline medical condition (sports injury during last month, sum factor of earlier musculoskeletal symptoms during the last month before entering the military, chronic impairment or disability due to prior musculoskeletal injury, chronic disease, regular medication), poor school success (educational level and grades combined) and poor self-assessed health, were entered into the model as known or possible risk factors. Prior physical activity during the previous three months before entering the military, participating in ball games, last degree achieved in school sports, belonging to a sports club, participation in competitive sports and urbanisation level of the home residence were considered as effect modifiers and entered into the multivariate model. A *P* value of less than 0.05

was considered statistically significant when interpreting the results from Cox's proportional hazard models.

Statistical analysis in intervention studies V and VI

All analyses were performed according to the intention-to-treat principle. In study V the primary analysis was "intervention group vs. control group" for assessment of the difference of change in injury incidence between the pre-study period and the study period. Secondary analysis was performed to assess differences between participants at two fitness levels (low vs. moderate to high). In study VI the primary analysis was intervention group vs. control group for assessment of a difference in change of LBP and disability outcomes between the pre-study year and intervention year.

To examine differences in the injury rates between the intervention and control groups, the unadjusted and adjusted hazard ratios (HR) between groups were obtained from the Cox's proportional hazard model for categorical outcomes and from the negative binomial model for count data (number of off-duty days). Negative binomial model was chosen instead of Poisson regression model due to distribution of the count data. Overdispersion parameter was taken into account by estimating the value in the negative binomial model. A P value of < 0.05 was considered statistically significant.

Results were expressed as HR and calculated with 95% CIs with age at baseline forced into the model. The interaction term of company (intervention vs. control) and study period (pre-study or study period) was entered into the model for analysing the difference of change in incidence between intervention and control companies. In the data analysis, risk factors of injury and LBP and possible confounders were added in the adjusted models based on former epidemiologic studies (studies II and III) after ensuring that these factors were possibly significant explanatory variables ($P < 0.20$) in the initial univariate models.

Multivariate adjustments in study V

Urbanisation level of the home residence was included in the multivariate model as a possible confounder. Higher age, smoking status (previous or current regular smoker), high alcohol intake, poor baseline medical condition (chronic impairment or disability due to prior musculoskeletal injury, earlier musculoskeletal symptoms and orthopaedic

surgery), poor school success (educational level and grades combined) and high WC were entered into the model as known or possible risk factors. Prior physical activity during the previous three months before entering the military and conscript's physical fitness index (CPFI) were considered as effect modifiers and entered into the multivariate model.

Multivariate adjustments in study VI

Mainly the same adjusting variables as in study V were entered also to the final multivariate model in the study VI. Urbanisation level of the home residence was included in the multivariate model as a possible confounder. Higher age, smoking status, poor baseline medical condition (sports injury, sum factor of earlier musculoskeletal symptoms, chronic impairment or disability due to prior musculoskeletal injury, orthopedic surgery) and poor school success (educational level and grades combined) were entered into the model as known or possible risk factors. Prior physical activity during the previous three months before entering the military and baseline physical fitness level according to combination of 12-minute running test and push-up test were considered as effect modifiers and entered into the adjusted model.

4.6 Informed consent and ethical approvals

This study was conducted according to the guidelines of the Declaration of Helsinki. Informed consent was obtained from all participants before the initiation of the study. Approval for the study protocol was obtained from the Ethics Committee of Pirkanmaa Hospital District on 11 April 2006. Trial registration considering intervention studies (V and VI) was done through the ClinicalTrials.gov with identifier number NCT00595816.

5. RESULTS

5.1 Summary of the epidemiology of MSDs

5.1.1 Occurrence, nature and severity of MSDs (I and II)

During the six-month follow-up of two successive cohorts there were 1629 MSDs and 2879 health clinic visits due to MSDs in 944 persons. A total of 652 of 944 (69%) conscripts sustained one or more MSDs during the six-month service. Of these, 35% had one, 24% had two, 17% had three, 11% had four, 7% had five and 6% had from six to ten MSDs. A total of 194 (21%) conscripts suffered from long-term MSD (≥ 10 service days lost due to one or several MSDs). The event-based incidence rate for MSD was 10.5 (95% CI: 10.0–11.1) and the person-based incidence rate was 7.1 (95% CI: 6.6–7.7) per 1000 person-days, respectively.

Overuse-related MSDs (70%) were more than twice as prevalent as traumatic MSDs (30%). Most MSDs were in the lower extremities (65%) followed by the back (18%), upper extremities including shoulders (11%), head (2%) and other parts of the body (torso excluding back; 3%) (Table 6). The most common types of MSDs were lower limb overuse injuries (48%) and LBP (16%).

The majority (69%, n=1119) of disorders were classified as minimal leading to a maximum 3-day exemption from military training, while mild (time-loss 3-7 days) MSDs accounted for 20% (n=328), moderate (time-loss 8-28 days) for 8% (n=138) and severe (time-loss > 4 weeks) for 3% (n=44) of all cases. Fractures (n=15), bone stress injuries (n=15), dislocations (n=22) and internal knee injuries (n=25) represented the most severe injuries and accounted for the majority of long-term exemptions from military training. Twenty-eight (3.0% of all) conscripts were discharged from military service due to MSDs after the two-week run-in period.

Occurrence peaked in August (37 admissions per 100 conscripts) when the July arrival was performing intensive basic training period. In winter the rates were slightly

lower, however there was similarly a peak in January (35 admissions per 100 conscripts) at the beginning of the basic training period of the second arrival. The lowest occurrence rates were seen in July, September and March (16 to 19 admissions per 100 conscripts).

Table 6. Distribution of musculoskeletal disorders (MDSs) by anatomical location in 944 male conscripts during six-month military service (Taanila et al. 2010)

Body part	Total number (%)	Acute / Overuse,%	Incidence* (95% CI)	Average number of health clinic visits per disorder
Lower extremity	1063 (65%)	26 / 74	6.9 (6.5–7.3)	1.8
Knee	315 (19%)	32 / 68	2.0 (1.8–2.3)	2.0
Ankle	192 (12%)	39 / 61	1.2 (1.1–1.4)	1.7
Foot	195 (12%)	8 / 92	1.3 (1.1–1.5)	1.9
Shin	103 (6%)	15 / 85	0.7 (0.5–0.8)	2.5
Back	300 (18%)	19 / 81	1.9 (1.7–2.2)	1.8
Low back pain	263 (16%)	18 / 82	1.7 (1.5–1.9)	1.8
Upper extremity	177 (11%)	56 / 44	1.1 (1.0–1.3)	1.5
Shoulder	87 (5%)	28 / 72	0.6 (0.5–0.7)	1.6
Head	32 (2%)	100 / 0	0.2 (0.1–0.3)	1.3
Other parts of body	57 (3%)	43 / 57	0.4 (0.3–0.5)	1.7
Total	**1629**	**30 / 70**	**10.5 (10.0–11.1)**	**1.8**

Total number, proportions of acute and overuse-related disorders and their incidence and mean number of health clinic visits per disorder are given according to the anatomical location.
* Event-based incidence expressed as total number per 1000 person-days

5.1.2 Etiology of MSDs (I and II)

Of the associated activities with MSDs, combat training in combat gear was more common (40% of all scenes) than marching on foot or bicycle (28%) or other physical exercise (13%). Disorders during marching were mostly overuse type, whereas traumatic injuries were more common during combat training in combat gear (Table 7).

Table 7. Proportions of acute and overuse-related musculoskeletal disorders (MSDs) in 955 male conscripts during 6-month military service. Three most common associated activities are shown in the table (Taanila et al. 2009)

Associated activity	Acute		Overuse		Total
	n	%	n	%	Number
Combat training in combat gear	59	36	107	64	166
March on foot or by bicycle	8	7	110	93	118
During other physical exercise	29	54	25	46	54
ALL ASSOCIATED ACTIVITIES	146	34	282	66	428

MSDs occurred mostly (93%) during military training. Some (7%) occurred during vacations and four cases (0.3%) while travelling to vacation or back to the garrison. Of the immediate causes of acute MSDs, falling down (17%) and collision with an object (16%) were most commonly associated with MSDs. The following immediate causes were: tackling or struggling during sports exercise (5%), jumping (5%), malposition of foot during ground contact (4%), traffic accident (4%), slipping (4%) and being compressed between two objects (4%) (Fig. 12). In 12% of acute MSDs, the immediate cause remained unclear.

Marching and running (36%) were the most common activities associated with overuse-related MSDs, followed by carrying and lifting loads (10%) and other organized physical exercise excluding marches and combat training (6%). For 27% of overuse-related MSDs, however, the associated activity remained unclear due to the gradual onset of the MSD.

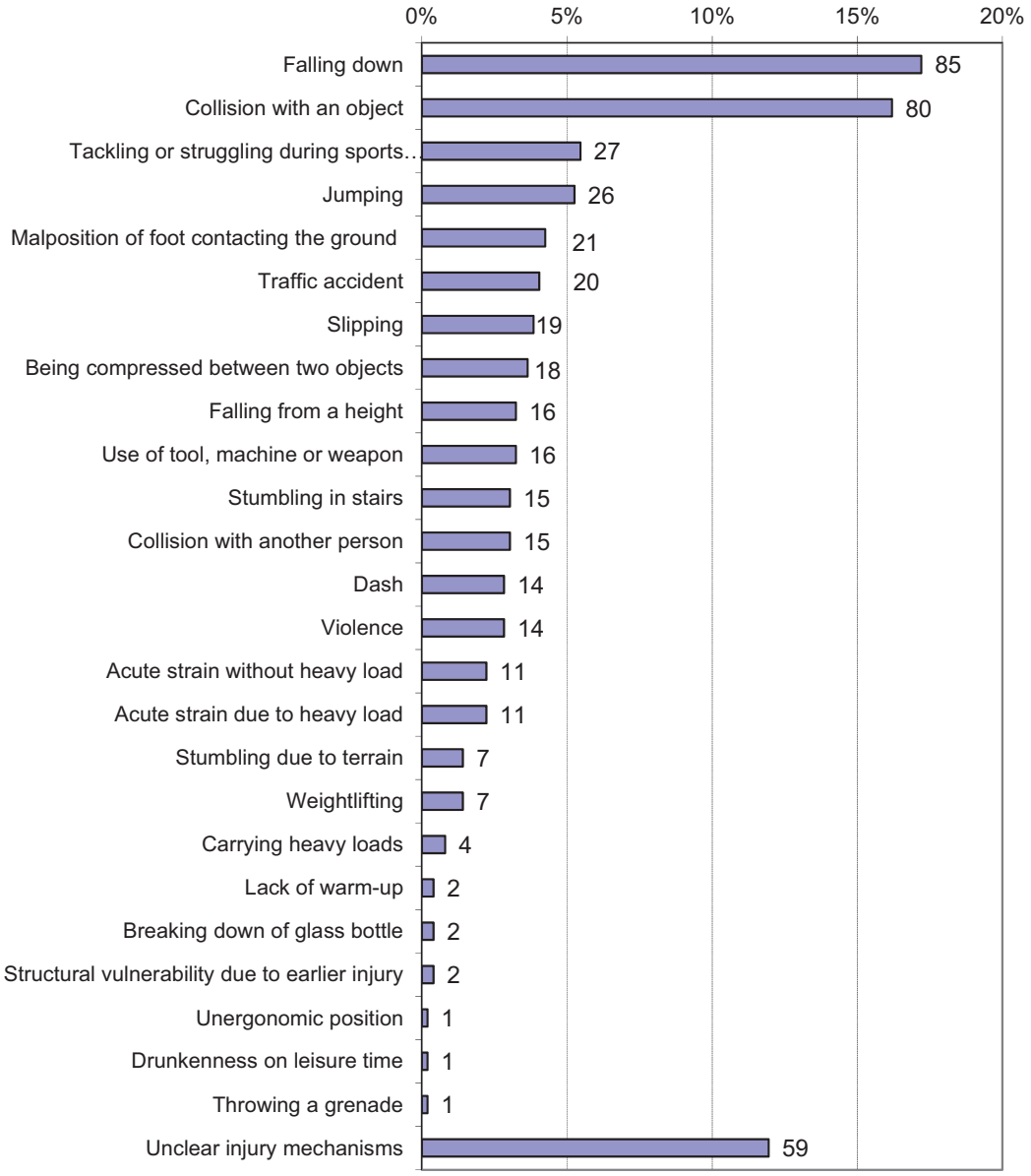


Figure 12. Injury mechanisms of acute MSDs

5.1.3 Reasons for medical discharge (IV)

The most common reasons for discharge were musculoskeletal (44%, n=59) injuries and disorders followed by mental and behavioral disorders (29%, n=39) and diseases of the respiratory system (12%, n=17). Other reasons accounted 14% (n=18) of discharges (Table 8). For discharged conscripts, the mean time in military service (±SD) was 65 ± 37 days.

5.1.4 Acute and overuse musculoskeletal injuries (II)

High hazard ratios of MSD were observed in those conscripts with low levels of *physical fitness test results* (Table 9). Each fitness test was associated with MSDI or long-term MSDI in univariate models (Table 9). However, after final adjustments, only the 12-minute running test (Cooper) maintained its significance for both MSDI (HR=1.6; 95% CI: 1.2–2.2) and long-term MSDI (HR=2.5; 95% CI: 1.4–4.5). In addition, the back lift test was associated with MSDI in the final model. Cooper's and individual muscular fitness test results were combined into one variable to explore whether co-impairment in aerobic and muscular fitness would increase the risk for MSDs. Combinations of poor fitness in Cooper's test and standing long jump or push-up or back lift tests proved to be the strongest predictors for both outcomes with a dose-response relationship (Table 9).

Table 8. Numbers and reasons for early medical discharge from military service after the 2-week run-in period in 1411 male conscripts during a 6-month military training period (adapted from Taanila et al. (2011))

Number	Diagnosis
Musculoskeletal disorders & injuries	
25	Overuse injury of the limb
9	Low back pain
8	Internal injury of the knee joint
4	Dislocations
3	Fracture of neck of femur
2	Other chest pain due to earlier fracture
2	Fracture of humerus
1	Fracture of carpal bones
1	Injury of the extensor muscle and tendon of a finger
1	Fracture of shaft of femur
1	Sprain of collateral ligament of knee
1	Sprain of wrist
1	Tendinopathies
Total 59 conscripts, 44% of all discharges	
Mental and behavioral disorders	
21	Adjustment disorders
9	Depressive episodes
7	Anxiety disorders
2	Personality disorders
Total 39 conscripts, 29% of all discharges	
Diseases of the respiratory system	
11	Acute upper respiratory infection
6	Asthma
Total 17 conscripts, 13% of all discharges	
Dermatological diseases	
2	Atopic dermatitis or urticaria
1	Erysipelas
1	Pilonidal cyst without abscess
Total 4 conscripts, 3% of all discharges	
Cardiovascular disorders	
1	Tachycardia
1	Subarachnoid haemorrhage
Total 2 conscripts, 2% of all discharges	
Gastrointestinal diseases	
1	Ulcerative colitis
1	Volvulus
Total 2 conscripts, 2% of all discharges	
Other reasons	
Total 10 conscripts, 8% of all discharges	

Table 9. Hazard ratios (HR) for musculoskeletal disorder (MSD) incidence and incidence of long-term MSD by physical fitness test variables at baseline (adapted from Taanila et al. (2010))

Physical fitness test result	Category	Total number (% of experienced MSD;% of experienced ≥ 10 service days lost due to MSDs)	HR for MSD incidence (n=652) *	HR for MSD incidence (n=652) **	HR for long-term MSD incidence (≥ 10 service days lost) (n=194) *	HR for long-term MSD incidence (≥ 10 service days lost) (n=194) **
Cooper's test (12-min running test)	Excellent (≥ 3000 m)	36 (67; 13)	}1 (Referent)	}1 (Referent)	}1 (Referent)	}1 (Referent)
	Good (≥ 2600 m)	214 (62; 13)				
	Fair good (≥ 2200 m)	435 (69; 20)	**1.2 (1.0–1.5)**	1.2 (0.9–1.5)	**1.5 (1.0–2.2)**	**1.6 (1.0–2.7)**
	Poor (< 2200 m)	240 (76; 28)	**1.7 (1.4–2.1)**	**1.6 (1.2–2.2)**	**2.3 (1.5–3.5)**	**2.5 (1.4–4.5)**
Pull-up test (consecutive repeats without time limit)	Excellent (≥ 14)	107 (65; 14)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥ 10)	140 (66; 16)	1.0 (0.7–1.4)	0.8 (0.5–1.1)	1.2 (0.6–2.2)	0.8 (0.4–1.8)
	Fair good (≥ 6)	266 (70; 18)	1.2 (0.9–1.5)	0.8 (0.6–1.2)	1.3 (0.7–2.3)	1.0 (0.5–1.9)
	Poor (< 6)	421 (71; 25)	1.3 (1.0–1.7)	0.8 (0.6–1.2)	**2.0 (1.2–3.4)**	1.1 (0.6–2.2)
Standing long jump test (2 attempts, best result)	Excellent (≥ 2,40 m)	141 (62; 13)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥ 2,20 m)	251 (69; 20)	1.3 (1.0–1.7)	1.2 (0.9–1.6)	1.6 (0.9–2.7)	1.1 (0.6–1.9)
	Fair good (≥ 2,00 m)	311 (69; 20)	**1.3 (1.0–1.7)**	1.2 (0.9–1.6)	1.6 (1.0–2.7)	1.0 (0.6–1.8)
	Poor (< 2,00 m)	231 (74; 26)	**1.6 (1.2–2.0)**	1.4 (1.0–1.9)	**2.3 (1.4–3.8)**	1.4 (0.7–2.6)
Sit-up test (repeats per 60 seconds)	Excellent (≥ 48)	122 (64; 16)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥ 40)	221 (71; 17)	1.2 (0.9–1.6)	1.0 (0.8–1.4)	1.0 (0.6–1.8)	0.8 (0.4–1.5)
	Fair good (≥ 32)	328 (70; 22)	1.3 (1.0–1.7)	1.0 (0.7–1.3)	1.4 (0.9–2.3)	0.8 (0.5–1.5)
	Poor (< 32)	263 (70; 24)	**1.4 (1.0–1.8)**	0.9 (0.7–1.3)	1.6 (1.0–2.6)	0.7 (0.4–1.4)
Push-up test (repeats per 60 seconds)	Excellent (≥ 38)	283 (70; 18)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥ 30)	216 (64; 16)	1.0 (0.8–1.2)	0.8 (0.7–1.1)	0.9 (0.6–1.4)	0.7 (0.4–1.1)
	Fair good (≥ 22)	263 (68; 21)	1.0 (0.9–1.3)	0.8 (0.6–1.0)	1.2 (0.8–1.8)	0.7 (0.4–1.1)
	Poor (< 22)	172 (76; 30)	**1.4 (1.1–1.8)**	1.0 (0.7–1.3)	**2.0 (1.4–3.0)**	1.0 (0.6–1.8)
Back lift test (repeats per 60 seconds)	Excellent (≥ 60)	450 (65; 18)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥ 50)	195 (68; 20)	1.1 (0.9–1.4)	1.0 (0.8–1.3)	1.1 (0.8–1.6)	0.9 (0.6–1.4)
	Fair good (≥ 40)	197 (73; 20)	**1.2 (1.0–1.5)**	1.1 (0.9–1.4)	1.2 (0.8–1.7)	0.8 (0.5–1.3)
	Poor (< 40)	92 (83; 32)	**1.8 (1.4–2.3)**	**1.5 (1.1–2.0)**	**2.0 (1.3–3.1)**	1.2 (0.7–2.0)
Conscript's muscular fitness index [1]	Excellent (13-15 p.)	94 (61; 12)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (9-12 p.)	249 (66; 17)	1.3 (0.9–1.7)	1.2 (0.8–1.6)	1.5 (0.8–2.9)	1.2 (0.5–2.5)
	Fair good (5-8 p.)	336 (72; 22)	**1.5 (1.1–2.0)**	1.2 (0.9–1.8)	**2.0 (1.1–3.8)**	1.2 (0.5–2.5)
	Poor (0-4 p.)	255 (71; 25)	**1.6 (1.2–2.2)**	1.1 (0.8–1.7)	**2.6 (1.3–4.8)**	1.1 (0.5–2.7)
Conscript's physical fitness index [2]	Excellent (≥ 21,00)	37 (59; 8)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (17.0−20.99)	270 (66; 16)	1.3 (0.8–2.0)	0.9 (0-6–1.4)	2.1 (0.6–6.6)	1.1 (0.3–3.7)
	Fair good (13.0−16.99)	420 (69; 21)	1.5 (1.0–2.4)	1.0 (0.6–1.6)	2.8 (0.9–9.0)	1.2 (0.3–4.1)
	Poor (< 13.00)	196 (77; 28)	**2.0 (1.3–3.2)**	1.2 (0.7–2.0)	**4.4 (1.4–14.0)**	1.6 (0.4–5.8)
Combination of Cooper's & standing long jump test	Excellent [3]	77 (58; 9)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good [4]	335 (65; 19)	1.3 (0.9–1.8)	1.1 (0.8–1.6)	**2.2 (1.0–4.9)**	1.5 (0.6–3.3)
	Fair good [5]	394 (72; 20)	**1.6 (1.2–2.2)**	**1.5 (1.0–2.1)**	**2.5 (1.2–5.4)**	1.8 (0.8–4.1)
	Poor [6]	117 (79; 33)	**2.1 (1.5–3.0)**	**1.6 (1.0–2.6)**	**4.8 (2.2–10.8)**	**3.0 (1.2–7.8)**

Combination of Cooper's & push-up test	Excellent [3]	135 (64; 13)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good [4]	361 (67; 17)	1.2 (0.9–1.5)	1.1 (0.8–1.4)	1.3 (0.8–2.2)	1.3 (0.7–2.4)
	Fair good [5]	336 (70; 23)	**1.3 (1.0–1.7)**	1.0 (0.7–1.4)	**1.9 (1.1–3.1)**	1.4 (0.7–2.8)
	Poor [6]	91 (82; 36)	**2.3 (1.7–3.1)**	**1.8 (1.2–2.8)**	**3.6 (2.0–6.5)**	**2.8 (1.2–6.2)**
Combination of Cooper's & back lift test	Excellent [3]	171 (60; 12)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good [4]	437 (68; 20)	**1.3 (1.0–1.6)**	**1.3 (1.0–1.7)**	**1.8 (1.1–2.9)**	1.7 (1.0–3.0)
	Fair good [5]	272 (74; 22)	**1.5 (1.2–2.0)**	**1.4 (1.0–1.9)**	**2.0 (1.2–3.3)**	1.5 (0.8–2.8)
	Poor [6]	43 (91; 42)	**3.6 (2.5–5.2)**	**2.9 (1.9–4.6)**	**5.0 (2.6–9.3)**	**2.7 (1.2–5.9)**

Variable distribution was charted in 944 male conscripts during the first two weeks of military service and MSD outcomes were registered during the following six-month military service. Long-term MSD was defined as an incidence of time loss of at least 10 active service days due to one or several MSDs. Statistically significant findings are indicated with bold type.
* Adjusted for age (univariate).
** Adjusted for age, company, smoking, frequency of drunkenness before military service, baseline medical conditions (sports injury during the last month before military entry, chronic impairment or disability due to prior musculoskeletal injury, earlier musculoskeletal symptoms, chronic disease), school success (educational level and grades combined), father's occupation, opinion about physical demands for a soldier, urbanisation level of the place of residence, self-assessed health, waist circumference, height, participating in individual aerobic sports, last degree achieved in school sports, belonging to a sports club, self-assessed physical fitness, participation in competitive sports and physical activity during the previous 3 months before entering the military (21 adjusting variables).
[1] Muscular fitness index (MFI) is the sum of individual muscular fitness test results including push-up, sit-up, pull-up, standing long jump and back muscle tests.
[2] Conscript's physical fitness index (CPFI) = (12 min running test result (m) + 100 x MFI) / 200.
[3] Excellent or good result in Cooper's test and excellent result in standing long jump / push-up / back lift tests.
[4] Excellent result in standing long jump / push-up / back lift test and fair good or poor result in Cooper's test, or excellent result in Cooper's test and good, fair good, or poor result in standing long jump standing long jump / push-up / back lift test, or good result in Cooper's test and good or fair good result in standing long jump / push-up / back lift test, or fair good result in Cooper's test and good result in standing long jump test.
[5] Poorer results than aforementioned, except the combination of poor results in both tests.
[6] Poor results in both tests.

Other baseline risk factors associated with MSDs were high WC (>102 cm; HR=1.7; 95% CI: 1.3–2.2), high BMI (>30 kg/m^2; HR=1.8; 95% CI: 1.3–2.4), earlier musculoskeletal symptoms (HR=1.7; 95% CI: 1.3–2.1) and poor school success (educational level and grades combined; HR=2.0; 95% CI: 1.3–3.0) (Table 10).

In addition, risk factors of long-term MSDs (≥ 10 service days lost due to one or several MSDs) were analyzed: poor result in a 12-minute running test, earlier musculoskeletal symptoms, high WC, high BMI, not belonging to a sports club and poor result in the combined outcome of the 12-minute running test and standing long jump test were strongly associated with long-term MSDI (Tables 9 and 10).

Table 10. Hazard ratios (HR) for musculoskeletal disorder (MSD) incidence and incidence of long-term MSD by socioeconomic, health and health behavior variables at baseline (adapted from Taanila et al. (2010))

Variable	Category	Total number (% of experienced MSD;% of experienced ≥ 10 service days lost due to MSDs)	HR for MSD incidence (n=652) *	HR for MSD incidence (n=652) **	HR for long-term MSD incidence (≥ 10 service days lost) (n=194) *	HR for long-term MSD incidence (≥ 10 service days lost) (n=194) **
School success (combination of school type attended and grades)	Excellent [1]	138 (52; 12)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good [2]	410 (70; 18)	**1.7 (1.3–2.2)**	**1.4 (1.1–1.9)**	1.6 (0.9–2.7)	1.1 (0.6–1.9)
	Satisfactory [3]	319 (72; 24)	**1.9 (1.5–2.5)**	**1.5 (1.1–2.0)**	**2.3 (1.3–3.8)**	1.3 (0.7–2.4)
	Poor [4]	67 (81; 37)	**2.7 (1.9–3.9)**	**2.0 (1.3–3.0)**	**4.2 (2.2–7.7)**	**2.2 (1.1–4.5)**
Body mass index[5] (BMI = (kg) / (m)^2)	Underweight (< 18.5)	44 (66; 20)	1.1 (0.7–1.5)	1.1 (0.7–1.6)	1.1 (0.6–2.2)	1.1 (0.5–2.2)
	Normal (18.5–25.0)	539 (67; 19)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Pre-obese (25.0–30.0)	220 (71; 19)	1.1 (0.9–1.3)	**1.2 (1.0–1.5)**	1.0 (0.7–1.5)	1.1 (0.7–1.6)
	Obese (≥ 30.0)	66 (82; 33)	**1.7 (1.3–2.3)**	**1.8 (1.3–2.4)**	**2.0 (1.3–3.2)**	**1.9 (1.2–3.2)**
Waist circumference (WC, cm)	Thin (< 80)	177 (64; 20)	1.0 (0.8–1.2)	1.0 (0.8–1.2)	1.2 (0.8–1.8)	1.1 (0.7–1.6)
	Normal (80 – 94)	499 (68; 17)	1 (Referent)	1 (Referent)	1 (Referent))	1 (Referent)
	Increased (94 –102)	126 (74; 23)	1.2 (1.0–1.5)	1.2 (1.0–1.6)	1.4 (0.9–2.1)	1.3 (0.8–2.0)
	High (≥ 102)	91 (79; 32)	**1.6 (1.2–2.0)**	**1.7 (1.3–2.2)**	**2.1 (1.4–3.3)**	**2.2 (1.3–3.5)**
Smoking habits	Never smoked regularly	492 (62; 14)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Has smoked regularly	439 (76; 28)	**1.5 (1.2–1.7)**	1.1 (0.9–1.3)	**2.1 (1.6–2.9)**	**1.5 (1.0–2.1)**
Self-assessed health[6]	Good or very good	500 (66; 17)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Average or inferior	434 (72; 24)	**1.3 (1.1–1.6)**	1.0 (0.9–1.3)	**1.6 (1.2–2.1)**	0.9 (0.7–1.3)
Sum factor of musculoskeletal symptoms	Minimal symptoms [7]	305 (62; 14)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Mild symptoms [8]	357 (68; 21)	**1.2 (1.0–1.5)**	**1.4 (1.1–1.7)**	**1.7 (1.1–2.4)**	**1.9 (1.3–2.9)**
	Clear symptoms [9]	271 (78; 28)	**1.8 (1.5–2.2)**	**1.7 (1.3–2.1)**	**2.4 (1.7–3.6)**	**2.6 (1.7–3.9)**
Sweating exercise (Brisk leisure time	≥ 3 times per week	287 (62; 13)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	1–2 times per week	282 (72; 21)	**1.3 (1.1–1.6)**	1.2 (0.9–1.5)	**1.7 (1.1–2.5)**	1.2 (0.7–2.0)
	Only leisured exercise	183 (69; 24)	**1.4 (1.1–1.8)**	1.2 (0.9–1.6)	**2.1 (1.4–3.2)**	1.4 (0.8–2.3)
	No physical exercise	182 (75; 29)	**1.6 (1.3–2.0)**	1.2 (0.9–1.6)	**2.5 (1.7–3.9)**	1.3 (0.7–2.3)
Chronic disease	No	687 (68; 21)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Yes	247 (72; 21)	1.2 (1.0–1.4)	1.1 (0.9–1.3)	1.0 (0.8–1.4)	1.1 (0.8–1.6)
Orthopaedic surgery	Never	858 (68; 20)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Yes	74 (73; 27)	1.2 (0.9–1.6)	1.1 (0.8–1.6)	1.3 (0.8–2.1)	1.4 (0.9–2.4)
Chronic impairment or disability [10]	No	789 (67; 19)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Yes	140 (81; 31)	**1.6 (1.3–2.0)**	**1.4 (1.1–1.7)**	**1.8 (1.3–2.5)**	1.4 (0.9–2.1)
Sports injury during last month	No	842 (67; 20)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Yes	88 (82; 25)	**1.4 (1.1–1.8)**	**1.4 (1.0–1.8)**	1.3 (0.8–2.0)	1.2 (0.7–2.0)

Variable distribution was charted in 944 male conscripts during the first week of military service and MSD outcomes were registered during the following six-month military service. Long-term MSD was defined as an incidence of time loss of at least 10 active service days due to one or several MSDs. Statistically significant findings are indicated with bold type.

* Adjusted for age (univariate).

** Adjusted for age, company, smoking, frequency of drunkenness before military service, baseline medical conditions (sports injury during the last month before military entry, chronic impairment or disability due to prior musculoskeletal injury, earlier musculoskeletal symptoms, chronic disease), school success (educational level and grades combined), father's occupation, opinion about physical demands for a soldier, urbanisation level of the place of residence, self-assessed health, waist circumference, height, participating in individual aerobic sports, last degree achieved in school sports, belonging to a sports club, self-assessed physical fitness, participation in competitive sports and physical activity during the previous 3 months before entering the military (21 adjusting variables).

[1] Attended upper secondary school, polytechnic or university and reported excellent or good grades.
[2] Other subjects from upper secondary school, polytechnic or university and conscripts from vocational school whose grades were excellent or good.
[3] Respondents with poorer grades in vocational school.
[4] Attended only comprehensive school or had permanently interrupted vocational or upper elementary school.
[5] Not adjusted by WC since BMI and WC strongly interconnected ($\chi 2$-test, $p<0.001$).
[6] Compared to age-mates.
[7] 'Minimal symptoms': maximum seven-day lasting symptom in one anatomical region during the last month before entering the military.
[8] 'Mild symptoms': symptoms in two to six anatomical regions, but the symptoms had lasted a maximum of one week during the last month before military entry.
[9] 'Clear symptoms': included the remaining conscripts.
[10] Due to prior musculoskeletal injury.

5.1.5 LBP and disability (III)

LBP incidence and severity

During the study period, a total of 286 health clinic visits due to LBP were registered in the garrison clinic. A total of 155 of 982 (16%) conscripts suffered from LBP during the 6-months' follow-up time. Of those, 27% (n=42) had recurrent LBP (≥ 3 health clinic visits). The LBP incidence rate was 1.2 (95% CI: 1.0-1.4) per 1000 person-days. The majority (75%) of LBP was classified as minimal, leading to a maximum 3-day exemption from military training, while mild LBP accounted for 15%, moderate for 7%, and severe for 3% of all cases. Thirty-five (3.6%) conscripts were discharged from military service due to musculoskeletal injuries or disorders after the 2-week run-in period. Of them, 5 (14%) had a diagnosis relating to LBP (M54.5 LBP: n=3, M54 dorsalgia: n=2).

Risk factors of LBP

From the *socioeconomic background* variables lower level of education (only comprehensive or vocational school) compared to higher education (secondary school graduates, polytechnic and university students) was associated with both incidence (HR=1.6; 95% CI: 1.1–2.3) and recurrence of LBP (HR 2.6; 95% CI: 1.0–6.6) even after multivariate adjustments. Low school degrees were associated with LBP, but not with recurrent LBP. In addition, company was associated with LBP, risk being lowest in the mortar company and highest in the engineer company (Table 11).

With regard to *health*, baseline health problems were associated with incidence of LBP in age-adjusted model. After further adjustments, former sports injury (HR=1.7; 95% CI: 1.0–2.8), and musculoskeletal symptoms in anatomical regions other than the back (HR=1.6; 95% CI: 1.0–2.5) remained predictive of LBP. High BMI increased the risk for recurrent LBP in the multivariate model (Table 11).

With regard to *health behaviors,* health damaging behavior was not related to incidence of LBP. Smoking was associated with LBP in the age-adjusted model, but after final adjustments, the association weakened (Table 11). Similarly previous physical activity was not associated with LBP.

With regard to *physical fitness* single test items of poor fitness showed no predictive associations with incidence or recurrence of LBP with the exception of poor fitness in push-up predicting incidence of LBP, which, however, diminished after multivariable adjustments. Contrary to that, predictive associations between co-impairments of fitness with LBP were more systematic. Highest risk for both incidence and recurrence of LBP were detected among conscripts with poor level of fitness both in push-up and back-lift test (HR=2.8; 95% CI: 1.4–5.9), back-lift and Cooper's test, and push-up and Cooper's test. Co-impairment in sit-up and push-up predicted incidence of LBP but not recurrence (Table 12).

Table 11. Hazard ratios (HR) for low back pain (LBP) incidence and incidence of recurrent LBP by socioeconomic, health and health behavior variables at baseline (adapted from Taanila et al. (2012))

Variable	Category	Total number (% of experienced LBP;% of experienced recurrent‡ LBP)	HR for LBP incidence (n=155) *	Adjusted HR for LBP incidence (n=155) **	HR for recurrent ‡ LBP incidence (n=42) *	Adjusted HR for recurrent ‡ LBP incidence (n=42) **
Level of education	High [1]	448 (12; 2)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Lower [2]	534 (19; 6)	**1.9 (1.3-2.3)**	**1.6 (1.1–2.3)**	**3.2 (1.5–6.6)**	**2.8 (1.2–6.3)**
Degrees achieved in school	High	346 (12; 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Low or average	636 (18; 5)	**1.6 (1.1–2.3)**	**1.5 (1.0–2.2)**	0.8 (0.5–1.5)	0.8 (0.4–1.6)
Age	18–20 years	928 (15; 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	21–28 years	54 (26; 2)	**2.1 (1.2–3.7)**	1.8 (1.0–3.4)	0.5 (0.1-3.3)	0.5 (0.1–3.8)
Company	Anti-tank company	191 (15; 3)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Signal company	368 (18; 6)	1.3 (0.9–2.1)	1.4 (0.9–2.3)	2.5 (1.0–6.6)	**3.0 (1.0–8.7)**
	Mortar company	253 (8; 1)	0.8 (0.5–1.4)	1.0 (0.5–1.8)	0.6 (0.1–2.5)	0.8 (0.2–3.6)
	Engineer company	170 (24; 7)	**1.8 (1.1–2.9)**	**2.0 (1.2–3.3)**	2.8 (1.0–7.9)	**3.5 (1.1–11.0)**
Body mass index (BMI =(kg)/(m)^2)	Underweight (< 18.5)	43 (7; 0)	0.4 (0.1–1.4)	0.2 (0.0–1.3)	NA	NA
	Normal (18.5–25.0)	570 (17; 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Pre-obese (25.0–30.0)	220 (15; 3)	0.9 (0.6–1.4)	0.9 (0.6–1.3)	0.8 (0.3–1.7)	0.7 (0.3–1.8)
	Obese (≥ 30.0)	66 (23; 9)	1.4 (0.8–2.4)	1.4 (0.8–2.4)	2.1 (0.9–5.3)	**2.6 (1.0–6.6)**
Waist circumference (WC, cm)	Thin (< 80)	198 (12; 4)	0.8 (0.5–1.3)	0.8 (0.5–1.4)	1.1 (0.4–2.5)	1.2 (0.5–3.0)
	Normal (80 – 94)	521 (17; 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent))
	Increased (94 – 102)	121 (21; 6)	1.4 (0.9–2.2)	1.3 (0.8–2.0)	1.7 (0.7–4.0)	1.7 (0.7–4.5)
	High (≥ 102)	82 (17; 6)	1.1 (0.6–2.0)	1.3 (0.7–2.4)	1.8 (0.7–4.8)	2.8 (1.0–7.9)
Other musculoskeletal symptoms	Minimal symptoms [3]	421 (13; 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Mild symptoms [4]	375 (16; 5)	1.4 (1.0–2.0)	1.3 (0.9–2.0)	1.3 (0.7–2.7)	1.4 (0.6–2.8)
	Clear symptoms [5]	186 (22; 5)	**2.0 (1.3–3.0)**	**1.6 (1.0–2.5)**	1.6 (0.7–3.6)	1.4 (0.6–3.2)
Smoking habits	Never regularly	571 (13; 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Has smoked regularly	409 (20; 5)	**1.7 (1.3–2.4)**	1.1 (0.8–1.6)	1.5 (0.8–2.7)	1.0 (0.5–1.9)

Variable distribution was charted in 982 male conscripts during the first week of military service and LBP outcomes were registered during the following 6-month military service. Statistically significant findings are indicated in bold type.

‡ ≥ 3 health clinic visits or ≥ 5 active service days lost due to low back pain.

* Adjusted for age.

** Adjusted for age, company, smoking, baseline medical conditions (sports injury, sum factor of earlier musculoskeletal symptoms, regular medication, chronic impairment or disability due to prior musculoskeletal injury, orthopedic surgery), educational level, school degree level, father's occupation, and participating in individual aerobic sports (12 adjusting variables).

NA: not applicable

[1] Secondary school graduates, polytechnic and university students.

[2] Only comprehensive or vocational school.

[3] 'Minimal symptoms': maximum 7-day lasting symptom in one anatomical region during the last month before military entry.

[4] 'Mild symptoms': symptoms in 2 to 6 anatomical regions but the symptoms had lasted a week maximum during the last month before military entry.

[5] 'Clear symptoms': included the remaining conscripts.

Table 12. Hazard ratios (HR) for low back pain (LBP) incidence and incidence of recurrent LBP by physical fitness test variables at baseline (adapted from Taanila et al. (2012))

Physical fitness test result	Category	Total number (% of experienced LBP;% of experienced recurrent‡ LBP)	HR for LBP incidence (n=155) *	Adjusted HR for LBP incidence (n=155) **	HR for recurrent ‡ LBP incidence (n=42) *	Adjusted HR for recurrent ‡ LBP incidence (n=42) **
Cooper's test (12-min running test)	Excellent (≥ 3km)	39 (13; 3)	}1 (Referent)	}1 (Referent)	}1 (Referent)	}1 (Referent)
	Good (≥ 2.6 km)	252 (13; 3)				
	Fair (≥ 2.2 km)	427 (19; 4)	**1.6 (1.1–2.4)**	1.5 (1.0–2.3)	1.4 (0.6–3.1)	1.3 (0.5–3.1)
	Poor (< 2.2 km)	242 (15; 6)	1.4 (0.9–2.2)	1.3 (0.8–2.1)	2.2 (1.0–5.1)	2.0 (0.8–5.2)
Sit-up test (repeats per 60 seconds)	Excellent (≥ 48)	175 (12; 3)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥ 40)	225 (16; 4)	1.4 (0.8–2.4)	1.5 (0.8–2.8)	1.5 (0.5–4.4)	1.7 (0.5–5.7)
	Fair (≥ 32)	316 (16; 5)	1.5 (0.9–2.5)	1.4 (0.8–2.4)	1.8 (0.6–4.9)	2.0 (0.6–6.1)
	Poor (< 32)	253 (18; 5)	1.6 (1.0–2.7)	1.7 (0.9–3.0)	1.8 (0.6–5.2)	2.0 (0.6–6.5)
Push-up test (repeats per 60 seconds)	Excellent (≥ 38)	344 (13; 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥ 30)	220 (17; 3)	1.4 (0.9–2.2)	1.3 (0.8–2.1)	0.8 (0.3–2.1)	0.8 (0.3–2.1)
	Fair (≥ 22)	237 (16; 4)	1.4 (0.9–2.1)	1.2 (0.8–1.9)	1.1 (0.5–2.6)	0.9 (0.4–2.2)
	Poor (< 22)	168 (20; 7)	**1.8 (1.1–2.8)**	1.6 (1.0–2.6)	1.8 (0.8–4.1)	1.6 (0.7–3.9)
Back-lift test (repeats per 60 seconds)	Excellent (≥ 60)	499 (13; 3)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥ 50)	189 (19; 7)	1.4 (0.9–2.1)	1.2 (0.8–1.9)	**2.2 (1.0–4.5)**	2.1 (1.0–4.7)
	Fair (≥ 40)	196 (17; 4)	1.2 (0.8–1.9)	1.2 (0.7–1.8)	1.1 (0.4–2.6)	1.0 (0.4–2.5)
	Poor (< 40)	85 (21; 6)	1.6 (1.0–2.8)	1.6 (0.9–2.8)	2.0 (0.7–5.4)	1.5 (0.5–4.3)
Combination of push-up and Cooper's test	Excellent [1]	178 (11; 3)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good [3]	379 (16; 4)	1.5 (0.9–2.5)	1.4 (0.8–2.3)	1.3 (0.5–3.7)	1.4 (0.5–4.6)
	Fair [4]	305 (17; 4)	**1.7 (1.0–2.9)**	1.5 (0.8–2.5)	1.6 (0.6–4.5)	1.4 (0.4–4.5)
	Poor [5]	97 (22; 9)	**2.4 (1.3–4.4)**	**2.1 (1.1–4.2)**	**3.7 (1.3–11.2)**	**3.8 (1.1–13.9)**
Combination of back-lift and Cooper's test	Excellent [1]	219 (12; 3)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good [3]	435 (15; 4)	1.3 (0.9–2.1)	1.3 (0.8–2.1)	1.2 (0.5–2.8)	1.2 (0.5–3.3)
	Fair [4]	262 (19; 5)	**1.6 (1.0–2.6)**	1.5 (0.9–2.5)	1.6 (0.6–4.0)	1.4 (0.5–3.9)
	Poor [5]	43 (32; 12)	**2.4 (1.1–4.9)**	**2.4 (1.1–5.4)**	**4.4 (1.4–13.8)**	**4.0 (1.1–14.7)**
Combination of sit-up and push-up test	Excellent [2]	142 (11; 3)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good [3]	280 (15; 4)	1.5 (0.8–2.7)	1.5 (0.8–2.8)	1.4 (0.5–4.5)	1.7 (0.5–6.3)
	Fair [4]	440 (17; 4)	**1.8 (1.0–3.1)**	1.6 (0.9–3.0)	1.6 (0.5–4.8)	1.7 (0.5–5.9)
	Poor [5]	107 (21; 7)	**2.4 (1.3–4.7)**	**2.2 (1.1–4.5)**	2.7 (0.8–9.3)	2.9 (0.7-12.2)
Combination of push-up and test back-lift	Excellent [2]	268 (12; 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good [3]	315 (16; 4)	1.4 (0.9–2.2)	1.4 (0.8–2.2)	1.0 (0.4–2.4)	1.2 (0.5–2.8)
	Fair [4]	347 (17; 4)	1.4 (0.9–2.2)	1.3 (0.8–2.0)	1.1 (0.5–2.4)	0.9 (0.4–2.2)
	Poor [5]	39 (28; 13)	**2.7 (1.4–5.5)**	**2.8 (1.4–5.9)**	**4.2 (1.4–12.3)**	**4.3 (1.3–13.9)**

Variable distribution was charted in 982 male conscripts during the first 2 weeks of military service and LBP outcomes were registered during the following 6-month military service. Statistically significant findings are indicated in bold type.

‡ ≥ 3 health clinic visits or ≥ 5 active service days lost due to low back pain

* Adjusted for age.

** Adjusted for age, company, smoking, baseline medical conditions (sports injury, sum factor of earlier musculoskeletal symptoms, regular medication, chronic impairment or disability due to prior musculoskeletal injury, orthopedic surgery), educational level, school degree level, father's occupation, and participating in individual aerobic sports (12 adjusting variables).

[1] Excellent or good result in Cooper's test and excellent result in push-up / back lift test.

[2] Excellent results in both tests.

[3] Excellent result in Cooper's / sit-up / push-up / back-lift tests and good or fair good result in the combined test, or good results in both tests.

[4] Poorer results than aforementioned, except the combination of poor results in both tests.

[5] Poor results in both tests.

5.1.6 Incidence and risk factors of untimely medical discharge (IV)

Incidence and reasons for medical discharge

Of the 1411 participants, 9.4% (n=133) sustained untimely medical discharge after the two-week run-in period during the six-month service. The incidence rate for discharge was 0.57 (95% CI: 0.48-0.67) per 1000 person-days. There was a trend towards more medical discharges among arrivals entering the military in July (11%) than in January (8%) (p=0.058).

Risk factors of medical discharge

After adjustment in multivariate analyses, poor school success (educational level and grades combined) was associated with a 4.6-folded risk for discharge (95% CI: 2.0–11.0) compared to excellent school success with a dose-response relationship. With regard to *health*, low self-assessed health was associated with overall medical discharge (HR=2.8; 95% CI: 1.6–5.2) and especially with discharge due to mental reasons (HR=7.8; 95% CI: 2.7–22.4) in a dose-response manner. WC over 102 cm was clearly associated with discharge compared to normal WC (HR=2.4; 95% CI: 1.3–4.6). From the *health behavior* variables, never belonging to a sports club was a strong risk indicator (HR=4.9; 95% CI: 1.2–11.6) for discharge. Interestingly, conscripts who used alcohol more than once a month had lower risk for discharge (HR=0.5; 95% CI: 0.3–0.8) compared to conscripts who drank alcohol more seldom (Table 13).

With regard to *physical fitness,* clear association between low physical fitness and discharge was found. In univariate analysis all the army physical fitness tests were associated with untimely discharge. After adjustment in multivariate analyses the strongest association was found between poor result in 12-minute running test and discharge (HR=3.3; 95% CI: 1.7–6.4). In addition, poor result in push-up test nearly doubled the risk for discharge (HR=1.8; 95% CI: 1.0–3.2). When combining individual muscular fitness test results, co-impairment in 12-minute running and push-up or pull-up tests were the strongest risk indicators. In addition, co-impairments in sit-ups, push-ups, pull-ups and standing long jump test were associated clearly with discharge (Table 14).

Table 13. Hazard ratios (HR) for early medical discharge from military service by school success, health and health behavior variables at baseline (adapted from Taanila et al. (2011))

Socioeconomic background & company	Category	Total number (% of discharged)	HR for discharge (n=133) *	HR for discharge (n=133) **
School success (educational level and grades combined)	Excellent [1]	218 (4)	1 (Referent)	1 (Referent)
	Good [2]	608 (8)	**2.2 (1.0–4.7)**	2.0 (0.9–4.2)
	Satisfactory [3]	467 (11)	**3.2 (1.5–6.7)**	**2.5 (1.2–5.5)**
	Poor [4]	96 (22)	**6.4 (2.8–14.5)**	**4.6 (2.0–11.0)**
Waist circumference (WC, cm)	Thin (< 80)	271 (7)	1.5 (0.9–2.6)	1.2 (0.7–2.2)
	Normal (80 – 94)	739 (5)	1 (Referent)	1 (Referent)
	Increased (94 – 102)	178 (6)	1.1 (0.5–2.2)	0.9 (0.4–1.9)
	High (≥ 102)	122 (12)	**2.5 (1.4–4.5)**	**2.4 (1.3–4.6)**
Self-assessed health [5]	Good or very good	743 (5)	1 (Referent)	1 (Referent)
	Average	558 (12)	**2.4 (1.6–3.5)**	**1.7 (1.1–2.6)**
	Inferior	88 (26)	**5.7 (3.4–9.5)**	**2.8 (1.6–5.2)**
Chronic disease	No	1012 (8)	1 (Referent)	1 (Referent)
	Yes	377 (14)	**1.8 (1.3–2.6)**	**1.6 (1.1–2.3)**
Sports injury during last month	No	1254 (9)	1 (Referent)	1 (Referent)
	Yes	130 (15)	**1.7 (1.0–2.7)**	**1.7 (1.0–2.9)**
Smoking habits	Never smoked regularly	735 (7)	1 (Referent)	1 (Referent)
	Has smoked regularly	650 (12)	**1.6 (1.2–2.3)**	1.3 (0.8–1.9)
Use of alcohol	< 1 time per month	254 (13)	1 (Referent)	1 (Referent)
	1–2 times per week	894 (8)	**0.6 (0.4–0.9)**	**0.5 (0.3–0.8)**
	≥ 3 times per week	240 (11)	0.8 (0.5–1.4)	**0.5 (0.3–1.0)**
Frequency of drunkenness before military service	< 1 time per week	1075 (9)	1 (Referent)	1 (Referent)
	≥ 1 time per week	313 (12)	1.4 (1.0–2.1)	1.1 (0.7–1.8)
Sweating exercise (Brisk leisure time sport)	≥ 3 times per week	438 (6)	1 (Referent)	1 (Referent)
	1–2 times per week	415 (8)	1.4 (0.8–3.8)	0.9 (0.5–1.6)
	Only leisured exercise	257 (12)	**2.2 (1.3–3.8)**	1.2 (0.7–2.1)
	No physical exercise	278 (15)	**2.7 (1.7–4.5)**	1.2 (0.7–2.2)
Belongs to a sports club	Yes, active member	206 (2)	1 (Referent)	1 (Referent)
	No, but former member	802 (9)	**4.9 (1.8–13.4)**	**3.7 (1.5–16.0)**
	No, never member	375 (14)	**7.4 (2.7–20.4)**	**4.9 (1.2–11.6)**

Variable distribution was charted in 1411 male conscripts during the first week of military service and discharge outcomes were registered during the following 6-month military service. Statistically significant findings are indicated with bold type.

[1] Attended upper secondary school, polytechnic, or university and reported excellent or good grades.

[2] Other subjects from upper secondary school, polytechnic, or university and conscripts from vocational school whose grades were excellent or good.

[3] Respondents with poorer grades in vocational school.

[4] Attended only comprehensive school or had permanently interrupted vocational or upper elementary school.

[5] Compared to age-mates.

* Adjusted for age (univariate).

** Adjusted for age, company, smoking (previous or current smoker), alcohol intake, baseline medical conditions (sports injury during last month, sum factor of earlier musculoskeletal symptoms during the last month before entering the military, chronic impairment or disability due to prior musculoskeletal injury, chronic disease, regular medication), school success (educational level and grades combined), urbanisation level of the place of residence, participating in ball games, last degree achieved in school sports, physical activity during the previous 3 months before entering the military, self-assessed health, belonging to a sports club and participation in competitive sports (17 adjusting variables).

Table 14. Hazard ratios (HR) for early medical discharge from military service by physical fitness test variables at baseline (adapted from Taanila et al. (2011))

Physical fitness test result	Category	Total number (% of discharged)	HR for discharge (n=133) *	HR for discharge (n=133) **
Cooper's test (12-minute running test)	Excellent (≥ 3000 m)	51 (6)	}1 (Referent)	}1 (Referent)
	Good (≥ 2600 m)	330 (4)		
	Fair (≥ 2200 m)	630 (6)	1.5 (0.8–2.8)	1.4 (0.8–2.7)
	Poor (< 2200 m)	358 (14)	**3.7 (2.1–6.7)**	**3.3 (1.7–6.4)**
Standing long jump test (two attempts, best result observed)	Excellent (≥ 2,40 m)	241 (5)	1 (Referent)	1 (Referent)
	Good (≥ 2,20 m)	363 (8)	1.6 (0.8–3.0)	1.5 (0.8–3.0)
	Fair (≥ 2,00 m)	442 (6)	1.2 (0.6–2.3)	1.0 (0.5–2.0)
	Poor (< 2,00 m)	332 (11)	**2.3 (1.2–4.2)**	1.7 (0.9–3.3)
Sit-up test (repeats per 60 seconds)	Excellent (≥ 48)	221 (5)	1 (Referent)	1 (Referent)
	Good (≥ 40)	319 (4)	0.9 (0.4–2.1)	0.7 (0.3–1.7)
	Fair (≥ 32)	459 (9)	2.0 (1.0–3.9)	1.4 (0.7–3.0)
	Poor (< 32)	379 (12)	**2.8 (1.4–5.5)**	1.9 (0.9–4.0)
Push-up test (repeats per 60 seconds)	Excellent (≥ 38)	450 (6)	1 (Referent)	1 (Referent)
	Good (≥ 30)	312 (5)	1.0 (0.5–1.8)	0.9 (0.5–1.6)
	Fair (≥ 22)	350 (7)	1.3 (0.8–2.3)	1.0 (0.6–1.9)
	Poor (< 22)	266 (15)	**2.7 (1.7–4.5)**	**1.8 (1.0–3.2)**
Conscript's physical fitness index [1]	Excellent (≥ 21.00)	69 (3)	1 (Referent)	1 (Referent)
	Good (17.00−20.99)	409 (6)	2.0 (0.5–8.4)	1.4 (0.3–5.9)
	Fair (13.00−16.99)	590 (6)	2.1 (0.5–8.7)	1.1 (0.2–4.7)
	Poor (< 13.00)	297 (14)	**5.1 (1.2–21.2)**	2.5 (0.6–11.1)
Co-impairment in Cooper's and push-up tests	No	1219 (6)	1 (Referent)	1 (Referent)
	Yes, poor results in both tests	146 (18)	**3.1 (2.0–4.8)**	**2.6 (1.6–4.3)**
Co-impairment in push-up and standing long jump tests	No	1241 (7)	1 (Referent)	1 (Referent)
	Yes, poor results in both tests	137 (19)	**3.1 (2.0–4.8)**	**2.5 (1.5–4.1)**
Co-impairment in sit-up and push-up tests	No	1215 (7)	1 (Referent)	1 (Referent)
	Yes, poor results in both tests	163 (18)	**3.0 (2.0–4.6)**	**2.6 (1.6–4.1)**

Variable distribution was charted in 1411 male conscripts during the first week of military service and discharge outcomes were registered during the following 6-month military service. Statistically significant findings are indicated with bold type.

[1] Conscript's physical fitness index (CPFI) = (12-min running test result (m) + 100 x muscular fitness test points) / 200.

* Adjusted for age (univariate).

** Adjusted for age, company, smoking (previous or current smoker), alcohol intake, baseline medical conditions (sports injury during last month, sum factor of earlier musculoskeletal symptoms during the last month before entering the military, chronic impairment or disability due to prior musculoskeletal injury, chronic disease, regular medication), school success (educational level and grades combined), urbanisation level of the place of residence, participating in ball games, last degree achieved in school sports, physical activity during the previous 3 months before entering the military, self-assessed health, belonging to a sports club and participation in competitive sports (17 adjusting variables).

5.2 Effectiveness of neuromuscular exercise and counseling in the prevention of MSDs

5.2.1 Neuromuscular exercise and counseling to decrease the risk of acute musculoskeletal injury (V)

The details of the flow of participants through the study are shown in Figure 4. The rate of consent to participate was 98%. Most drop-outs were due to a change of company after 8 weeks basic military training period. Twenty dropouts in the intervention group and 29 in the control group were due to musculoskeletal injuries (HR=0.81; 95% CI: 0.42−1.57). Data for these men who dropped out were included in the analyses for the time they participated. The intervention training compliance was good. On average 83% of the conscripts attended the training sessions reaching the present minimum number of exercise bouts.

Number and incidence of acute injuries and corresponding HR for men in the intervention and control companies during pre-study and study period are shown in Table 15. The intervention companies had somewhat higher risk of injury before the intervention. In the intervention companies, the risk for acute ankle injuries decreased significantly compared to control companies during the study period (adjusted HR=0.34; 95% CI: 0.15–0.78, p=0.011). The risk decline was observed in persons with a low baseline fitness level, as well as in those with moderate-to-high baseline fitness. In addition, among men with moderate- to-high baseline fitness, the risk for acute upper extremity injury decreased significantly in the intervention companies compared to control companies (adjusted HR=0.37; 95% CI: 0.14–0.99, p=0.047). Furthermore, the intervention companies tended to have fewer time loss due to acute injuries (adjusted HR=0.55; 95% CI: 0.29–1.04) (Table 15).

Table 15. Incidence per 1,000 person-days of different types of musculoskeletal injuries and hazard ratios for changes in incidence between the intervention and control companies during pre-study and study periods (Parkkari et al. 2011)

Variable	Company	Pre-study period (n=508/436)‡		Study period (n=501/467)‡		HR age adjusted (95% CI)	HR adjusted model* (95% CI)
		No	Incidence	No	Incidence		
Acute injuries, all	Int.	246	3.16	150	2.14	0.74 (0.52−1.06)	0.75 (0.51−1.09)
	Ctrl.	149	2.73	155	2.44		
Lower extremity	Int.	136	1.75	90	1.28	0.84 (0.55−1.30)	0.82 (0.52−1.31)
	Ctrl.	91	1.67	96	1.51		
Knee	Int.	50	0.64	48	0.68	1.05 (0.55−2.00)	1.32 (0.65−2.67)
	Ctrl.	35	0.64	38	0.60		
Ankle	Int.	37	0.48	17	0.24	**0.38 (0.17−0.86)**	**0.34 (0.15−0.78)**
	Ctrl.	21	0.38	37	0.58		
Upper extremity	Int.	53	0.68	31	0.44	0.57 (0.28−1.16)	0.52 (0.24−1.12)
	Ctrl.	26	0.48	31	0.49		
Total number of off-duty days ‡‡	Int.	917	11.8	546	7.8	**0.46 (0.26−0.83)**	0.55 (0.29−1.04)
	Ctrl.	419	7.7	677	10.7		
Discharged from military service **	Int.	34	0.44	42	0.60	0.78 (0.41−1.51)	0.81 (0.42−1.57)†
	Ctrl.	26	0.48	52	0.82		
		Follow-up days					
	Int.	77871		70222			
	Ctrl.	54620		63494			

HR, hazard ratio; 95% CI, 95% confidence interval; Int, intervention company; Ctrl, control company. HRs were calculated by using the Cox proportional hazard model if not otherwise mentioned. Statistical significance level was set at $P < 0.05$. HRs are based on the interaction term of each study group (intervention or control), and study period was entered into the model to analyse the difference in the change in incidence between the groups.

‡ Number of conscripts in the intervention and control companies per study period

* Adjusted for age, urbanisation level of the home residence, smoking, alcohol intake, earlier musculoskeletal symptoms, orthopedic surgeries, chronic disabilities due to earlier musculoskeletal injuries, school success (educational level and grades combined), previous physical activity, waist circumference and conscript's physical fitness index (12 adjusting variables).

‡‡ Due to acute injuries. Rate ratio was obtained using a negative binomial model

** After the 2-week run-in period

† Not adjusted by waist circumference and physical fitness level, since 36 discharged cases had missing information

5.2.2 Neuromuscular exercise and counseling to decrease the risk of LBP and disability (VI)

The number of events and the incidence of the outcome measures of LBP and disability for men in the intervention and control companies, and corresponding HRs (intervention vs. control) during the pre-study and intervention year are shown in Table 16. The intervention companies had a somewhat higher number of events and incidence of LBP than the controls during the pre-study year. Total number of off-duty days due to LBP

were significantly decreased in the intervention companies compared to controls (adjusted HR=0.42; 95% CI: 0.18–0.94, p=0.035). The decrease in the number of conscripts with five or more off-duty days was larger in the intervention group (21 vs. 5) than in the control group (10 vs. 7), but the adjusted difference (HR=0.44; 95% CI: 0.11–1.77) was not statistically significant. The incidence of LBP and related healthcare visits was not significantly different between the groups (Table 16).

Table 16. Incidence per 1,000 person-days of different categories of low back pain (LBP) and hazard ratios for changes in incidence between the intervention and control companies during follow-up and intervention year (Suni et al. 2012)

Variable	Company	Pre-study period (n = 463/396)‡		Study period (n = 449/427)‡		HR age adjusted (95% CI)	HR adjusted model* (95% CI)
		No	Incidence	No	Incidence		
LBP	Int.	82	1.34	58	1.13	0.95 (0.55−1.65)	0.93 (0.53−1.63)
	Ctrl.	49	1.17	47	1.02		
Total number of health clinic visit due to LBP‡‡	Int.	145	2.38	82	1.60	0.81 (0.42−1.56)	0.82 (0.43−1.57)
	Ctrl.	81	1.93	77	1.66		
Total number of off-duty days due to LBP‡‡	Int.	285	4.67	124	2.41	**0.40 (0.17−0.91)**	**0.42 (0.18−0.94)**
	Ctrl.	131	3.13	154	3.33		
At least 5 off-duty days due to LBP	Int.	21	0.34	5	0.10	0.44 (0.11−1.73)	0.44 (0.11−1.77)
	Ctrl.	10	0.24	7	0.15		
Follow-up days	Int.		61027		51383		
	Ctrl.		41900		46296		

HR, hazard ratio; 95% CI, 95% confidence interval; Int, intervention company; Ctrl, control company. HRs were calculated by using the Cox proportional hazard model if not otherwise mentioned. Statistical significance level was set at $P < 0.05$. HRs are based on the interaction term of each study group (intervention or control), and study period was entered into the model to analyse the difference in the change in incidence between the groups.

‡ Number of conscripts in the intervention and control companies per study period

* Adjusted for age, smoking, baseline medical conditions (sports injury, sum factor of earlier musculoskeletal symptoms, chronic impairment or disability due to prior musculoskeletal injury, orthopaedic surgery), school success (educational level and grades combined), urbanisation level of the place of residence, physical activity during the previous three months before entering the military and baseline physical fitness level (12-minute running test and push-up test combined) (11 adjusting variables)

‡‡ Rate ratio obtained from Negative binomial model

6. DISCUSSION

6.1 Summary of the main findings

In this thesis, the occurrence, nature, etiology, risk factors and prevention of musculoskeletal disorders, low back pain and untimely medical discharge on medical reasons were examined among male conscripts during 6-month military service. All companies without special qualification requirements in the Pori Brigade were enrolled in the study. The participants were conscripts of four successive age cohorts (N=2057). In the pre-study year, before adoption of the intervention, two successive cohorts of conscripts in four companies were followed prospectively for 6 months to study the baseline incidence of acute injuries and LBP. After the pre-study year, the companies were randomized into two groups (2 intervention companies: anti-tank, engineer; and 2 control companies: signal, mortar), and the two new successive cohorts were followed prospectively for 6 months providing the data for the intervention year.

The key finding considering epidemiologic studies was the strong predictive association of poor physical fitness for MSDs and military discharge in previously healthy conscripts. A new and consistent finding of co-impairments in aerobic and muscular fitness as a predictor for MSDs and military discharge was presented. Furthermore, the associations between poor physical fitness and the study outcomes were even stronger for long-term acute and overuse injuries and recurrent LBP in a dose-responded manner.

Another consistent finding in all risk factor studies was that conscripts with poor school success (educational level and grades combined) had increased risk for MSDs and military discharge. In addition, obesity defined by waist circumference and body mass index was associated with overuse and acute injuries, as well as military discharge. The specific finding that poor self-assessed health was associated with discharge due to mental health reasons highlights the need for improved identification and early intervention among these young men.

In the prevention part of this study, the effectiveness of a 6-month NME and counseling program for reducing the incidence of acute lower limb injuries and LBP disability was studied in healthy conscripts. In the intervention groups, the risk for acute ankle injury decreased 66% compared to the control groups. In addition, the number of off-duty days due to LBP was reduced by 58% in the intervention companies compared to the controls.

6.2 General features of MSDs and untimely medical discharge in Finnish conscripts

This study showed that MSDs are an important cause of morbidity among Finnish conscripts. Over two thirds (69%) of conscripts sustained one or more MSDs during the six-month service. The event-based incidence rate for MSDs was 10.5 (95% CI: 10.0–11.1) and the person-based incidence rate was 7.1 (95% CI: 6.6–7.7) per 1000 person-days, respectively. These incidences were approximately two-folded compared to findings in previous studies among Norwegian (Heir & Eide 1996) and Danish (Rosendal et al. 2003) conscripts.

The high number of MSDs among Finnish conscripts is noteworthy. Complaints causing no time loss, like minor bruises and wounds not treated in the garrison clinic were not registered in the present study, so it is unlikely that over-reporting of minor MSDs would explain the difference between the studies. In the present study, the follow-up time was longer than in earlier Nordic studies (Heir & Glomsaker 1996; Rosendal et al. 2003). This neither explains the higher incidence of MSDs, because the intensity of military training is probably lower after the initial first weeks, which may be seen as lower injury rates during a longer follow-up time (Almeida et al. 1999b). The selection of conscripts is stricter in Norway and Denmark (Appelqvist-Schmidlechner et al. 2010), screening out those conscripts with less physical and mental resources for military service. This decreases the incidence of MSDs and probably explains some of the difference in the incidence of MSDs.

The incidence of traumatic injury hospitalization was 94 per 1000 conscripts per year in 1990s in the Finnish Defence Forces (Mattila et al. 2006), which is higher than the reported 45 hospitalizations per 1000 person-years in the U.S. Army personnel (Jones & Knapik 1999). When comparing this rate to outpatient clinic visit rates of 18.6 per 1000

person-days due to MSDs in the present study, there are approximately 72 outpatient clinic visits per one hospitalization in the Finnish conscription army. In the U.S. Military, there are 115 outpatient clinic visits per one hospitalization (Ruscio et al. 2006), indicating probably easier access to hospitalization in the Finnish conscription army.

There is a lack of earlier studies reporting temporal differences in the garrison clinic or hospital admission rates. However, in this thesis, peaks could be observed in August and drops in July, September and March. Knapik and colleagues (2002) reported that injury incidence among U.S. Army conscripts is higher in the summer than in the fall and suggested that environmental temperature is the main factor behind the finding. The contents of the Finnish military service explain the present finding probably better than environmental temperature changes. In the second week of July, a new arrival enters into military and a majority of the old batch ends service. The last week of military service is usually physically less demanding so as is the first week of service before medical check-ups, reducing the admissions to the garrison clinic in July. An explanation for the lower rates seen in September and March is probably the change from basic military training period to special training stage. At the beginning of the special training stage, more theoretical education is scheduled and military service is physically slightly less demanding, lowering the admission rates.

Etiological circumstances and injury mechanisms associated with MSDs

The observed high proportion of military training-related disorders in the present study is in agreement with previous studies (Reynolds et al. 1994; Jones & Knapik 1999) (Table 1). The extensive study conducted across all U.S. Military suggested that efforts focused at first on mitigation of sports and physical training–related injuries, and then on reducing falls would be beneficial to reduce the number limited duty days caused by injuries (Ruscio et al. 2010). In consonance with the present study, falls were most commonly associated with acute injuries and marching and running were the most common activities associated with overuse-related MSDs in U.S. Military (Ruscio et al. 2010). Combat training in combat gear and organized physical exercises including team ball games (football, basketball, floorball) were also activities commonly associated with MSDs in this thesis, consistent with previous findings (Table 1).

Acute and overuse injuries

Most MSDs were in the lower extremities (65%) followed by the back (18%) (Table 6). This distribution of MSDs affecting especially the lower limb is consistent with the findings of several previous studies concerning military recruits (Almeida et al. 1999b; Kaufman et al. 2000; Piantanida et al. 2000; Snedecor et al. 2000) as well as conscripts in mandatory armies (Heir & Glomsaker 1996; Heir & Eide 1997; Rosendal et al. 2003; Mattila et al. 2006). It seems that the basic military training consisting primarily of weight-bearing activities exerts a load particularly on the lower limbs and low back (Reynolds et al. 2009). Most conscripts are not used to marching long distances over rough terrains with a heavy load, which may be a factor behind overuse injuries (Santtila et al. 2006). The high proportion of disorders affecting the low back and the lower limbs is noteworthy due to their commonly chronic nature, causing time loss and premature discharges from military service.

The high proportion of sprains, strains and lower limb overuse injuries is in accordance with previous studies (Jones et al. 1993b; Heir & Eide 1997; Kaufman et al. 2000; Songer & LaPorte 2000; Mattila et al. 2006). Heir and Glomsaker (1996) reported similar results in Norwegian conscripts considering a high number of knee overuse injuries.

LBP and disability

The cumulative incidence of LBP, prompting at least one visit to a garrison clinic during 6-month military service, was 16% in previously healthy conscripts, consistent with previously published figures for young military (Milgrom et al. 1993; O'Connor & Marlowe 1993; Milgrom et al. 2005) and civilian populations (Burton et al. 1996; Feldman et al. 2001). The literature of risk indicators of LBP during military training is sparse, although LBP is the leading cause of musculoskeletal disability discharge in conscription (Sahi & Korpela 2002) and professional armies (Feuerstein et al. 1997; Lincoln et al. 2002). In the U.S. Armed Forces (2003), LBP is the second most common reason to seek healthcare causing a loss of billions of dollars annually (Songer & LaPorte 2000). Unspecified LBP is the most prevalent diagnosis behind hospitalizations due to LBP among Finnish conscripts (Mattila et al. 2009). Chronic LBP is debilitating

in military service and results in a notable increase in the use of health services (Ulaska et al. 2001).

In this study, a clearly higher risk for recurrent LBP was observed in the signal and engineer companies compared to other companies. There were no qualification requirements when allocating the conscripts, which would explain the finding. Thus probably some military tasks conducted in the signal and engineer companies (e.g. carrying electric-reels, digging and construction) are associated with elevated risk of recurrent LBP. A comprehensive study conducted recently by using the U.S. Defense Medical Epidemiology Database concluded that service in the Army or Air Force compared to service in Navy or Marine is a clear risk factor for LBP (Knox et al. 2011). More specifically, some military tasks like artillery (Reynolds et al. 2002), helicopter aviation (Bridger et al. 2002; Pelham et al. 2005), fighter piloting (Hamalainen 1999), and parachuting (Bar-Dayan et al. 2003) are documented to be physically demanding for the back.

There is growing evidence that acute LBP occurs when abnormal loading causes microdamage in spinal ligaments, discs, facets, and capsules. This triggers acute inflammation, which in turn elicits muscle spasms and movement control impairments (Solomonow et al. 2003; Olson et al. 2004; Courville et al. 2005; Olson et al. 2006; Panjabi 2006; Le et al. 2007). The consequences of these changes along with psychological and societal processes are potential factors behind the development of recurrent or chronic LBP (McGill 1997; Taimela & Luoto 1999; Hodges & Moseley 2003; Panjabi 2006). Conscripts who suffer from chronic LBP before entering military service have a ten-fold higher risk to experience LBP during military service compared to the risk before the service (Ulaska et al. 2001). This finding reflects the fact that basic military training is physically demanding for the back and requires an adequate level of physical fitness.

Untimely medical discharge

Of the 1411 participants, 9.4% (n=133) sustained untimely medical discharge after the two-week run-in period during the six-month service, resulting incidence rate for discharge 0.57 (95% CI: 0.48-0.67) per 1000 person-days. This is consistent with previously described results in the Finnish Defence Forces. During the whole military service, including the first two weeks, approximately 13% to 15% (3500-4000 persons)

of young men who enter the compulsory military service are prematurely discharged annually (Lehesjoki et al. 2010). The most common reasons for discharge were musculoskeletal injuries and disorders (44%) followed by mental and behavioral disorders (29%) and diseases of the respiratory system (12%). These findings are consistent with previous findings, but in general, mental and behavioral disorders are the leading reasons for untimely medical discharge in Finland (Sahi & Korpela 2002).

6.3 Poor physical fitness and other significant risk factors for MSD and medical discharge

Poor physical fitness predisposing to MSDs and medical discharge was a consistent and strong finding in every risk factor study of this thesis. One could ask what is actually measured in army physical fitness tests of aerobic and dynamic muscular endurance. Clearly motivation and ambition have a role in this setting of fitness testing. On the other hand, good performances are rewarded as an extra day off from army, which probably motivates conscripts to do their best in fitness tests. Clearly good physical fitness is associated with engaging in sports regularly (Heir & Eide 1997). Physical activity may result in adaptation of the body and thereby help to prevent MSDs when the conscript is subjected to new strains (Heir & Eide 1997; Jones et al. 2002). However, actual fitness testing was superior to the question charting physical activity in forecasting the risk for the outcome (Table 9 and 10). It is possible that some conscripts under- or overvalue their engagement in physical activity when answering the questionnaire, depending of their prevailing mood or self-esteem. It is interesting that the variables which were most clearly associated with the outcomes of the present study, namely school success and physical fitness, are largely interconnected and related to physical activity in other studies among the young. According to a Swedish study, continuation of engaging in sports exercise after childhood was clearly associated with good school success and high volume of physical exercise in childhood (Jakobsson et al. 2012). The authors concluded that young people who are sporty and good at school remain more often in club sports during their teens and engage more often in physical activities later in their life.

Obesity measured as high BMI (> 30 kg/m^2) and high WC (> 102 cm) was associated with acute and overuse injuries in this thesis, which is in consonance with some earlier

findings (Table 2). In addition, an association between obesity and recurrent LBP is consistent with a meta-analysis (Shiri et al. 2010b). High WC was also associated with premature discharge compared to normal WC, which was previously unreported. In the majority of the previous studies, overweight and obesity were defined as BMI according to the WHO standards, instead of using measurements of WC or body fat percentage (Table 2).

Lower education and poor school success were strongly associated with MSDs and medical discharge in every risk factor study of this thesis. Moreover, a combined variable of low education level and poor school success proved to be a strong predictor of MSDs and failure in military success. The association of low educational level and MSDs has not been extensively investigated in the military setting among the young, which deserves more attention in further studies. Furthermore, the present finding that poor overall school success was a strong predictor for both MSDs and medical discharge is new. Interestingly, according to a recent Finnish report among conscripts (Absetz et al. 2010), education was clearly associated with other common risk factors, namely smoking and frequency of drunkenness. Those with lower education smoked over 3 times more than those with higher education, but an increase in smoking occurred in both groups during the 6-month service. Moreover, an increase in the frequency of drunkenness was seen particularly among the less educated; there was a significant growth in the proportion of those who at least once a week drank themselves into a highly intoxicated condition.

In the present study, *age* was not associated with MSDs or medical discharge after multivariate adjustments, but it was not possible to investigate the effect of age thoroughly, because 95% of conscripts were nearly the same age (18-20 yrs). However, older age was associated with LBP before multivariate adjustments, consistent with findings among professional soldiers (Feuerstein et al. 1999; Lincoln et al. 2002; Knox et al. 2011). The disagreement considering age as a risk factor for MSDs may be explained by the fact that at the beginning of military service all trainees engage in the same intensity and frequency of physical training, but after that older persons tend to be of higher rank (Jones & Knapik 1999; Leggat & Smith 2007), probably due to better education before military entrance. Soldiers who have higher rank may have less exposure to vigorous physical training, consequently lowering the risk for injuries.

6.3.1 Acute and overuse musculoskeletal injuries

Low physical fitness was a strong predictor of acute and overuse injuries. A number of studies have documented the association of low levels of aerobic fitness and subsequent risk of injury (Table 2). Poor muscular strength and endurance are also reported to be risk factors for injuries during military training, although not as frequently (Table 2).

In Finland, the proportion of conscripts with low physical performance capacity has increased dramatically during last decades: The number of conscripts with a poor result (< 2200 m) in Cooper's test increased 5.6-fold between 1980 and 2004 (Santtila et al. 2006). Poor physical fitness and increased obesity lead to problems meeting minimum physical requirements set for military service and predisposes for musculoskeletal injuries (Jones & Knapik 1999; Knapik et al. 2001b; Rosendal et al. 2003; Mattila et al. 2007b). The same trend indicating declined running performance of recruits probably due to increased body weight has been observed in professional armies as well (Knapik et al. 2006b).

Persons with slower 2-mile running times have lower aerobic capacity than persons with faster running times (Knapik et al. 2001b). Individuals with lower aerobic capacity probably experience greater physiological stress than individuals with better aerobic fitness during long-term military basic training (marching, running, combat training), which may predispose to acute and overuse injuries (Jones & Knapik 1999; Knapik et al. 2001b). Various hypothetical mechanisms have been presented to explain this association. Conscripts with lower aerobic fitness levels may perceive military training as more difficult and fatigue more rapidly (Garcin et al. 2004). It has also been proposed that fatigue leads to changes in gait and kinematics in lower extremities (Willson & Kernozek 1999; Benjaminse et al. 2008), which may result in musculoskeletal stress in specific body areas and predispose to injuries (Johnston et al. 1998; Benjaminse et al. 2008). Muscular fatigue may lead to a greater reliance on other muscle groups as the active muscle groups begin to fatigue (Gleeson et al. 1998). Persons who are unaccustomed to this muscle stress may have a higher risk for acute and overuse injuries.

Studies conducted in Norwegian (Heir & Eide 1997) and Danish (Rosendal et al. 2003) conscripts reported low self-assessed physical fitness to be associated with acute and overuse injuries. These findings were only partly concordant with the results of this thesis. Interestingly, self-assessed physical fitness was associated with acute and

overuse injuries only in the age-adjusted model, but the association weakened after further adjustments including past physical activity. In earlier studies, the results were unadjusted to other significant variables (Rosendal et al. 2003) or conducted with a short follow-up time (Heir & Eide 1997). Probably self-assessed physical fitness is a practical variable predisposing the injury risk when exact data from physical fitness tests are not available.

In the present study, both high BMI and high WC as a marker of *obesity* were associated with acute and overuse injuries. However, the U-shaped association by Jones et al. (1993a), indicating that underweight is also a risk factor, was not observed. The associations were slightly stronger when WC was used instead of BMI. Obesity impairs functional ability in everyday living (Ferraro & Booth 1999; Lakdawalla et al. 2004). According to literature, obesity is strongly associated with the common disabling conditions (arthritis, mental health disorders, learning disabilities and back ailments) in both adult and child populations (Ells et al. 2006). In addition, a relationship between obesity and metabolic conditions such as type 2 diabetes, coronary heart disease and stroke has been well defined (Grundy 2000). Obesity is associated with difficulties in physical demands with strenuous work and pain after the strain. According to a Swedish study (Larsson & Mattsson 2001), obese people are impeded in sport activities, walking outdoors and up and down stairs, and in squatting, stooping and lifting. High BMI alters body geometry and postural stability (Rodacki et al. 2005; Hue et al. 2007). In turn, these alterations may reduce movement efficiency and increase the risk of injury (Reynolds et al. 2002). Reducing weight improves the balance control in obese civilian men and decreases the risk of falling injuries (Teasdale et al. 2007).

Finnish compulsory military service reaching a vast majority of 19-year-old young men offers a unique opportunity for intervention against obesity. Furthermore, in obese Finnish conscripts, military training assists in reducing body mass and improving cardiorespiratory fitness (Santtila et al. 2008; Absetz et al. 2010). The most favorable timing for intervention seems to be at the beginning of the military, since healthy changes in nutrition and other lifestyle habits are most noticeable in the first 8 weeks of service when the conscripts learn the basic military skills (Absetz et al. 2010).

The finding that *lower education and poor school success* were associated with acute and overuse injuries is concordant with a previous study reporting low education as a risk factor for foot injuries (Reynolds et al. 2000). There is a lack of studies

investigating the association between musculoskeletal injuries and education level in the military setting, but lower grade of mental ability is reported to be associated with acute injuries (Taimela et al. 1991) among young men.

Of the health behavior characteristics, *smoking* was clearly associated with acute and overuse injuries in univariate models, but after further adjustments the associations weakened. The present finding, that *high frequency of drunkenness* prior to the beginning of military service is a risk factor for acute and overuse injuries, has not been reported before. Risk taking behavior and cognitive deficits are more common among smokers, which may partly explain the altered risk in adjusted models (Jones & Knapik 1999; Dinn et al. 2004). Moreover, smoking and alcohol intake are strongly associated with each other among young men (Koopmans et al. 1997; Myers & Kelly 2006). This interaction attenuates the association between outcome and predictive variables when both variables were placed in the same model. Altarac and colleagues (2000) reported that cigarette smoking is associated with exercise-related injuries during basic military training. After controlling for other factors, the adjusted odds-ratio for smokers was approximately 1.5-fold compared to non-smokers. Similar findings have also been reported in other military studies (Jones et al. 1993b; Reynolds et al. 1999; Knapik et al. 2010; Grier et al. 2011). Although among young smokers, the aerobic capacity is similar to non-smokers (Knapik et al. 2001b), smoking may be associated with acute and overuse injuries in many other ways. Smoking causes a deficit in bone density (Ward & Klesges 2001). This effect may be detected even in young healthy persons (Ortego-Centeno et al. 1997). Several studies have concluded that smoking hampers wound and fracture healing and impairs fibroblast function (Kyro et al. 1993; Jorgensen et al. 1998; Wong & Martins-Green 2004). Overuse injuries are known to result from repetitive microtrauma leading to inflammation and local tissue damage (Wilder & Sethi 2004). There is no clear evidence, however, of the association between smoking and stress fractures among young military recruits, because the effect of smoking on bone mineral density is thought to depend on long-term exposure (Altarac et al. 2000).

6.3.2 LBP and disability

According to a review (Hamberg-van Reenen et al. 2007), the relation between physical fitness in muscular endurance, strength and spinal mobility and LBP is unclear in

population level due to a limited number of good quality studies. Similarly the findings from military settings (Karvonen et al. 1980; O'Connor & Marlowe 1993; Feuerstein et al. 1999; Daniels et al. 2005) are inconclusive considering low physical fitness as a risk factor for the incidence of LBP.

The key finding of the study III, that poor results in dynamic trunk muscle endurance tests combined with poor aerobic endurance (Cooper's test) are strong predictors of LBP, supports the importance of trunk muscular endurance (core strength). Similar findings have not been reported among young populations, nor have previous studies explored the association between co-impairment of physical fitness and the risk of LBP. Co-impairment of the trunk extensor and flexor muscles may be an indicator of compromised spinal stability.

High BMI and abdominal obesity were marginally ($p < 0.10$) associated with recurrent LBP in the multivariate model, which is in consonance with a recent meta-analysis reporting an association between obesity and chronic LBP (Shiri et al. 2010b). Greater body weight has been linked to an increased risk for LBP during military service (Reynolds et al. 2002), but findings are contradictory among Israeli recruits (Milgrom et al. 1993). Severely obese persons do not meet military entrance standards in professional armies (Knapik et al. 2001b), which may partly explain the equivocal results of different studies. The association between BMI and LBP is unlikely to be causal (Dempsey et al. 1997; Leboeuf-Yde et al. 1999). However, Rodacki et al. (2005) found that for obese persons, the acute response of the spine to loading leads to greater reduction in stature. Conclusion was that obese persons need a greater recovery period to re-establish intervertebral disc height, suggesting an explanation for the high incidence of LBP in obese individuals (Rodacki et al. 2005). Probably by improving trunk muscular endurance, spinal shrinkage as a marker of spinal loading would be decreased (McGill 2002).

In general, the association of *low educational level* and LBP has not been investigated in the military setting among the young. Higher levels of intellectual capacity and type of education, however, are reported to protect against severe LBP (Hestbaek et al. 2005; Leboeuf-Yde et al. 2006). The present findings concerning the predictive value of low education level for recurrent LBP support previous findings. The ability to cope with minor LBP during military training might depend on educational background and intellectual capacity (Leboeuf-Yde et al. 2006).

Mechanisms underlying the effects of educational status on the risk for LBP warrant further investigation.

Smoking was associated with LBP, consistent with previous findings (Deyo & Bass 1989; Dempsey et al. 1997; Leboeuf-Yde et al. 1998). In the multivariate model, however, the association diminished. The link between smoking and LBP seems to be weak, although persistent (Leboeuf-Yde et al. 1998; Feldman et al. 2001; Mattila et al. 2008; Shiri et al. 2010a), and the causality of the association has not been proven even in large epidemiological studies (Leboeuf-Yde 1999; Shiri et al. 2010a). Overall, alcohol and smoking are probably indicators for risk-taking behavior rather than causal risk factors for MSDs among the young during military training.

6.3.3 Untimely medical discharge

The hypothesis of the study IV, that *co-impairment in physical fitness* is a predictor of medical discharge, was based on our previous findings presented in studies II and III, in which risk factors of MSDs during military training were investigated. Low levels of aerobic and muscular fitness were associated with premature discharge, which is in consonance with some previous studies (Snoddy & Henderson 1994; Pope et al. 1999; Blacker et al. 2008; Niebuhr et al. 2008). Moreover, the present finding that co-impairments in cardiorespiratory and muscular fitness were predictors for medical discharge was new.

High WC as a marker of *obesity* was independently associated with premature discharge, whereas BMI was not. The problem using BMI is that BMI does not distinguish lean mass from fat tissue (Fogelholm et al. 2006) especially among young male military candidates (Mullie et al. 2008). Therefore, BMI should be interpreted with caution when used as a screening tool for entry into military training (Peake et al. 2012). Mattila and colleagues (2007c) demonstrated that a high proportion of body fat measured by dual-energy x-ray absorptiometry (DEXA) is clearly associated with poor running performance and muscular strength among conscripts, and they proposed a stricter entry level BMI for Finnish conscripts. Morbidly obese persons might be temporarily discharged from the army in Finland, mainly on the basis of their subjective perception of being unable to cope with military service (Mattila et al. 2007c). Overall, obesity alone without other predictors like attenuated physical fitness does not seem to

be a major risk factor for discharge from the U.S. Military (Poston et al. 2002; Niebuhr et al. 2009) although it is associated with 49% higher healthcare utilization (Cowan et al. 2011).

The finding that *lower education and poor school success* were associated with medical discharge was concordant with a previous Finnish (Salo 2008) and U.S. Military study (Knapik et al. 2001a), but generally this association has not been investigated.

The new interesting finding was that conscripts who had *never been members of a sports club* had an elevated risk for medical discharge. Leisure time physical activity was associated with medical discharge with a dose-response relationship but this was perceived only in age-adjusted models. After further adjustments by other characteristics, including belonging to a sports club and self-assessed health, low leisure time physical activity was not a predictor of medical discharge, whereas being an active in a sports club proved to be a clear protective factor.

Belonging to a sports club is strongly associated with leisure time physical activity, which seems to lower the risk for discharge (Talcott et al. 1999; Larsson et al. 2009). Sports clubs may also enhance health in ways other than through physical fitness. Promoting healthy lifestyle is one of the main goals for Finnish youth sports clubs according to Koski (2009). Moreover, sports clubs offer informal education on teamwork, interaction skills, and assessing values (Kokko 2010). Other factors associated with benefits acquired in sports clubs may be that in sports clubs children and adolescents learn to obey rules and follow the instructions of coaches, skills that probably help conscripts to adapt to the discipline required in compulsory military service. Sports club participation probably reflects adjustment experiences similarly as school success. Previous adjustment experiences are shown to be important for success in the military (Salo 2008).

6.4 Prevention of acute extremity injuries, LBP and disability and untimely medical discharge in young conscripts

According to the epidemiological findings of this study, young men who are at higher risk for acute and overuse injuries, LBP and disability, as well as medical discharge can be identified before entry into the military service. Furthermore, the majority of the

observed risk factors are modifiable and favorable for future interventions. Thus preventive measures and programs can be implemented.

The present findings suggest that increasing both aerobic and muscular fitness is a desirable goal in a pre-training program before entering military service. A good result (≥ 2600 m) in the 12-min running test is a desirable goal in a pre-training program. The enhanced aerobic and muscular fitness would have a positive effect on the occurrence of injuries, LBP and discharge. Screening for low fitness in dual combinations of aerobic and dynamic trunk muscle endurance tests, i.e., sit-up, push-up, long-jump, back-lift and 12-min running test would be beneficial. This could help to distinguish conscripts at increased risk for MSDs during military service that may benefit from targeted intervention programs.

A recent Finnish report indicates that smoking and frequency of drunkenness increase during military service and that these risk factors are associated with lower education (Absetz et al. 2010). Moreover, traditional models of reward associated with masculinity ("work hard, play hard") prevail among Finnish conscripts leading to risk taking behavior. The report concluded that new models of masculine sociability and competition would be needed, so that the society could better exploit the opportunity to promote health in military service. Currently, there has only been partial success in implementing the health benefits of military service. According to previous studies, all the major socioeconomic and health behavior risk factors for MSDs and medical discharge presented in this study, including low education, obesity, physical inactivity, smoking and alcohol abuse, are strongly interconnected (Koopmans et al. 1997; Jones & Knapik 1999; Dinn et al. 2004; Myers & Kelly 2006; Jakobsson et al. 2012). Because the association of poor school success with MSDs and medical discharge was so evident in the present study, it seems that NME and counseling should be targeted especially to those conscripts with lower level of education, because other significant risk factors accumulate to this group of young men. Moreover, the education level cannot be modified, but the majority of other risk factors can be altered, thus being favorable for future interventions. In the intervention part of the present study, counseling based on the cognitive-behavior modeling was organized. The aim was to increase the awareness of military tasks that could lead to acute injuries or were potentially harmful to the lower back. Instruction on how to perform tasks in a less risky manner was also included. An illustrated and easily readable guidance book and a 1-hour lecture were the

components of counseling. The authors thought that this information would be beneficial especially for those with lower educational background. Furthermore, during NME program, these skills including proper squatting and lifting techniques were acquired in practice.

Prevention of acute and overuse injuries

A neuromuscular training and injury prevention counseling program was effective in preventing acute ankle and upper extremity injuries in an unselected population-based cohort of young male army conscripts that were engaged in high level of physical activity. In the present study, a strong emphasis was placed on proper technical performance of every single exercise maneuver. Before the intervention, the instructors were educated with regard to the correct training technique and how to best instruct each exercise, observe typical mistakes in each exercise maneuver, as well as how to appropriately correct mistakes. Some previous studies indicated that neuromuscular training can play a crucial role in preventing acute lower extremity injuries (Table 3) and the current intervention study supports these findings. The study by Olsen and colleagues (2005) showed that a structured warm-up program among young handball players reduced the risk of traumatic knee and ankle injuries, and the overall risk for severe and non-contact injuries. In a Finnish randomized study among top level pivoting sport athletes (Pasanen et al. 2008b), significant reductions in the risk of ankle injuries were found. Soligard and colleagues (2008) found that a comprehensive neuromuscular training program was effective in decreasing severe and overuse injuries among young soccer players. A recent study by Walden and co-workers (2012) showed that a neuromuscular warm-up program organized for 4564 adolescent female football players was effective in preventing ACL injuries (RR 0.36; 95% CI:0.15–0.85). In a Danish RCT-study among 942 male professional and amateur soccer players (Petersen et al. 2011), the number of acute hamstring injuries was significantly reduced by a 10-week progressive strengthening program of Nordic hamstring exercise, especially considering recurrent injuries (RR 0.14; 95% CI: 0.04–0.51) (Table 3).

Overall, the effects of training interventions on sports injury prevention have been studied in over 30 randomized trials (Table 3). These interventions can be divided into many subgroups considering the main method of training: balance board, multi-interventions using balance boards, multi-interventions without balance boards, warm-

up programs and strengthening. However, the most crucial points in effective interventions seems to be proper supervision, good compliance (> 75%) and proper volume of training (> 30 min per week, or multiple sessions in a week) rather than the training program category (Table 3). Our NME program focused on to enhance conscripts' movement control and agility, as well as to increase the stability of the trunk, knee, and ankle. Special attention was aimed to improve the control of the lumbar NZ and specifically to avoid full lumbar flexion in order to prevent LBP (Warming et al. 2008). Core stability as a subset of motor control (McNeill 2010) also has an important role in the prevention of lower extremity injuries (Leetun et al. 2004).

Prevention of LBP

Our study comprised a pre-planned NME and counseling intervention program to prevent LBP and disability in young men with a previously healthy back that were engaged in high level of physical activity including heavy military tasks. The target for the NME was to improve the conscripts' movement control of the lower back, and to enhance trunk muscular endurance and spine stability. Special emphasis was placed on developing patterns of squatting with control of the lumbar NZ, i.e., learning to differentiate between lumbar spine flexion and hip flexion (McGill 2002; Suni et al. 2006; Luomajoki et al. 2008). By improving the control of lumbar NZ, microdamage occurring in spinal ligaments, discs, facets, and capsules could be prevented (Solomonow et al. 2003; LaBry et al. 2004). Counseling comprised a guidebook and a 1-hour lecture aimed at improving the conscripts' awareness of potentially harmful actions or situations for low back injury and pain. These rather simple preventive actions in the intervention companies were successful in reducing the total number of off-duty days by 58% compared to control companies, indicating less severe injuries to spinal structures or altered experience of LBP and related behavior. The incidence of LBP or health clinic visits due to LBP, however, was not different between the groups.

Current evidence emphasizes a biopsychosocial approach, when considering the effects of interventions which could prevent recurrent and chronic LBP (Weiner 2008). Psychological and social factors are associated with back pain and disability, and they serve as prognostic indicators (Foster & Delitto 2011). Accordingly, studies of programs combining physical exercise with some type of education or counseling have reported small positive effects in patients with LBP (Lonn et al. 1999; Suni et al. 2006; Warming

et al. 2008). The evidence of systematic review indicated that patients with chronic LBP may benefit from exercises and return sooner to normal daily activities and work (van Tulder et al. 2000). To date, however, there are no other randomized controlled studies in which these preventive interventions would be targeted to healthy individuals.

The theoretical basis of the NME and counseling to reduce LBP through improving the control of the lumbar NZ and avoiding full lumbar flexion was the hypothesis of microdamage occurring in spinal ligaments, discs, facets, and capsules (Solomonow et al. 2003; LaBry et al. 2004; Panjabi 2006). When the microdamage exceeds a certain threshold due to high loads, many repetitions, long duration, and/or insufficient rest, acute inflammation is triggered (Le et al. 2007). This in turn elicits muscle spasms and significant changes in muscular activity and synchronization (Olson et al. 2004; Olson et al. 2006), leading to chronic LBP (Panjabi 2006).

The results indicated that conscripts in the intervention group experienced less severe injuries to spinal structures than conscripts in the control group, which led to physicians prescribing fewer off-duty days. Plausible biologic explanations for the less severe injury include the following: First, the conscripts in the intervention companies may have been more aware than controls of activities harmful to the lower back and thus more able to avoid full lumbar flexion (LaBry et al. 2004; Olson et al. 2004; Courville et al. 2005) especially in heavy tasks, such as lifting, as suggested in the guidebook. Second, NME might have improved conscripts' ability to resist compressive loading due to enhanced muscular endurance (McGill 2002) and/or co-contraction of the trunk muscles during daily tasks (Cholewicki et al. 1997; Kavcic et al. 2004). Third, the conscripts' movement control might have improved due to the NME and/or they were able to imitate (i.e., learn by observing) (van der Helden et al. 2010) the correct postures of common tasks introduced in the guidebook.

A psychosocial explanation for reduced off-duty days could be the altered experience of LBP and related behavior. Theoretically, the latter could be best explained by altered pain-related fear avoidance beliefs (Leeuw et al. 2007; Jensen et al. 2010; Linton & Shaw 2011). Pain has clear emotional and behavioral consequences that influence the development of persistent problems and treatment outcome (Linton & Shaw 2011). It is possible that the conscripts in the intervention companies were less afraid than controls or felt more competent to return to duty regardless of their experience of LBP. Avoiding loading that is harmful for the back was systematically emphasized in the guidebook in

different types of activities, and illustrated examples of how to conduct these duties in a less harmful manner were presented. Furthermore, the key elements of the skills needed to correct behaviors potentially harmful to the lower back were rehearsed in the NME program.

Only two former randomized controlled trials (Lonn et al. 1999; Suni et al. 2006) have emphasized the control of the lumbar NZ as a main goal of exercise and counseling interventions. Previous study among middle aged men with recurrent LBP, but well able to work, indicated that these types of interventions contribute to decreasing the intensity of LBP and positively improving personal expectations concerning the maintenance of future work ability (Suni et al. 2006). The findings of an earlier study (Lonn et al. 1999) of exercise and ergonomic counseling for 13 weeks indicated reduced incidence and recurrence of LBP in non-chronic working patients. The main difference between the studies is that the present study focused on primary prevention of LBP, the others on secondary prevention. In addition, the disability measures in the studies were not comparable.

Prevention of untimely medical discharge

Earlier studies of this thesis (II, III) showed that co-impairments in cardiorespiratory and muscular fitness (i.e., poor results in Cooper's test combined with a poor result in standing long jump, push-up or back lift tests) are highly associated with musculoskeletal injuries and disorders, showing a dose-response relationship. Similar findings considering poor muscle fitness and aerobic capacity (Jones & Knapik 1999; Knapik et al. 2001b; Rosendal et al. 2003; Mattila et al. 2007b) and obesity (Heir & Eide 1996; Jones & Knapik 1999) as risk factors for MSDs have been reported earlier. The most common reasons for discharge were musculoskeletal, followed by mental and behavioral disorders (Table 8). Bearing in mind the high number of discharges due to musculoskeletal reasons, it was logical that low levels of physical fitness and high WC were associated with premature discharge in a graded manner in study IV. Conscripts' tasks requiring both strength and aerobic capacity, such as loaded marching, may be further negatively affected by obesity (Santtila et al. 2006), demonstrating a situation where several components may play an important role in the aetiology of musculoskeletal injury. The results in study IV indicated that poor self-assessed health predicted discharge especially for mental health reasons. Similar findings have been

reported among Swedish conscripts (Larsson et al. 2009) and U.S. Air Force recruits (Lubin et al. 1999). Multimaki and colleagues (2005) found that mental health service use was strongly associated with medical discharge at the call-up as well. In a recent Finnish study, psychosocial problems were more prevalent among men who interrupted their service compared with those exempted from service at the call-up (Appelqvist-Schmidlechner et al. 2010). This can be explained by the fact that somatic diseases can be identified more easily than psychosocial problems at call-up. Based on the present findings, direct questions about mental and physical well-being can be used to distinguish persons with an elevated risk for discharge before the onset of military training. Moreover, mental reasons leading to discharge tend to be long-term and debilitating. Only every seventh conscript discharged due to mental reasons performs military service in a 5-year follow-up after the discharge (Parkkola 1999). These findings highlight the need for an improved identification and early intervention among these young men. Recently, a thesis representing the results of a psychosocial support program targeted at young men discharged from military service concluded that those young men need to be identified and integrated into the education process (Appelqvist-Schmidlechner 2011). Young men who do not complete compulsory military or civil service require psychosocial support in order to avoid marginalization from the society. Wider dissemination of the *Time Out! Getting Life Back on Track* support program in Finland was recommended, which would offer means to manage the problem (Appelqvist-Schmidlechner 2011).

In conclusion, the effective methods in the prevention of MSDs would probably decrease the number of untimely medical discharges while the most common reasons for discharge were musculoskeletal injuries and disorders in study IV. Moreover, physical and mental problems often overlap, leading together to premature discharge (Talcott et al. 1999; Niebuhr et al. 2006; Salo 2008). Hence, it is better to focus on overall discharge when examining the value of screening and preventive methods. As Salo (2008) identified determinants of military maladjustment leading to discharge, physical adjustment is important but not the only challenge that a conscript has to confront. Attitudinal, social and authoritarian adjustment has a vital role when predicting a conscript's military service success (Salo 2008). The majority of the observed risk factors in study IV are modifiable. The findings suggest that increased aerobic and muscular fitness is a desirable goal for pre-training programs before

entering service. Attention to appropriate WC and strategies addressing psychological well-being may strengthen the medical discharge prevention program.

Earlier Finnish studies, based on questionnaires, provide tools for predicting problems in military adjustment and discharge due to mental and adjustment disorders (Parkkola 1999; Salo 2008). Probably majority of these physical, mental and behavioral intrinsic risk factors could be identified already during school years. The sooner these problems are noticed, the easier they are modifiable. The transfer of information from school authorities to call-up boards and military authorities considering these problems should be uncomplicated. This could help to identify the young men in a need of support in time and reduce the burden of premature discharge both for the individual and the society.

Implementation of present results into practice

The NME and injury prevention counseling program presented in this thesis was effective in preventing acute ankle and upper extremity injuries as well as disability due to LBP in young male army conscripts. The program included 9 NME exercises, one session lasting 30-45 min at moderate intensity, carried out 3 times per week for the first 8 weeks of military service in addition to normal military physical training (17 hours per week mostly at low-to-moderate intensity activity). However, while the overall physical strain is high especially at the beginning of military service, additional NME may further increase the loading of musculoskeletal system especially among the conscripts with low fitness level (Tanskanen 2012). Optimally, NME program should be conducted in addition to basic military training and sufficient recovery and sleep time should be secured especially during combat field training.

NME program can be integrated to warm-up and cooling-down activities. Additionally, a warm-up program including similar elements that NME program presented in this thesis, is safe aerobic exercise, which has been shown to improve static balance and sideways jumping speed (Pasanen et al. 2009). Hence, neuromuscular warm-up exercises can be recommended to be included in the weekly training schedules in various physical activities and sports (Table 3). For the low-fit conscripts and school children, a neuromuscular training during warm-up and cooling-down offers a way to learn basic physical skills, and it is good aerobic exercise for the whole body without high load on lower extremities or low back. On the basis of the findings brought out in

current and in previous studies (Pasanen et al. 2008b; Verhagen & Bay 2010; Coppack et al. 2011; Walden et al. 2012), it seems that sufficient compliance and proper supervision are vital in effective neuromuscular prevention protocols.

6.5 Methodological considerations

6.5.1 Assessment of methodological quality

The methodological quality of the RCT-studies of this thesis can be assessed by using a criteria list proposed by van Tulder et al. (2003) and Hübschner et al. (2010) including 9 criteria 1) *Randomization method*: An independent statistician who had no information about the study subjects performed the randomization using a computer program. The unit randomization was used instead of individual randomization due to the army setting. This prevented contamination of the intervention contents between the recruits. Cluster analysis was not done due to a low number of units (4 companies). The effect of the conducted intervention would not have changed with the cluster analysis but 95% confidence intervals would have widened. However, the practical significance of the findings can be seen without the statistical cluster analysis. Moreover, due to that fact that our study outcomes (acute injuries and LBP) were not very common in the units the possible cluster effect was regarded as small. 2) *Concealed treatment allocation*: Before military entrance, assignment of conscripts to intervention and control companies was conducted by the office secretary who works outside the brigade. The secretary had not seen the conscripts, and had no information about the chosen intervention and control companies. 3) *Baseline similarity of study groups*: Regarding the most important prognostic variables for acute injuries and LBP, similarity was achieved except the variable of educational status (Table 4). However, knowledge of the incidence rates during the pre-study year for the similar companies and statistical adjustments helped to control the differences and possible selection bias. 4) *Blinding of assessors*: An independent physician in the garrison clinic defined the outcomes. The study subjects were aware of their role in intervention and control companies since placebo NME was not used in control companies 5) *Co-interventions*: Attention of the injury risk was a part of the educational program in the intervention companies, i.e. attention effect was

intentionally included in the training. There were no co-interventions in the study companies. 6) *Compliance*: Compliance with the intervention training was good (83%) and over the generally accepted level of 75%. 7) *Drop-out rate*: Drop-out rate after the randomization of the conscripts including refusal to participate (2%) and drop-out during the two-week run-in period (4%) was low and acceptable (<25%) because conscripts who dropped out from the military or changed company (21%) were included in the analyses and this was taken into account when calculating exposure times. 8) *Timing of the outcome assessment*: This was identical for all study groups and for all outcome measures. 9) *Intention-to-treat analysis*: All analyses were performed according to the intention-to-treat principle.

The VASTE Study presented in this thesis had several strengths. First, the definitions of outcomes were clear and defined by ICD-10 codes set by an independent physician in the garrison clinic. Second, the data was collected using computerized patient records in studies II-VI guaranteeing a consistent and comprehensive method for data acquisition because all patients who entered the garrison clinic were recorded in the computerized system. Third, the participation rate was high (98%). Fourth, the military environment provided highly standardized conditions for investigating the effect of individual risk factors: Conscripts underwent daily military programs that were nearly equal considering the time, intensity and quality of physical training providing equal opportunity for food supply, rest and sleep. Fifth, the design of the study was prospective. Finally, due to compulsory nature of military service in Finland, reaching annually about 80% of the age cohort entering into the service, the population-based sample of incoming conscripts formed a comprehensive sample of Finnish young male adults who had passed their medical examination performed by a physician before military entry. Moreover, there were no qualification requirements when the conscripts were allocated to study companies and the conscripts of each age-cohort were randomly assigned into the companies. Compulsory military service provided an interesting opportunity to examine how a population-based sample of young men reacts to the challenges of regular physical exercise.

The VASTE Study had also some limitations. First, the findings can only be generalized to young men because no more than 3% of the conscripts were females and they were excluded from the analyses. Second, after the initial 8 weeks of basic training, the training programs became more divergent due to the more specialized military tasks

in each company. This also caused drop-out of some participants due to a company change. On the other hand, all conscripts were followed up for the first 8 weeks of service and the results were adjusted by company. Third, because the threshold for seeking medical care may vary between individuals, some conscripts may have been more inclined to seek professional care than others. Fourth, although the compulsory military service concerns all Finnish male citizens, approximately 7% of all eligible men choose to perform non-military service in Finland and approximately 15% of conscripts are exempted from duty after physician examinations at the call-up or during the first week of military service due to minimum physical and mental requirements established for military service (Mattila et al. 2007c; Lehesjoki et al. 2010). Fifth, the method of group randomization (intervention vs. control companies) was used to avoid a contamination bias. The potential bias, therefore, is that the effect of company on the outcome measures is not fully included in the present results. Knowledge of the incidence rates of acute injuries and LBP in the pre-study year for the different companies, however, helped to control this effect.

The mandatory military service in Finland differs from a recruit army system, such as in the United States. In a conscription army, the pace and content of military training have to be carefully adjusted to the fitness level of the conscripts. In addition, length of service (180-360 days), the number of conscripts, as well as practices and training schedules differ substantially from those in the professional army. Therefore, the results presented in this study cannot be directly extrapolated to a recruit army.

6.6 Implications for further studies

The present thesis underlines the importance of MSDs as a cause of morbidity and premature discharge from military service in the Finnish Defence Forces. Given that the great majority (80%) of young men enter into the military service in Finland, the high occurrence of MSDs in this population has an impact on public health. The current findings help to recognise and identify the risk factors in order to take preventive actions to decrease the number of MSDs among conscripts. Preventive measures during military service should be targeted to decreasing LBP and lower limb injuries, which are the largest burden among MSDs with a tendency towards becoming chronic. The

current best evidence for successful secondary prevention of LBP is provided by psychosocial and cognitive-behavioral interventions, as well as exercises enhancing motor control, flexibility and muscular strength and endurance of the trunk muscles (Hayden et al. 2005; Suni et al. 2006; George et al. 2007; van Middelkoop et al. 2010). However, as the efficiency of those programs has not been well established, especially regarding primary prevention or early prevention of recurrence of LBP, more evidence is needed (van Tulder et al. 2006; George et al. 2007; van Middelkoop et al. 2010). For the prevention of acute lower limb injuries, several practical neuromuscular training strategies are shown to be effective (Table 3). More research is needed to identify the effective methods to prevent lower limb overuse injuries. Overall, the most beneficial neuromuscular warm-up strategy components and the mechanisms behind their effectiveness should be identified in order to decrease the risk for injuries. Future studies should also evaluate potential underlying dose-response relationships in more detail, because the training frequency and duration of the NME programs vary largely between the studies (Table 3). In addition, the generalizability and implementation of the efficient programs to other sports, gender and age groups are unclear and more research is needed before implementation of the present results outside from military.

Results brought out in this study are valuable not only for military personnel but also for policymakers who, for instance, decide the volume of physical exercise organized in schools and distribute economical support for health enhancing physical activities and sports federations. Remembering the fact that 80% of young men in Finland enter military service, the present findings have also an impact outside the military environment, among young men who engage in sports and physical exercise. For investigators, the results represented in this study provide a wide view to the intrinsic and modifiable risk factors for MSDs and medical discharge. However, knowledge of injury rates and risk factors provided by research are of limited value unless they are implemented with effective intervention programs. Randomized clinical intervention studies provide essential information on preventive measures and their efficacy, and these studies should precede large scale prevention programs. The critical point is, however, that RCTs often lack generalizability, because intervention efficacy is investigated in well-controlled experimental circumstances and effectiveness is usually lower in routine circumstances (Croft et al. 2011).

Jones & Knapik (1999) suggested over a decade ago that in order to decrease injuries in the U.S. Army, injury control requires five major steps: (1) surveillance to determine the size of the injury problem; (2) studies to determine causes and risk factors for these injuries; (3) studies to ascertain whether proposed interventions actually reduce injuries; (4) implementation of effective interventions; and (5) monitoring to see whether interventions retain their effectiveness. This thesis brings answers to the first three items. Overall, surveillance systems considering causes behind the diagnoses of outpatient clinic visits due to musculoskeletal injuries are sparse, and more research focusing on the specific causes is needed (Ruscio et al. 2010). Local and nationwide surveillance of the injury data is crucial and the provided information should be delivered to young men at the call-up and to conscripts especially at the beginning of the service. The information should also be given to military educators and supervisors of the companies to enable them to perceive immediately the changes in injury occurrence and to react to those changes. This could alert commanders when levels of injuries are elevated (Grier et al. 2011). Further, policymakers should be informed, so that they could see the size of the problem and to make the right decisions.

Well-planned randomized controlled studies are needed to provide more evidence from effective interventions on the prevention of overuse injuries in military environment. For example, studies investigating the effect of physical training program in good time before entry into the compulsory military service are needed. The effect of the intervention program should be tested among those who are at the highest risk for MSDs. According to this thesis, the young men with high risk for problems during military service can be identified before entry into the military by using a questionnaire. Data of individual body characteristics including WC and BMI, in addition to physical fitness test results measured in schools according to standard test protocol, would help to identify those with the highest risk for problems. These young men would probably benefit from tailored physical training programs targeted to enhance aerobic and muscular fitness gradually. The specific finding that poor self-assessed health was especially associated with discharges due to mental reasons highlights the need for improved identification and early intervention. The last stage to easily contact an entire age cohort of young males in Finland is at the time of military call-up at 18 years of age.

7. CONCLUSIONS

Recalling the aims of the present study, the following conclusions can be drawn:

1. The incidence rate of MSDs is high during compulsory military training, especially during combat training, marching and running. Finnish conscripts have a great risk for lower extremity injuries and LBP, and a majority of these MSDs are overuse-related. Fractures, bone stress injuries, dislocations and internal knee injuries represented the most severe injuries accounting long-term exemptions from military training. (I, II)

2. Low cardiorespiratory fitness level in a 12-minute running test at entry into the military service is strongly associated with MSDs in a dose-response manner. Moreover, co-impairments in cardiorespiratory and muscular fitness (i.e., poor results in Cooper's test combined with a poor result in standing long jump, push-up or back lift tests) are the strongest predictors for MSDs. In addition, abdominal obesity, earlier musculoskeletal symptoms and poor school success are clearly associated with MSDs during military training. (II)

3. The risk for LBP during military training is clearly raised among conscripts with low educational level and poor physical fitness level in both muscular and aerobic performance. (III)

4. Musculoskeletal, mental and behavioral disorders are the main reasons for medical discharge from military. Low levels of physical fitness assessed with a 12-min running test, poor school success, and not belonging to a sports club are clearly associated with medical discharge in a graded manner. Poor self-assessed health is strongly associated with discharges due to mental health reasons. These findings highlight the need for an improved pre-enlistment examination. (IV)

5. The neuromuscular exercise program and education to improve conscripts' motor and muscular performance were effective in preventing acute ankle and upper-extremity

injuries in the military environment when implemented as a part of the military service. (V)

6. The neuromuscular exercises and education to enhance conscripts' muscular and motor performance with special attention to the control of the lumbar neutral zone (NZ) were effective in preventing absenteeism due to LBP in the military environment when implemented as a part of the military service. (VI)

7. To distinguish young men at increased risk for MSDs and medical discharge during military service, we suggest screening of all 9th grade students for low fitness in dual combinations of aerobic and dynamic trunk muscle endurance tests, that is, sit-up, push-up, back lift, and 12-minute running test. The present findings suggest that a desirable goal in a pre-training program before entering the military service is a running distance of 2600 m or more in the 12-min running test. Because the study population was a representative sample of the young males in Finland, these results have also public health implications. Neuromuscular training including balance and coordination exercises that enhance proprioceptive sensation may reduce the burden of injuries and LBP in sports clubs, in leisure time activities, as well as in school sport lessons. Neuromuscular exercises can be easily integrated to traditional warm-up or cool-down exercises. (II-VI)

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Tampere, on a sunny morning in November 2012

Henri Taanila

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VARUSMIESTEN TUKI- JA LIIKUNTAELINVAIVOJEN JA TAPATURMIEN EHKÄISYTUTKIMUS
Vammalomake 2006 - 2007

Vammalomake täytetään kaikista terveydenhuollon ammattilaisen vastaanotolle tulleista selkävaivoista sekä muista tuki- ja liikuntaelimistön äkillisistä ja rasitusvammoista.

Nimi:…… Syntymäaika: ……

Loukkaantumispäivämäärä: …… Matkapuhelin: ……

Yksikkö: ……..

Vastaa A tai B: A. Kuulun miehistöön ☐ B. Olen saanut johtajakoulutuksen ☐

1. Missä tapaturma tai vamma tapahtui? Ympyröi sopivin vaihtoehto.

1. Varusmiespalveluksen aikana
2. Loman aikana
3. Matkalla lomalle tai varuskuntaan

2. Mikäli vamma syntyi varusmiespalveluksen aikana, tapahtuiko se

0. Vamma ei tullut varusmiespalveluksen aikana
1. taistelukoulutuksessa ilman taisteluvarustusta
2. taistelukoulutuksessa taisteluvarustuksessa
3. sulkeisharjoituksessa
4. kävely- tai pyörämarssin aikana
5 liikuntakoulutuksessa, missä lajissa? esim. salibandy, hiihto ……..
6. muussa tilanteessa, missä? .....

3. Mikäli vamma tapahtui loman aikana, tapahtuiko se

1. kotona
2. liikunnan aikana
3. muussa vapaa-ajan toiminnassa

4. Mikä tai mitkä kehon osat loukkaantuivat? Ympyröi yksi tai useampia kohtia.

1. päälaki / takaraivo / ohimo
2. kasvot
3. silmä
4. hampaat
5. kaula / niska
6. hartia
7. kylki / rintakehä
8. vatsa
9. selkä
10. pakara
11. nivunen
12. reisi
13. polvi
14. sääri
15. nilkka
16. jalkaterä
17. kantapää
18. varpaat
19. olkapää
20. olkavarsi
21. kyynärpää
22. kyynärvarsi
23. ranne
24. kämmen
25. sormet
26. muu kehon osa, mikä?
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5. Millainen oli syntynyt vamma? Ympyröi yksi tai useampia kohtia.

1. alaselkävaiva, jossa kipu on paikallisesti alaselässä
2. alaselkävaiva, jossa kipu säteilee ympäristöön, mutta jossa kipusäteily jää jaloissa polven yläpuolelle
3. alaselkävaiva, jossa kipu säteilee polven alapuolelle sääreen tai jalkaterään saakka
4. selkävaiva muualla kuin alaselässä
5. hankauma tai rakko
6. palovamma tai paleltuma
7. venähdys tai nyrjähdys
8. ruhje tai kolhaisu (mustelma)
9. haava
10. nivelsiderepeämä
11. polven sisäinen ristisiderepeämä
12. polven kierukkavamma
13. olkapään kiertäjäkalvosimen repeämä
14. jännerepeämä tai –irtoama
15. lihasrevähdys, lihaskramppi
16. luun sijoiltaan meno nivelessä
17. luunmurtuma
18. kallon sisäinen vamma
19. silmävamma
20. hammasvamma
21. jänteen kiinnittymiskohdan tulehdus
22. jännetulehdus / jännetupentulehdus
23. limapussintulehdus
24. muu, mikä? .....

6. Oliko kyseessä

1. uusi vamma
2. vanhan vamman / vaivan uusiutuminen

7. Oliko kyseessä

1. äkillinen vamma (tapaturma)
2. rasitusvamma (kipu kehittyi vähitellen)

8. Aiheuttiko loukkaantumisen <u>pääasiassa</u> jokin <u>omasta toiminnastasi</u> johtunut <u>vai</u> siitä riippumaton <u>ulkopuolinen syy</u>?

1. itsestä johtuva syy
2. ulkopuolinen syy
3. molemmat yhdessä

9. Mikä oli loukkaantumisen <u>ensisijainen aiheuttaja</u>? Ympyröi sopivin vaihtoehto.

1. sääolosuhteet (kuumuus, kylmyys)
2. valon vähyys
3. epätasainen maasto
4. kompastuminen esteeseen
5. kompastuminen omiin jalkoihin
6. liukastuminen, liukas alusta
7. liukastuminen, liukas jalkine
8. putoaminen (kaivanto, kuoppa..)
9. putoaminen (portaat, tikkaat, telineet ..)
10. törmäys toiseen henkilöön
11. törmäys esineeseen
12. nykäisy
13. hyppääminen
14. raskaan taakan nostaminen (esim. telamiina, reppu)
15. kevyen taakan nostaminen (esim. kivääri, kevyt laatikko)
16. kaluston käsittely (esim. aseen huolto)
17. kaivaminen
18. äkillinen liike tai kuormittuminen

19. työkalu, kone tai laite
20. puutteellinen vaatetus
21. viallinen varustus
22. suoritustekniikkavirhe
23. kuntotestaustilanne
24. uusi liike
25. kamppailutilanne
26. tahallinen väkivalta
27. alku- tai loppuverryttelyn puute
28. vammakohdan ylirasitus (rasitusvamma)
29. pitkään samassa asennossa oleminen
30. yleinen väsymys
31. vammakohdan heikkous tai vanha vamma
32. muu syy, mikä?
    ……
    ……

10. Missä vammaa hoidettiin? (yksi tai useampi vaihtoehto)

1. hoidin itse, sinnittelin vaivan kanssa puhumatta muille
2. hoidin itse, keskustelin vaivasta muiden kanssa
3. varuskunnan kuntotalolla fysioterapeutin toimesta
4. varuskunnan terveysasemalla lääkärin vastaanotolla
5. varuskunnan terveysasemalla muun kuin lääkärin toimesta
6. kotona
7. terveyskeskuksessa
8. yksityislääkärillä
9. sairaalassa
10. muualla, missä? …….....

11. Estikö tai haittasiko vamma varusmiespalvelukseen osallistumisen joksikin aikaa?

1. kyllä, sain VMTL:ää, montako päivää? …….
2. kyllä, sain VP:tä, montako päivää? …….
3. kyllä, muu palveluhelpotus, mikä ja montako päivää? …….
4. ei estänyt

12. Estikö vamma liikunnan harrastamisen joksikin aikaa?

1. kyllä, montako päivää? …….
2. ei, mutta haittasi liikkumista, montako päivää? ……..
3. ei estänyt

13. Jääkö vammasta pysyvää haittaa?

1. kyllä
2. ei
3. en osaa sanoa

14. Lääkärin tekemä vamman <u>diagnoosi</u> (rtg-MRI löydökset ym.):

……
……

Täytä vammalomake välittömästi loukkaantumisesi jälkeen ja palauta se varuskunnan terveydenhoitohenkilökunnalle. Vastaukset 10.-14. täydennetään tarvittaessa myöhemmin.

Kiitos, kun olet mukana kehittämässä varusmiespalveluksen turvallisuutta!

TULTA
liikuntaohjelma
tulevaisuuden taistelukuntoon

VASTE | VARUSMIESTEN SELKÄVAIVOJEN JA TAPATURMIEN EHKÄISYTUTKIMUS

Hyvä varusmies!

TULTA-liikuntaohjelman tärkeä tavoite on opettaa sinua hallitsemaan lannerankasi asento ns. neutraalialueella erilaisissa nostotehtävissä ja muissa selälle hankalissa asennoissa.

Hyvä asennon hallinta turvallisella nautraalialueella ehkäisee selkävammoja ja -kipua. Se on myös tehokas keino ehkäistä aiemman selkäkivun uusiutuminen.

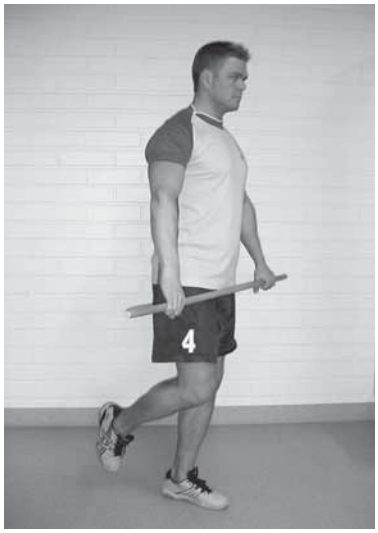
Lihasväsymys heikentää asennon ja liikkeiden hallintaa, minkä vuoksi ohjelmassa harjoitetaan myös vartalonlihasten kestävyyttä.

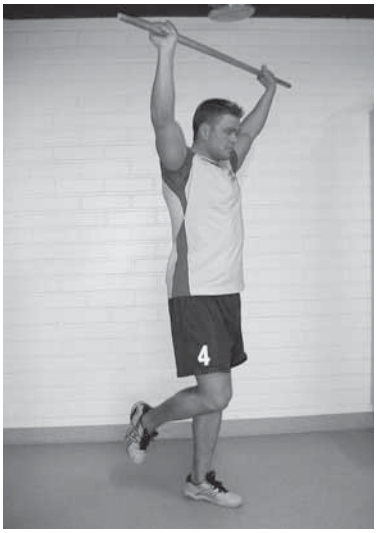
Liikuntaohjelma kehittää myös ketteryyttä ja reiden takaosan lihasten eksentristä eli jarruttavaa lihasvoimaa. Hyvä lihaskunto ehkäisee erityisesti alaselän, polven ja nilkan vammoja.

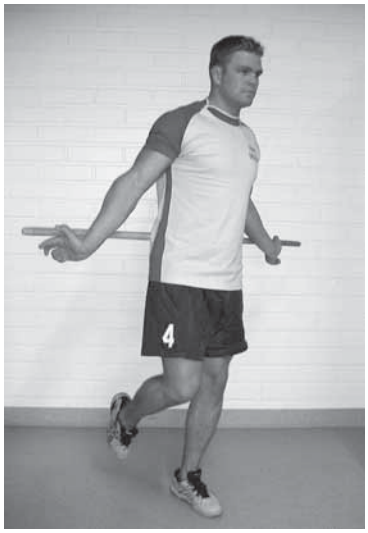
Harjoitusohjelman sisällön ovat suunnitelleet UKK-instituutin erikoistutkija Jaana Suni, tutkija Marjo Rinne ja ylilääkäri Jari Parkkari.

1. Tasapainoharjoitus yhdellä jalalla

- Seiso lattialla yhdellä jalalla, ota leveä ote kepistä, keppi vartalon edessä.
- Nosta kädet ylös ja vie keppi kyynärpäitä koukistaen niskan taakse lapojen tasolle. Pidä niska pitkänä ja vedä lapoja yhteen.
- Jatka käsien liikettä alaspäin lähellä selkärankaa, käännä kyynärvarsia ulospäin.
- Toista liikettä yhteensä 20 kertaa, vaihda tukijalkaa 10 toiston jälkeen.





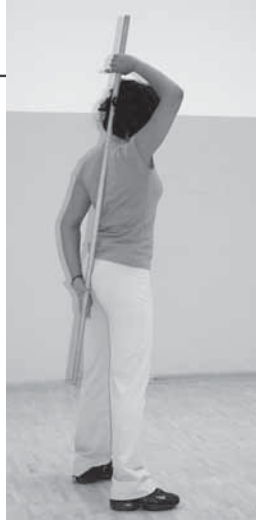


Harjoitus kehittää tasapainoa ja koordinaatiota sekä parantaa hartianseudun liikkuvuutta.

Maastossa liikkumiseen tarvitaan hyvää tasapainoa. Miten sinulta onnistuu kävely lankkua pitkin?

Nilkka, polvi ja selkävammojen jälkeen on tarpeen harjoittaa tasapainoa, sillä kipu heikentää nivelten asennon hallintaa.

2. Kyykistykset kepillä



- Seiso leveässä haara-asennossa. Pidä keppi selän takana pystyssä niin, että se on kiinni takaraivossa, lapojen välissä ja ristiluussa. Käsien ote on kepistä takaraivon yläpuolelta (oikea) ja ristiluun alapuolelta (vasen).
- Aloita liike koukistamalla lonkkia, jolloin vartalo kallistuu suorana eteen. Koukista sen jälkeen sekä lonkkia että polvia kunnes polvikulmaksi tulee noin 90 astetta. Pidä polvet ja varpaat samassa linjassa. Nouse ylös.
- Säilytä alaselän asento koko liikkeen ajan turvallisella neutraalialueella. Jos keppi pysyy koko kyykistyksen ajan kiinni ristiluussa, olet onnistunut kyykistymään alaselkä neutraaliasennossa.
- Tee 16 toistoa, vaihda käsien asento päinvastaiseksi (vasen ylhäällä) 8 toiston jälkeen.

Jatka liikettä yhdellä jalalla:

- Vaihda käsien asento päinvastaiseksi (oikea ylhäällä)
- Kallista vartalo eteen ja kyykisty oikealla jalalla, ojenna samanaikaisesti vasen jalka suoraksi taakse.
- Toista liike 8 kertaa.
- Vaihda käsien asento päinvastaiseksi ja tee 8 kyykistystä vasemmalla jalalla.
- Harjoitus vaikeutuu, jos teet sen pehmeällä alustalla.

Harjoitukset kehittävät alaselän neutraalialueen hallintaa, parantavat tasapainoa ja alaraajojen ojennusvoimaa.

Säilytä alaselän asento turvallisella neutraalialueella kaikissa raskaissa nostoissa ja muissa selälle hankalissa asennoissa.

Tee arkielämässä kaikki kevyet nostot yhdellä jalalla, säästät selkääsi!

3. Siltanosto kyljellä

- Asetu matolle oikealle kyljelle kyynärnojaan polvet koukussa.
- Nosta kylki irti lattiasta, työnnä lantio eteen ja ojenna lonkat suoraksi vartalon suuntaisesti.
- Pysy nostoasennossa 5 sekuntia, laskeudu alas.
- Toista siltanosto 5 kertaa.
- Tee sama liike 5 kertaa vasemmalla kyljellä.

Jatka harjoitusta seuraavasti:

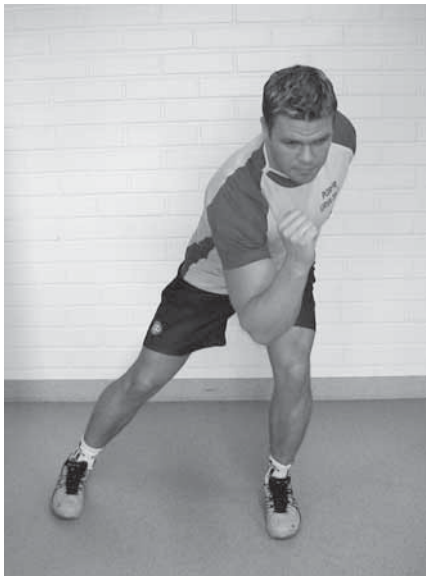
- Asetu matolle oikealle kyljelle kyynärnojaan polvet suorina, jolloin jalkaterät tukevat liikettä. Aseta päällimmäisen jalan jalkaterä alemman etupuolelle.
- Nosta kylki irti lattiasta ja pysy asennossa 5 sekuntia.
- Kierry sen jälkeen vatsamakuulle päin molempien kyynärvarsien varaan punnerrusasentoon ja pysy asennossa 5 sekuntia.
- Kierry tämän jälkeen vasemmalle kyljelle kyynärnojaan siltanostoasentoon, pysy asennossa 5 sekuntia ja laskeudu alas.
- Olet nyt tehnyt yhden liikkeen, toista se vielä 5 kertaa.

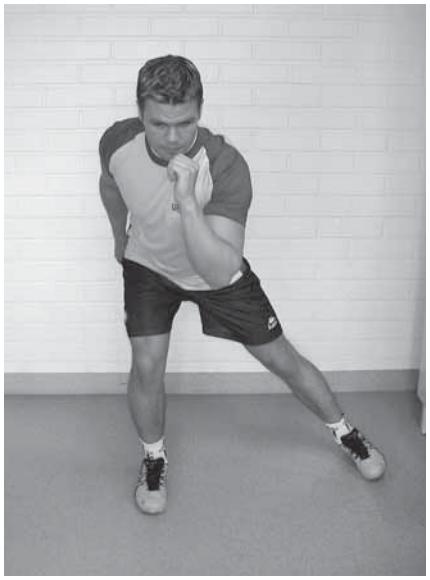
Harjoitus parantaa vartalonlihasten kykyä tukea selkärankaa ja harjoittaa erityisesti kylkilihaksia.

Hyvä vartalonlihasten ”tukikorsetti” suojaa selkävammoilta ja on edellytys kaikille raskaille ja taitoa vaativille suorituksille.

4. Luisteluhyppely

- Seiso kapeassa haara-asennossa, polvet lievästi koukussa.
- Kallista vartaloa eteenpäin lonkista, pidä selkä suorana.
- Vie oikea jalka pitkälle sivulle, vedä se takaisin vasemman jalan viereen ja ”heilauta” samanaikaisesti vasen jalka sivulle.
- Vedä vasen jalka takaisin oikean viereen ja heilauta samanaikaisesti oikea jalka sivulle.
- Rytmitä liike tekemällä 4 hidasta hyppyä + 8 nopeaa hyppyä vuorotelle.
- Yhdistä pikajuoksijan käsiliike hyppelyrytmiin: Vie sivulla olevan jalan puoleinen kyynärpää kohti vastakkaista polvea.
- Kiinnitä huomiota keskivartalon asentoon, pidä napa koko ajan suoraan eteenpäin.
- Jatka hyppelyä jalalta toiselle 1 minuutin ajan.





Harjoitus kehittää alaselän asennon hallintaa, koordinaatiota ja ketteryyttä sekä alaraajojen ojentajalihasten kestävyysvoimaa.

Varusmiestehtävissä tarvitset koordinaatiota sulkeisharjoituksissa, maastossa ja hiihtäessä. Näistä taidoista on iloa myös mm. laskettelurinteessä ja tanssilattialla.

5. Muunneltu punnerrus

- Asetu vatsalleen matolle ja aseta kämmenet matolle hartiatasoon lähelle vartaloa.
- Jalat ovat haara-asennossa (noin lantion leveys), varpaat tukevasti matolla.
- Lyö kämmenet yhteen selän takana ja tuo ne takaisin lattiaan hartiatasoon. (Voit lyödä kädet myös reisien sivulle, jos kädet eivät yllä selän taakse.)

- Punnerra itsesi ylös, niin että kädet ojentuvat, pidä vartalo mahdollisimman suorana (lantio ja polvet irtoavat yhtä aikaa lattiasta).

- Kosketa tässä yläasennossa **oikealla kädellä vasenta kämmenselkää**, palaa takaisin punnerrusasentoon ja laskeudu matolle.
- Aloita uusi punnerrus lyömällä kämmenet yhteen selän takana. Kosketa punnerrusasennossa **vasemmalla kädellä oikeaa kämmenselkää**.
- Toista punnerruksia 1 minuutin ajan niin nopeasti kuin jaksat.

Harjoitus parantaa yläraajojen ojentajalihasten voima-kestävyyttä sekä vartalonlihasten kykyä tukea ja hallita selkää.

Jos selviät hyvin tästä haastavasta harjoituksesta on toimintakykysi myös sotilaana hyvä!

6. Lonkan koukistajalihasten venytys

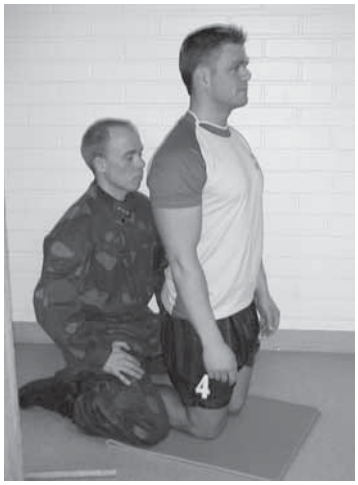
- Seiso matolla leveässä käyntiasennossa vasen jalka edessä, oikea takana.
- Ota oikealla kädellä tukeva ote kepin yläpäästä ja aseta se pysty-asentoon lattialle vasemman jalkaterän tasolle.
- Aloita liike koukistamalla taaemman jalan polvea koukkuun ja laskeudu rauhallisesti alaspäin kohti lattiaa koukistaen molempia polvia.
- Kierrä samalla oikeaa lantion puoliskoa kohti vasenta polvea ja taivuta vartaloa hieman vasemmalle.
- Pidä paino enemmän etummaisella jalalla.
- Tunne venytys oikean lonkan etupuolella ja reisilihaksessa. Myös oikea kylki venyy.
- Pysy asennossa n. 10 sekuntia, nouse seisoma-asentoon.
- Toista venytys yhteensä 5 kertaa.
- Harjoitus venyttää lonkkaa koukistavia lihaksia ja kylkiä. Kireät lonkankoukistajalihakset voivat aiheuttaa puristuksen tunnetta alaselässä.

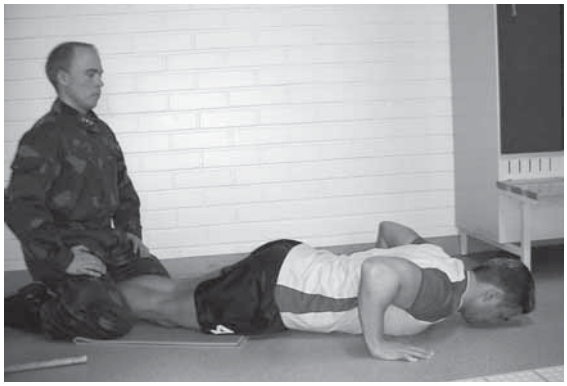
Riittävä venyvyys lonkkanivelissä ja lonkan koukistajalihaksissa on edellytys selän hyvälle hallinnalle monissa varusmiestehtävissä ja arkitoimissa.

Jatkuva istuminen lisää lonkan koukistajalihasten kireyttä!

7. Takareisien harjoitus polviseisonnassa

- Harjoitus tehdään parin kanssa, joka tukee harjoittelevaa henkilöä nilkoista.
- Asetu polviseisontaan matolle.
- Nosta kädet kyynärpäistä koukkuun, kämmenet eteenpäin.
- Lähde rauhallisesti kallistamaan koko kehoa suorana alaspäin kohti lattiaa.
- Hidasta liikettä jännittämällä takareisien ja pakaroiden lihaksia.
- Ota käsillä lattiasta vastaan, kun et enää pysy hidastamaan liikettä. Molemmat kämmenet koskettavat lattiaa.
- Punnerra itsesi nopeasti ja molemmin käsin takaisin lähtöasentoon.
- Pyri pitämään vartalo hallitusti suorana myös paluuvaiheessa.
- Toista liike 8–12 kertaa.
- Vaihda osia parisi kanssa, sinä tuet nilkoista ja hän tekee liikkeen.





Harjoitus kehittää takareiden lihasten kykyä tehdä jarruttavaa lihastyötä. Hyvän takareiden lihaskunnon on todettu vähentävän polven vammautumisen vaaraa monen eri lajin urheilijoilla.

Varusmiehille sattuu runsaasti polvivammoja. Tällä harjoituksella pyritään ehkäisemään erityisesti näitä vammoja.

8. Reiden takaosanlihasten venytys

- Käytä tässä seisten tehtävässä venytyksessä keppiä apuna harjoituksessa kuten kyykistysliikkeissä (liike 5). Varmistat sillä alaselän asennon säilymisen turvallisella neutraalialueella ja tehokkaan venytyksen.
- Astu seisoma-asennosta oikealla jalalla pitkä askel eteen. Siirrä paino takimmaiselle jalalle ja nosta oikea jalka lepäämään kantapään varaan.
- Pidä venytettävän jalan polvi koko venytyksen ajan pienessä koukussa ja vedä samalla nilkkaa koukkuun.
- Suurin osa painosta on takimmaisella tukijalalla, jonka polvi on hieman koukistuneena.
- Aloita venytys koukistamalla takimmaista polvea lisää. Kallista samalla vartaloa lonkista eteenpäin, säilytä alaselän neutraaliasento.
- Tunnet venytyksen reiden takaosan- ja pohkeen lihaksissa. Varmista kepin avulla, ettei alaselkä pyöristy (keppi ei saa irrota ristiluusta).
- Pysy venytysasennossa noin 20 sekuntia.
- Vaihda käsien asento kepissä ja tee sama venytys oikealla jalalla.
- Toista venytys molemmilla jaloilla vuorotellen yhteensä 3 kertaa.

Harjoitus lisää takareiden lihasten venyvyyttä. Hyvä venyvyys vähentää takareiden lihasten revähtämisen varaa monissa urheilulajeissa (esim. jalkapallo, pikajuoksu). Se tekee myös alaselän asennon säilyttämisen neutraalialueella helpommaksi.

Hyvä takareiden venyvyys helpottaa arkielämässä mm. kengännauhojen sitomista.

9. Loppuvenytys kylkimakuulla

- Asetu selin makuulle ja vedä oikea polvi koukkuun.
- Käänny vasemmalle kyljelle ja ojenna suorana olevaa vasenta jalkaa koko liikkeen ajan kevyesti taaksepäin.
- Vedä koukussa oleva oikea polvi vasemmalla kädellä mahdollisimman lähelle rintakehää. Olet nyt venytyksen alkuasennossa.
- Kierrä tämän jälkeen ylävartaloa oikealla taakse ja vie samalla oikea käsi suorana taakse kohti lattiaa.
- Tunnet venytyksen oikeassa rintalihaksessa ja kyljessä.
- Tehosta venytystä hengittämällä voimakkaasti sisään venytyksen ääriasennossa.
- Tarkkaile, että ojennat vasenta jalkaa hieman koko ajan, jotta alaselän neutraaliasento säilyy.
- Pysy venytysasennossa noin 1 minuutti.
- Toista liike oikealla kyljellä.

Harjoitus parantaa rintarangan liikkuvuutta kiertosuunnassa. Hyvä liikkuvuus vähentää alaselän vammautumisen vaaraa tilanteissa, joihin sisältyy voimakasta vartalon kiertoa (esim. golf, pesäpallo, tennis).

Arkielämässä lapiointi, haravointi, lumen luonti, sahaus ym. sujuvat helpommin ja selkäystävällisemmin, kun rintarangassa on hyvä liikkuvuus.

TULTA-lihaskuntoharjoituspäiväkirja, viikot 1–8

ID-tunnus: _____

	1. harjoitus	2. harjoitus	3. harjoitus	tarkistus (pv)
1. – 2. viikko	◯	◯	◯	_____
3. viikko	◯	◯	◯	_____
4. viikko	◯	◯	◯	_____
5. viikko	◯	◯	◯	_____
6. viikko	◯	◯	◯	_____
7. viikko	◯	◯	◯	_____
8. viikko	◯	◯	◯	_____

TULTA-lihaskuntoharjoituspäiväkirja, viikot 9–16

ID-tunnus: _____

	1. harjoitus	2. harjoitus	3. harjoitus	tarkistus (pv)
9. viikko	◯	◯	◯	_____
10. viikko	◯	◯	◯	_____
11. viikko	◯	◯	◯	_____
12. viikko	◯	◯	◯	_____
13. viikko	◯	◯	◯	_____
14. viikko	◯	◯	◯	_____
15. viikko	◯	◯	◯	_____
16. viikko	◯	◯	◯	_____

UKK-instituutti

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selkävammojen ja tapaturmien ehkäisyyn

VASTE | VARUSMIESTEN SELKÄVAIVOJEN JA TAPATURMIEN EHKÄISYHANKE

TIEDOSTAMALLA VAARAN PAIKAT VÄLTÄT ISON OSAN VAMMOISTA JA TAPATURMISTA.

•

HYVÄ SELÄN HALLINTA JA FYYSINEN KUNTO EHKÄISEVÄT PARHAITEN SELKÄKIPUJA JA VAMMOJA.

•

VINKIT ALASELÄN HALLINNASTA TURVAAVAT SELKÄSI HYVINVOINNIN ARKIELÄMÄSSÄ MYÖS VARUSMIESPALVELUKSEN JÄLKEEN.

•

HOIDA VAMMAT HUOLELLA KUNTOON, JOTTA NE EIVÄT UUSIUTUISI.

Oppaan julkaisija: UKK-instituutti
Tekijät: erikoistutkija Jaana Suni, TtT, dosentti ja ylilääkäri Jari Parkkari, LT, dosentti
Kuvat: Anu Mylläri, Eija Savolainen ja Juha Viljanen
Taitto: Tuula Äyräväinen

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Hyvä varusmies!

Puolustusvoimat haluaa kehittää varusmieskoulutustaan, niin että se tukee mahdollisimman monen varusmiehen palveluksesta suoriutumista ja edistää suomalaisten nuorten miesten terveyttä myös tulevaisuudessa.

Puolustusvoimat on huolissaan varusmiesten lisääntyneistä selkävaivoista sekä tuki- ja liikuntaelimistöön kohdistuvista vammoista ja tapaturmista. Myös varusmiesten fyysinen kunto on heikentynyt ja ylipainoisuus lisääntynyt.

VASTE-hanke on osa Liikuntavammojen valtakunnallista ehkäisyohjelma (LiVE), jota koordinoi UKK-instituutti.

VASTE-hankkeen tavoitteena on

- vähentää varusmiesten selkävaivoja ja niistä aiheutuvaa palvelukelpoisuuden alenemista.
- vähentää tapaturmia, erityisesti nilkka-, polvi- ja yläraajavammoja.
- parantaa varusmiesten hyvinvointia palvelusaikana.

Tämän oppaan avulla opit tiedostamaan vaaranpaikat varusmiespalveluksen aikana ja opit tehokkaat tavat torjua selkävaivat ja tapaturmat.

Tampereella 1.11.2011
Jari Parkkari, ylilääkäri
UKK-instituutti

Sisältö

Tiedosta vaaranpaikat, vältyt monelta vammalta!

MUISTILISTA

varusmiespalveluksen aikaisista tilanteista, joissa vammariski on korkea.

- Raskaiden taakkojen nostelu, esim. kalustoa autoon kuormattaessa, lisää alaselän vammariskiä.
- Raskaiden töiden tekeminen, kuten kaivaminen ja puiden sahaaminen alaselkä huonossa asennossa, lisää alaselän vammariskiä.
- Alaselän liiallinen pyöristyminen kevyissäkin toimissa, kuten sängyn petaus vuoteen yli kurottautumalla tai aseen huolto etukumarassa, lisää alaselän vammariskiä.
- Epätasaisessa maastossa liikkuminen lisää nilkan, polven ja alaselän tapaturmia.
- Huonossa valaistuksessa tai liukkaalla alustalla liikkuminen lisää kaatumisen ja tätä kautta ruhje- ja nyrjähdysvammojen sekä murtumien riskiä.
- Raju kilpaileminen ja törmäystilanteet liikuntaharjoituksissa lisäävät tapaturmariskiä.

Miksi selkä kipeytyy?

Selkä kestää hyvin suurtakin kuormitusta, kun vartaloa tuetaan tehokkaasti lihaksilla. Vahvat lihakset yksinään eivät kuitenkaan estä selkävammojen ja kivun syntymistä, tarvitaan myös taitoa selän asentojen ja liikkeiden hyvään hallintaan.

Selkäkivun aiheuttaa liiallinen tai toistuva vahingollinen kuormitus, minkä seurauksena kudokset ylikuormittuvat ja niihin syntyy vaurio. Vauriota seuraa nopeasti selkäkipu, johon monesti liittyy voimakas lihasten jännitystila, kuten noidannuoli.

Kipu on seurausta kudosten vauriosta, joka on syntynyt esimerkiksi nostotilanteessa. Kipu aiheuttaa vaikeuksia liikkeiden hallinnassa.

Kipu voi pitkittyessään aiheuttaa kierteen, joka hankaloittaa jokapäiväistä elämää.

Selkävaivoja potenut tietää, että monet päivittäiset toimet pitää opetella tekemään uudella, selälle sopivalla tavalla.

Hyvä lihaskunto ja alaselän hallinta ehkäisevät vammoja ja selkäkipua.

Vartalon lihakset ovat tärkeitä selän tukemisessa. Paras tukevuus eli stabiliteetti selässä saavutetaan, kun kaikki selkärankaa eri puolilta tukevat lihakset supistuvat yhtäaikaisesti.

Kun lanneranka on turvallisella neutraalialueella, sen asento on samanlainen kuin luonnollisessa seisoma-asennossa. Tällöin lanneranka ei ole kokonaan pyöristynyt tai ojentunut ja selässä on pieni notko. Selän hyvää asentoa voidaan harjoitella kepin avulla (kuva). Kepin tulee eteen kumartuessa pysyä kiinni pakarassa, yläselässä sekä takaraivossa.

Jos alaselkä pääsee voimakkaasti pyöristymään, selän syvät ojentajalihakset eivät tue lannerankaa ja vamma-alttius lisääntyy.

Opettele selkäystävälliset työskentelytavat varusmiestehtävissä.

Osa palvelustehtävistä on selän kannalta hankalia, koska selän tukevuuden ja lannerangan turvallisen asennon hallinta on niissä vaikeaa.

Noudata tässä oppaassa annettuja neuvoja kaikissa mahdollisissa tehtävissä. Selän säästäminen kannattaa aina!

Oikea nostotekniikka on tärkeä!

Nostettaessa tavaroita lattialta vartaloa tulee **kallistaa** aina **lonkista** eteen alaselkä suorana, jolloin

- alaselän asento säilyy turvallisella neutraalialueella
- kallistus tehostaa selän lihasten supistumista
- selän tukevuus paranee.

Ei näin

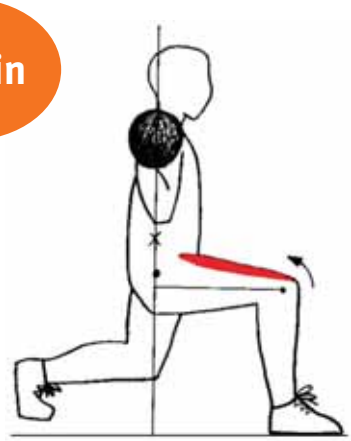
Oikein

Älä nosta jalkaterät rinnakkain vaan käyntiasennossa.

Näin nostettaessa on helpompi säilyttää alaselän turvallinen asento – kokeile itse niin huomaat!

Vältä kyykistelyä pystysuoralla selällä.

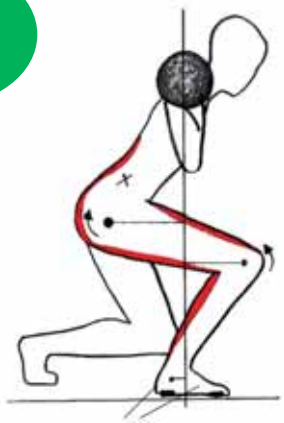
Ei näin



Alaselkä pyöristyy
- → alaselän lihaksisto ei aktivoidu
- → selän tukevuus on huono.

Opettele oikea kyykistystekniikka.

Oikein



Vartalo kallistuu lonkista eteen alaselkä suorana
- → alaselän lihakset aktivoituvat
- → alaselän asento säilyy turvallisella neutraalialueella
- → selän tukevuus on hyvä.

Tee raskaat nostot yhdessä kaverin kanssa. Suunnittele nostaminen etukäteen.

Tee kaikki kevyet nostot yhdellä jalalla seisten. Näin vältät automaattisesti vahingollisen alaselän pyöristymisen ja kiertoliikkeen.

Tarkista selkäsi asento lapioinnissa, sahauksessa, teltan pystytyksessä ym.

- Polviseisonnassa tai käyntiasennossa (jalat peräkkäin, ei rinnakkain) on helppo säilyttää alaselän asento turvallisella neutraalialueella.
- Kokeile ja huomaa.

Huomaa jalkojen ja selän oikea asento lapioitaessa.

Tarkista pyöräilyasentosi.

- Jos pyörän sarvet ovat liian alhaalla, alaselkä pyöristyy helposti taaksepäin.
- Jos satula on kallellaan taaksepäin, alaselkä pyöristyy väkisin taaksepäin.

Satulan kallistaminen edestä alaspäin estää tehokkaasti alaselän liiallisen pyöristymisen.

Selkä kipeytyy herkimmin aamulla.

Yön aikana selän välilevyjen vesipitoisuus lisääntyy. Aamuisin ne ovat levon jälkeen kaikkein pulleimmillaan ja herkimmillään vaurioitumaan.

Älä anna alaselkäsi pyöristyä

• kun peset kasvojasi tai hampaitasi

- Kumarru yhden jalan yli, niin että toinen jalka on lähellä lavuaaria, toinen taaempana.

Ei näin

Oikein

• kun petaat sänkyäsi

- Laskeudu toispolviseisontaan, kun ”virittelet” peittoa patjan alle.
- Vältä kurkottelua sängyn yli.
- Kävele sängyn toiselle puolelle, aina kun se on mahdollista.
- Jos joudut kurkottelemaan sängyn yli, kumarru yhden jalan yli.

Jos joudut heti heräämisen jälkeen tekemään raskaita nostoja tai muita selkää kuormittavia ponnisteluja, lämmittele.

- Verryttele kävelemällä reippaasti 5–10 minuuttia, jolloin keho lämpenee.
- Mieti oikeaa nostotekniikkaa ja kokeile sitä aina ensin ilman kuormaa.
- Harjoittele liikettä 3–5 kertaa, ennen kuin aloitat nostamisen.

Opettele istuma-asentoja, joissa alaselän asento säilyy turvallisella neutraalialueella.

- Älä päästä selkää pyöristymään taaksepäin. (kuva 1)
- Käytä vatsa- ja selkälihaksia alaselän tukemiseen. (kuva 2)
- Säilytä alaselän hyvä asento myös istuessasi autossa.

Kokeile tavallisella tuolilla seuraavia istuma-asentoja:

- Istu tuolin reunalla jalat leveässä haara-asennossa ja kallista vartaloa lonkista hieman eteen selkä suorana. (kuva 2)
- Vaihda välillä jalat käyntiasentoon. (kuva 3)

Huolehdi selkäsi hyvinvoinnista myös vapaa-ajalla.

Liikunta ja kuntosaliharjoittelu edistävät hyvää selän terveyttä. Hyvä lihaskunto ehkäisee erityisesti alaselän, polven ja nilkan vammoja.
Tee seuraavat harjoitukset 2–3 kertaa viikossa.

SILTANOSTO KYLJELLÄ

- Asetu matolle oikealle kyljelle kyynärnojaan polvet koukussa.
- Nosta kylki irti lattiasta, työnnä lantio eteen ja ojenna lonkat suoraksi vartalon suuntaisesti. (kuva 1)
- Pysy nostoasennossa 5 sekuntia, laskeudu alas.
- Toista siltanosto 5 kertaa.
- Tee sama liike 5 kertaa vasemmalla kyljellä.

Jatka harjoitusta seuraavasti:

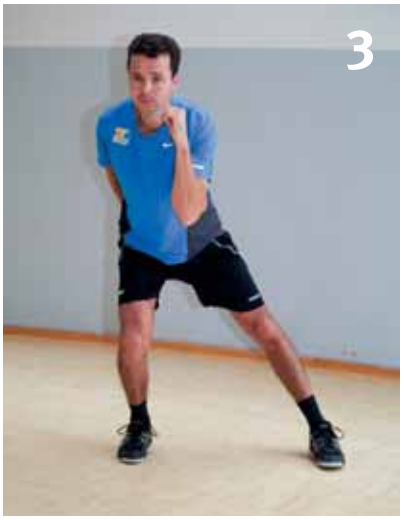
- Asetu matolle oikealle kyljelle kyynärnojaan polvet suorina, jolloin jalkaterät tukevat liikettä. Aseta päällimmäisen jalan jalkaterä alemman etupuolelle.
- Nosta kylki irti lattiasta ja pysy asennossa 5 sekuntia. (kuva 2)
- Kierry sen jälkeen vatsamakuulle molempien kyynärvarsien varaan punnerrusasentoon ja pysy asennossa 5 sekuntia. (kuva 3)
- Kierry tämän jälkeen vasemmalle kyljelle kyynärnojaan siltanostoasentoon, pysy asennossa 5 sekuntia ja laskeudu alas. (kuva 4)
- Olet nyt tehnyt yhden liikkeen, toista se vielä 5 kertaa.

Harjoitus parantaa vartalonlihasten kykyä tukea selkärankaa ja harjoittaa erityisesti kylkilihaksia.

Hyvä vartalonlihasten ”tukikorsetti” suojaa selkävammoilta ja on edellytys kaikille raskaille ja taitoa vaativille suorituksille.

LUISTELUHYPPELY

- Seiso kapeassa haara-asennossa, polvet lievästi koukussa.
- Kallista vartaloa eteenpäin lonkista, pidä selkä suorana. (kuva 1)
- Vie oikea jalka pitkälle sivulle, vedä se takaisin vasemman jalan viereen ja ”heilauta” samanaikaisesti vasen jalka sivulle. (kuva 2)
- Vedä vasen jalka takaisin oikean viereen ja heilauta samanaikaisesti oikea jalka sivulle.
- Rytmitä liike tekemällä 4 hidasta hyppyä + 8 nopeaa hyppyä vuorotellen.
- Yhdistä pikajuoksijan käsiliike hyppelyrytmiin: Vie sivulla olevan jalan puoleinen kyynärpää kohti vastakkaista polvea. (kuva 3)
- Kiinnitä huomiota keskivartalon asentoon, pidä napa koko ajan suoraan eteenpäin.
- Jatka hyppelyä jalalta toiselle yhden minuutin ajan.



Harjoitus kehittää alaselän asennon hallintaa, koordinaatiota ja ketteryyttä sekä alaraajojen ojentajalihasten kestävyysvoimaa.

Palvelustehtävissä tarvitset hyvää koordinaatiota mm. sulkeisissa, taistelukoulutuksessa sekä liikuntaharjoituksissa. Näistä taidoista on hyötyä myös vapaa-ajan harrastuksissa.

MUUNNELTU PUNNERRUS

- Asetu vatsalleen matolle ja aseta kämmenet matolle hartiatasoon lähelle vartaloa.
- Jalat ovat haara-asennossa (noin lantion leveys), varpaat tukevasti matolla. (kuva 1)
- Lyö kämmenet yhteen selän takana ja tuo ne takaisin lattiaan hartiatasoon. (Voit lyödä kädet myös reisien sivulle, jos kädet eivät yllä selän taakse.) (kuva 2)
- Punnerra itsesi ylös, niin että kädet ojentuvat, pidä vartalo mahdollisimman suorana (lantio ja polvet irtoavat yhtä aikaa lattiasta). (kuva 3)
- Kosketa tässä yläasennossa **oikealla kädellä vasenta kämmenselkää** (kuva 4), palaa takaisin punnerrusasentoon (kuva 5) ja laskeudu matolle. (kuva 1)
- Aloita uusi punnerrus lyömällä kämmenet yhteen selän takana. Kosketa punnerrusasennossa **vasemmalla kädellä oikeaa kämmenselkää**.
- Toista punnerruksia 30–60 sekunnin ajan niin nopeasti kuin jaksat.

Jos harjoitus tuntuu liian raskaalta, tee se pitämällä polvet maassa ja lyhennä harjoitusjakson pituutta.

Harjoitus parantaa yläraajojen ojentajalihasten voima-kestävyyttä sekä vartalonlihasten kykyä tukea ja hallita selkää.

Jos selviät hyvin tästä haastavasta harjoituksesta, on toimintakykysi myös sotilaana hyvä!

Tiedosta, että kuntosaliharjoittelussa alaselkä voi joutua huonoon asentoon.

- Ota huomioon sivulla 12 annetut vinkit hyvästä istuma-asennosta, kun teet mitä tahansa kuntosaliharjoituksia istuen.
- Muista alaselän kannalta oikea nosto- ja kyykistystekniikka (kyykyt, nostot, askellukset), kun harjoittelet sekä pienillä että suurilla painoilla. (kuvat s. 9)
- Varo selän äärivenytyksiä ja vältä kaikissa eteentaivutusliikkeissä alaselän täydellistä taaksepäin pyöristämistä.

Hyvä kunto ja nestetasapaino ehkäisevät vammoja ja uupumista.

Pitkäkestoiset marssit ja toistuva saman kehon osan rasittaminen lisäävät rasitusvammojen ja uupumisen riskiä.

→ Hyvä kestävyyskunto yhdessä lihaskunnon kanssa ehkäisevät tehokkaasti rasitusvammoja ja uupumista. Hyvässä kunnossa varusmiespalvelus tuntuu helpommalta ja vältyt turhilta vammoilta.

→ Ennen varusmiespalveluksen alkua suositellaan kestävyyskunnon parantamista kävelemällä tai hölkkäämällä neljä kertaa viikossa 30 minuuttia kerrallaan.

→ Lihaskuntoa kehittävää harjoittelua suositellaan tehtävän kaksi kertaa viikossa.

→ Pitkäkestoisen rasituksen aikana riittävä määrä lepotaukoja on tarpeen, jotta voidaan välttyä vammoilta ja uupumiselta.

→ Lämpimällä ilmalla nesteen tarve lisääntyy. Juo kulaus vettä 15 minuutin välein, kun rasitat itseäsi lämpimällä säällä.

TOP 5 vinkkiä terveelliseen ja turvalliseen liikkumiseen

1. Lämmittele ja verryttele lihaksia ja niveliä ennen taakkojen nostamista ja peli- ym. liikuntaharjoituksia.

2. Varmista oikeat suoritustekniikat.

3. Harrasta liikuntaa säännöllisesti ja monipuolisesti.

4. Käytä suojavarusteita, kuten kypärää ja suojalaseja, aina kun se on turvallisuuden takia tarpeen.

5. Järkevät ravintovalinnat pitävät vireytesi hyvällä tasolla.

Hoida vanhat vammat kuntoon.

Kolmannes kaikista varusmiesten terveysasemalla käynneistä johtuu vanhojen vaivojen ja vammojen uusiutumisista.

1. Vältä liian varhaista vammautuneen kohdan rasittavaa kuormittamista. Toipumisaika vammasta vaihtelee yksilöllisesti.
2. Lepää sairaana (esim. nuhakuume).
3. Anna terveysaseman henkilökunnan määrittää tarvittava toipumisaikasi.

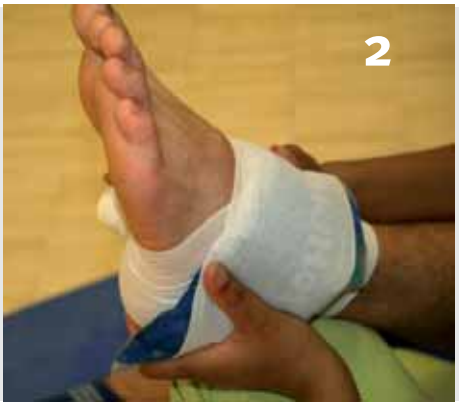
Vamman ensihoito – kolmen K:n hoito

Kompressio Purista käsin (= kompressio) vammakohtaa (kuva 1).

Koho Nosta raaja koholle.

Kylmähoito Aseta kylmä (esim. pikakylmähaude, lumi muovipussissa) vammakohdan päälle. Kierrä kylmän päälle joustava tukiside (kuva 2).

Anna kylmän vaikuttaa 20 minuuttia (raaja koholla), jonka jälkeen aseta kylmäpussin tilalle pelkkä paineside (kuva 3).



Pinnallisissa mustelmissa ja pienemmissä ruhjeissa riittää 10–15 minuutin kylmähoitojaksot. Pidä raajaa mahdollisimman paljon koholla. Toista hoitojaksoja 1–2 tunnin välein. Tuoreen vamman ensihoitovaihe kestää tavallisesti 2–3 vuorokautta.

Kylmäpakkauksen ja ihon väliin on aina laitettava paleltumisen estävä eriste, esimerkiksi ohut vaate tai side (kuva 2).
Katso KKK-video www.terveurheilija.fi

Opas selkävammojen ja tapaturmien ehkäisyyn on nähtävissä verkossa.
www.puolustusvoimat.fi/liikunta
www.ukkinstituutti.fi/selkakunnossa

Lihaskuntoharjoittelun ohjeita, ks. videot www.ukkinstituutti.fi/tulekuntomitta

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Musculoskeletal disorders in physically active conscripts: a one-year follow-up study in the Finnish Defence Forces

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Abstract

Background: Musculoskeletal disorders (MSDs) are an important cause for morbidity in military service. They result in disabilities needing long-term rehabilitation and functional impairment leading to premature discharge from military service. The purpose of the study was to investigate the incidence and nature of MSDs in Finnish conscripts.

Methods: Two successive arrivals of 18–28-yr-old male conscripts (*N* = 955, median age 19) were followed for six months. MSDs, including overuse and acute injuries, treated at the garrison clinic were identified and analysed.

Results: During the 12-month study period there were 437 outpatient clinic visits in 955 persons. The occurrence rate was 33% during 6-month service while the event-based incidence was 3.3 per 1000 person-days. Occurrence peaked in summer months. The most common types of MSDs were low back pain (LBP, 20%), lower limb overuse injuries (16%) and sprains or strains (13%). Disorders mostly occurred in combat training in combat gear (40%) and during marching on foot or bicycle (28%). Overuse-related MSDs were more prevalent (66%) than traumatic ones (34%). One-third (34%) of the MSDs were recurrent and 66% were new ones. Disorders of the back and the knee were most frequently recurrent conditions (44% for both). Fractures, knee ligament ruptures, dislocations and muscle strains accounted for the highest number of service days lost. Twenty-four (2.5%) out of 955 conscripts were prematurely discharged due to MSDs.

Conclusion: Preventive measures during military service should be targeted at decreasing low back pain and lower limb overuse injuries, because these inflict the largest burden of MSDs and tend to have a chronic nature.

Background

Current recommendations for physical activity and public health strongly suggest that engaging in regular physical activity improves cardiovascular health and reduces the risk of many chronic diseases [1]. However, with increasing amounts of physical activity, such as after arrival to military service, there is also an increased risk of musculoskeletal injury or disorder. A recently published hospital discharge register-based study reported an annual incidence for traumatic injury hospitalisation of 94 per 1000 conscripts over a 10-year study period, and concluded that injuries represent a major cause of morbidity in the Finnish Defence Forces. A limitation of the study was, however, that minor injuries not needing hospitalisation were not registered [2]. MSDs represent the second biggest reason for untimely discharge from military service in Finland, and their number rose heavily (62%) at the turn of the millennium [3]. Since over 80% of the male citizens in Finland complete their compulsory military service, musculoskeletal injuries and disorders during military service have also importance from the public health point of view. They result in disabilities needing expensive treatment, long-term rehabilitation and functional impairment leading to premature discharge from military service.

In spite of the overall high prevalence of injuries, there is not much epidemiological data concerning injuries during conscription military service. In addition to hospital discharge studies [2,4], some specific conditions in small target populations have been described such as acoustic injuries [5], frostbites [6], patellar dislocations [7], low back pain (LBP) [8] and stress fractures [9-13]. In the Norwegian and Danish conscription armies, some larger scale epidemiological studies have shown that a significant number of training days are lost due to injuries [14-16]. Before a measure or programme for injury prevention is initiated, the extent of the problem should first be defined. The purpose of this prospective one-year follow-up study was to investigate the incidence and nature of MSDs leading a conscript to seek medical care.

Methods

Subjects

The subjects of this study consisted of male conscripts (*N* = 955) from four companies of one brigade (Pori Brigade, Säkylä) in the Finnish Defence Forces. The four companies enrolled into the study were the anti-tank company, the signal company, the mortar company and the engineer company. The Pori Brigade is a typical garrison in the Finnish Defence Forces and the chosen companies form a representative sample of conscripts. During the study year, two arrivals of conscripts started service in the brigade: 359 in July 2006 and 604 in January 2007. Key characteristics of the two arrivals are presented in Table 1.

The health status of conscripts was checked during the first week of service by routine medical screenings performed by a physician. If a conscript was found to have had onset of a severe MSD before the beginning of the service, he was discharged. One participant released temporarily (for 24 months) from the service at the medical screening was excluded. Seven (< 1%) out of 962 conscripts refused to participate in the study. All the remaining conscripts agreed to participate and gave their informed consent before the initiation of the study. The age of the conscripts varied from 18 to 28 years (median 19 yr). All subjects were followed for six months starting from the first day of service. Approval for the study protocol was obtained from the Ethical Committee of Pirkanmaa Hospital District on the April 11, 2006 (ref: R06063).

Table 1: Baseline characteristics of two arrivals of 955 male conscripts.

Variable	1st arrival (N = 359)		2nd arrival (N = 596)		Missing (total number)	P-value[1]
Age[2] (range yrs)	20 (18–28)		19 (18–27)		3 (0%)	< 0.001
BMI[3] (range, kg/m^2)	23.7 (15.1–45.9)		23.8 (16.4–39.4)		88 (9%)	0.70
	Yes	No	Yes	No		
High level of education[4]	151 (42%)	201 (56%)	239 (40%)	351 (59%)	13 (1%)	0.47 [8]
High level of previous physical activity[5]	114 (32%)	238 (66%)	177 (30%)	412 (69%)	14 (1%)	0.45 [8]
Good self-assessed health[6]	194 (54%)	158 (44%)	308 (52%)	282 (47%)	13 (1%)	0.39 [8]
Clear musculoskeletal symptoms[7]	100 (28%)	251 (70%)	174 (29%)	416 (70%)	14 (1%)	0.74 [8]

1 P-value for difference between the arrivals
2 P-value was examined by using Mann-Whitney U test for median difference
3 Body mass index, P-value was examined by using Independent t test for mean difference
4 Graduated or studies in higher education institution
5 Sweating exercise at least three times per week during the last month before entry to military
6 Compared to age-mates
7 Symptoms lasting more than 7 days at least in one anatomical region during the last month before entry to military
8 P-value was examined by using χ^2 statistics for difference

Physical training programme

In the beginning of military service, all Finnish conscripts perform the basic training of 8 weeks of varying physical activities including marching, cycling, skiing, orienteering, swimming, drill training and combat training in combat gear. There is an average of 17 hours per week of military training and the intensity is constructed so as to be gradually increasing. In addition, conscripts perform other physical exercises such as jogging, team sports, and circuit training 7 hours per week on average. The basic training period is followed by diverse individual training programmes. However, over the following 4 months of service, the amount of moderate and high-intensity physical training is maintained at the same level in different companies. During the first 6 months of military service, conscripts are expected to complete approximately 450 hours of instructed physical training (19 hours per week).

In addition to the compulsory, supervised training garrisons offer a variety of opportunities for physical activity during leisure time including jogging, weight training and lifting and team sports. Approximately 20% to 40% of conscripts practice sports during their leisure time.

Musculoskeletal disorder registration

The data was collected between July 2006 and June 2007. A musculoskeletal disorder (including overuse and acute injuries) was defined as an event that resulted in physical damage to the body and for which the conscript sought medical care from the garrison clinic. At the clinic, assisted by the healthcare personnel, a conscript filled out a disorder questionnaire eliciting the type, anatomical location, severity, associated activities and cause of MSD. By using this form, minor injuries that would not have been detected by standard medical record data were also identified and analysed. All answers were checked by nurse or physician and any unanswered question was answered if possible. The proportion of unanswered questions was low (< 4% per question). Since conscripts may have had suffered from multiple MSDs during a single visit to the garrison clinic, the total numbers of MSDs exceeded the number of outpatient clinic visits.

The disorder questionnaire included 26 different defined MSD types and an open question for undefined MSD. The type of MSD was categorised as acute if the MSD had sudden onset involving known trauma. Overuse-related MSDs had a gradual onset without known trauma [17,18]. For instance, overuse conditions of the knee, shin, ankle and foot were categorised as lower limb overuse injuries, whereas sprains, strains, wounds, internal knee ligament ruptures and joint dislocations were typically categorised as acute injuries. LBP was defined to be either local pain in the lower back or pain radiating above the knee. The MSD was considered recurrent when the conscript has previously sustained an MSD of the same type and in the same location [17,18].

Disorders which had occurred during the conscript's leisure time or on the way to vacation or back to garrison were included, but those occurring prior to the beginning of the military service were excluded from the data. The aetiological circumstances of the onset of MSDs during actual military service were charted more thoroughly by use of an additional question (Fig. 1). After careful clinical examination and necessary diagnostic tests and radiological graphs the most accurate diagnosis was selected by a physician according to the 10th Revision of the International Statistical Classification of Diseases and Related Health Problems (ICD-10). The severity of MSD was categorised according to the number of days it prevented physical exercise: 1–7 days denoting minor, 8–30 days moderate and > 30 days severe disorder [19]. Premature release from military service was indicated when a physician determined a conscript unable to continue military training. There were three discharge categories: A) temporary medical discharge from military service; B) permanent medical discharge from service in peacetime; and C) applying for non-military service (Table 2).

Statistical analysis

SPSS 16.0 for Windows software (SPSS Inc., Chicago, IL) was used for statistical analysis. Occurrence rate was calculated by dividing the number of conscripts with one or more MSDs treated in the garrison clinic (numerator) for MSD by the total number of conscripts (denominator) and expressed as a percent. Person-based incidence was calculated by dividing the number of conscripts treated in the garrison clinic for MSD by the exposure time. Exposure time for person-based incidence was calculated until onset of the conscript's first MSD. Event-based incidence was calculated by dividing the total number of MSDs by the exposure time. Exposure time for event-based incidence was calculated until the end of follow-up. Time loss due to MSD was allowed for when calculating the exposure time for the event-based incidence. If a conscript was discharged from the military service, this was taken into account in exposure times. The incidences with 95% confidence intervals (CI) were expressed per 1000 person-days. Descriptive statistics were used to analyse the data. Cross-tabulations and chi-square test were used to analyse categorical variables. To examine differences in the occurrence rate of MSDs between the two arrivals of conscripts and between the service stages, the χ^2 statistics was used to test the hypothesis of no difference. Mann-Whitney U test was used to test if a difference existed between the arrivals in age variable. Since BMI was distributed normally, the difference of BMI between the arrivals was analysed by using the Independent t-test. A P value of < 0.05 was considered statistically significant.

Table 2: Numbers and reasons for premature discharge from military service.

A.	**Reasons for temporary medical discharge from military service**	
	Number	**Diagnosis**
	Mental and behavioural disorders	
	15	Adjustment disorders
	4	Depressive episodes
	3	Anxiety disorders
	1	Mental and behavioural disorders due to use of stimulants
	Total 23 conscripts, 26% of all premature discharges	
	Musculoskeletal disorders & injuries	
	8	Overuse injury of the limb
	3	Tendinopathies
	3	Dislocations
	3	Low back pain
	2	Juvenile osteochondrosis
	2	Internal injury of the knee joint
	1	Fracture of the neck of the femur
	1	Fracture of carpal bones
	1	Injury of the extensor muscle and tendon of a finger
	Total 24 conscripts, 27% of all premature discharges	
	Diseases of the respiratory system	
	Total 11 conscripts, 12% of all premature discharges	
	Cardiovascular disorders	
	Total 3 conscripts, 3% of all premature discharges	
	Gastrointestinal diseases	
	Total 2 conscripts, 2% of all premature discharges	
	Dermatological diseases	
	Total 2 conscripts, 2% of all premature discharges	
	Other reasons	
	1	Sleep disorders
	1	Postviral fatigue syndrome
	1	Pronounced myopia
	Total 3 conscripts, 3% of all premature discharges	
	Total 68 conscripts, 76% of all premature discharges	
B.	**Reasons for permanent medical discharge from military service**	
	Mental and behavioural disorders	
	2	Adjustment disorders
	2	Depressive episodes
	1	Mixed and other personality disorders
	1	Panic disorder
	Total 6 conscripts, 7% of all premature discharges	
C.	**16 persons (18% of all premature discharges) applied for non-military service**	

Cases are divided in temporary (A) and permanent (B) categories in 955 male conscripts during a 6-month period, including 16 conscripts who applied for non-military service (C).

Results

Occurrence of musculoskeletal disorders

During the 12-month study period (July 2006 – June 2007), altogether 437 outpatient clinic visits were registered in the garrison clinic due to MSDs. A total of 318 of 955 (33%) conscripts sustained one or several MSDs during the six-month service. Of these, 72% were treated once, 20% twice and 8% three or four times at the clinic. The event-based incidence for MSD was 3.3 (95% CI: 3.0–3.7) per 1000 person-days. Person-based incidence was 2.4 (95% CI: 2.2–2.6) per 1000 person-days.

Occurrence of MSDs was highest during the summer months with the peak in August (18 admissions per 100 conscripts) when the July arrivals were performing their intensive basic training period. In winter, the rates were

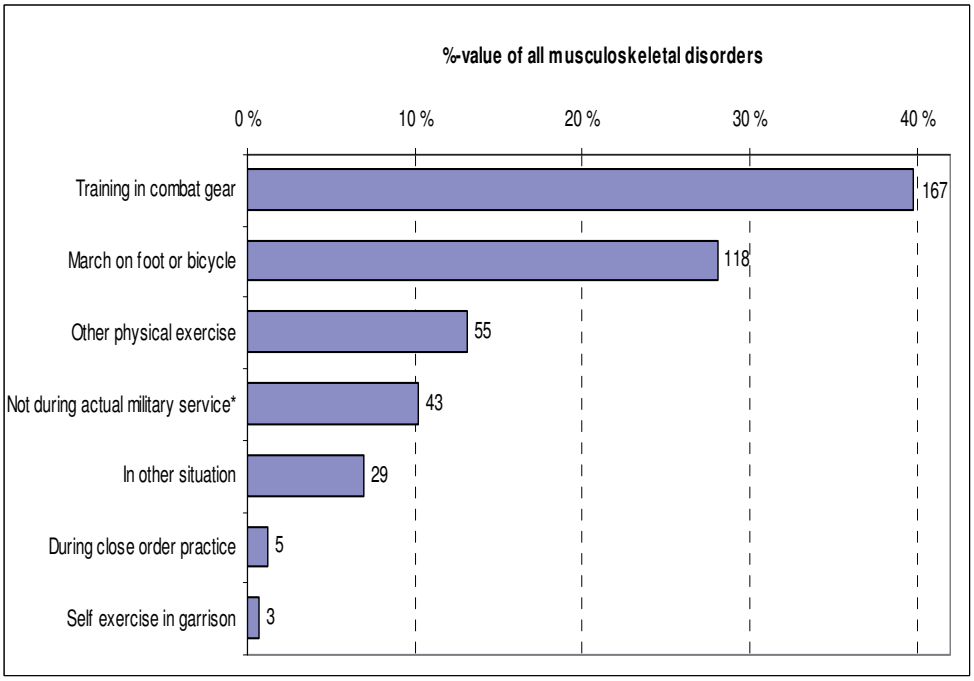

Figure 1
Distribution of musculoskeletal disorders by associated activities in 955 male conscripts during 6-month military service. * The term "not during actual military service" includes disorders during vacations, during travel to vacation or back to garrison or during off-duty time in the evenings. Count next to the bar is the absolute number.

generally lower with the lowest seen in March (3 admissions per 100 conscripts). No clear peak was found in January or February (8 and 7 admissions per 100 conscripts, respectively), when the second arrival served their first weeks. For the majority of conscripts military service has been divided into three stages of equal duration. During the first stage (basic training, service weeks 1–8), 15% of conscripts were treated at least once at the garrison clinic due to MSD. In the second (special training, service weeks 9–17) and third stages (team training, service weeks 18–26), the figures were approximately 14% and 13%, respectively. These rates were not statistically significantly lower compared to the rate of the basic training stage (χ^2-test, $P > 0.10$ for both). However, the first arrival of conscripts (July 2006) had a higher occurrence rate for MSDs (40%) than the second arrival starting in January 2007 (29%) (χ^2-test, $P < 0.001$).

Type and anatomical location of musculoskeletal disorders

The most common types of MSDs were LBP (20%), lower limb overuse injuries (16%) and sprains or strains (13%), which accounted for 49% of all disorders (Fig. 2). Most disorders were found on the lower limbs (61%). The upper limbs (including shoulders) were involved in 12% and the other parts of the body in 27% of the disorders. Anatomically, the most typical locations were the back (20%), the knee (18%), the ankle (12%), and the foot (9%), and they represented over half (60%) of all anatomical locations with MSDs (Fig. 3).

Overuse-related MSDs (66%) were nearly two times more prevalent than traumatic ones (34%). This distribution remained the same for both conscript batches. Foot and ankle disorders mostly originated from overuse (Table 3).

One third (34%) of the MSDs were recurrent disorders and 66% were new. Lower limb injuries or disorders in the ankle or foot were mostly new (84–87%), whereas disorders of the back and the knee were more frequently recurrent conditions (Table 4).

Associated activities and severity of musculoskeletal disorders

MSDs occurred mostly (91%) in the course of the military service, 9% during vacations and two cases (0.5%) occurred while travelling to holiday or back to the garrison.

Of the aetiological circumstances, combat training in combat gear was more common (40% of all scenes) than marching on foot or bicycle (28%) or other physical exercise (13%). In total, over 90% of the disorders emerging during military service were training-related (Fig. 1). Disorders during marching were mostly overuse type,

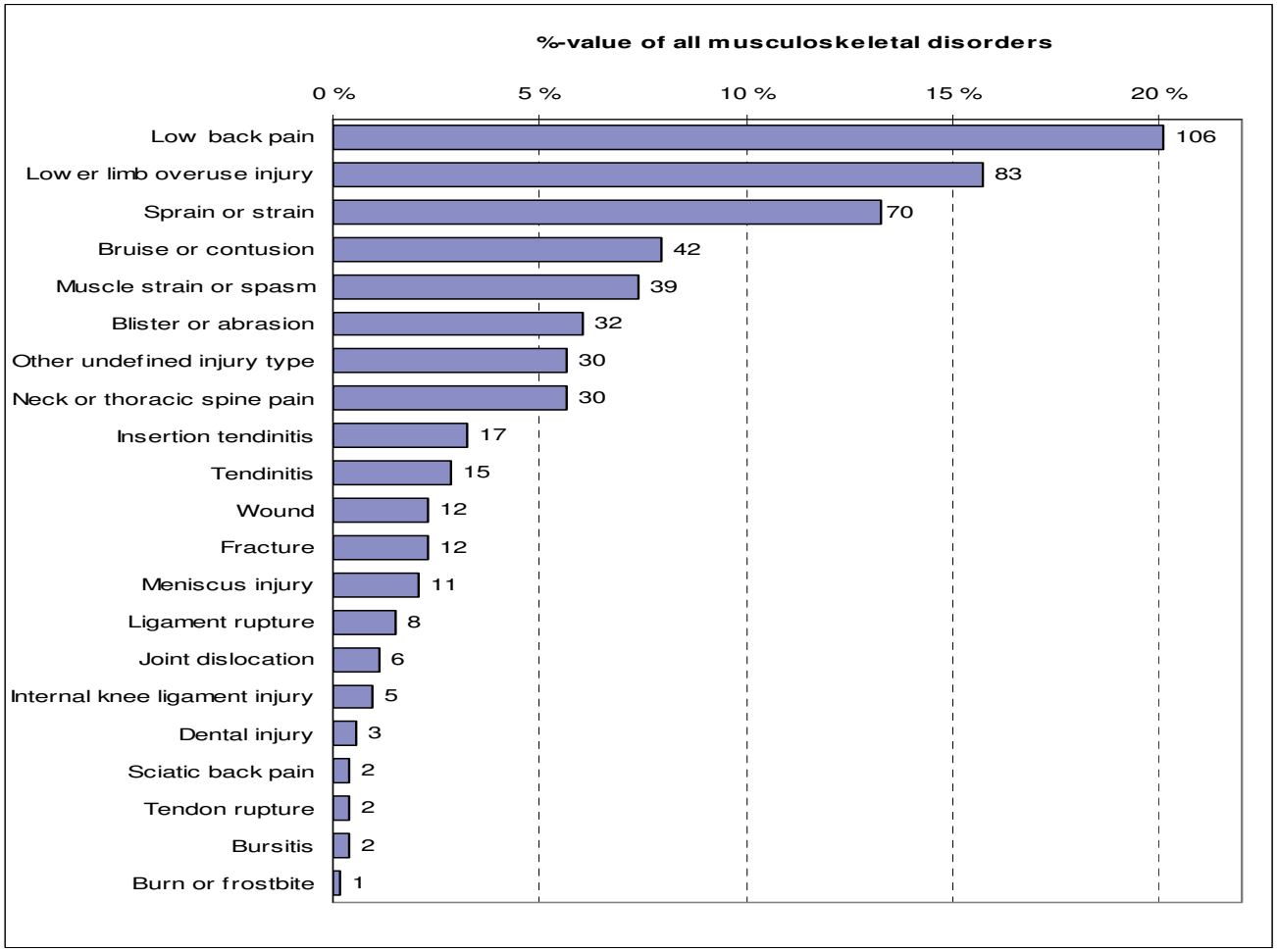

Figure 2
Distribution of musculoskeletal disorders by injury type in 955 male conscripts during 6-month military service. Count next to the bar is the absolute number.

whereas traumatic injuries were more common during combat training in combat gear or during other physical exercise (Table 5).

The majority (87%) of disorders were classified minor leading to a maximum of 7-day exemption from physical exercise, while moderate disorders accounted for 9% and severe disorders for 4% of all cases. Fractures, knee ligament ruptures, dislocations and muscle strains represented the most severe injuries and accounted for the highest number of service days lost. Seven of twelve fractures had traumatic origin (wrist (2 cases), brachium, finger, clavicle, foot and neck of the femur) and five were stress fractures (foot (4 cases), calcaneus). In addition, there were six dislocations (one patellar, one of the sternoclavicular joint and four anterior dislocations of the humerus).

Of the total of ninety discharges (9% of all conscripts), twenty-four (2.5%) conscripts were released temporarily (for at least 6 months) from military service due to musculoskeletal injuries consisting mostly of overuse injuries of the lower limb, LBP, tendinopathies and joint dislocations. All permanent releases (6 conscripts) were due to mental disorders (Table 2). Of these, three had a secondary diagnosis associated with permanent medical discharge. The associated diagnoses were M79.0 (unspecified rheumatism), J30 (vasomotor and allergic rhinitis) and F32.9 (unspecified depressive episode).

Discussion

MSDs are an important cause of morbidity among Finnish conscripts. The occurrence rate of MSDs was 33% (or 333 per 1000 conscripts) during a six-month service period. Most MSDs involved the lower limb (61%), but LBP was

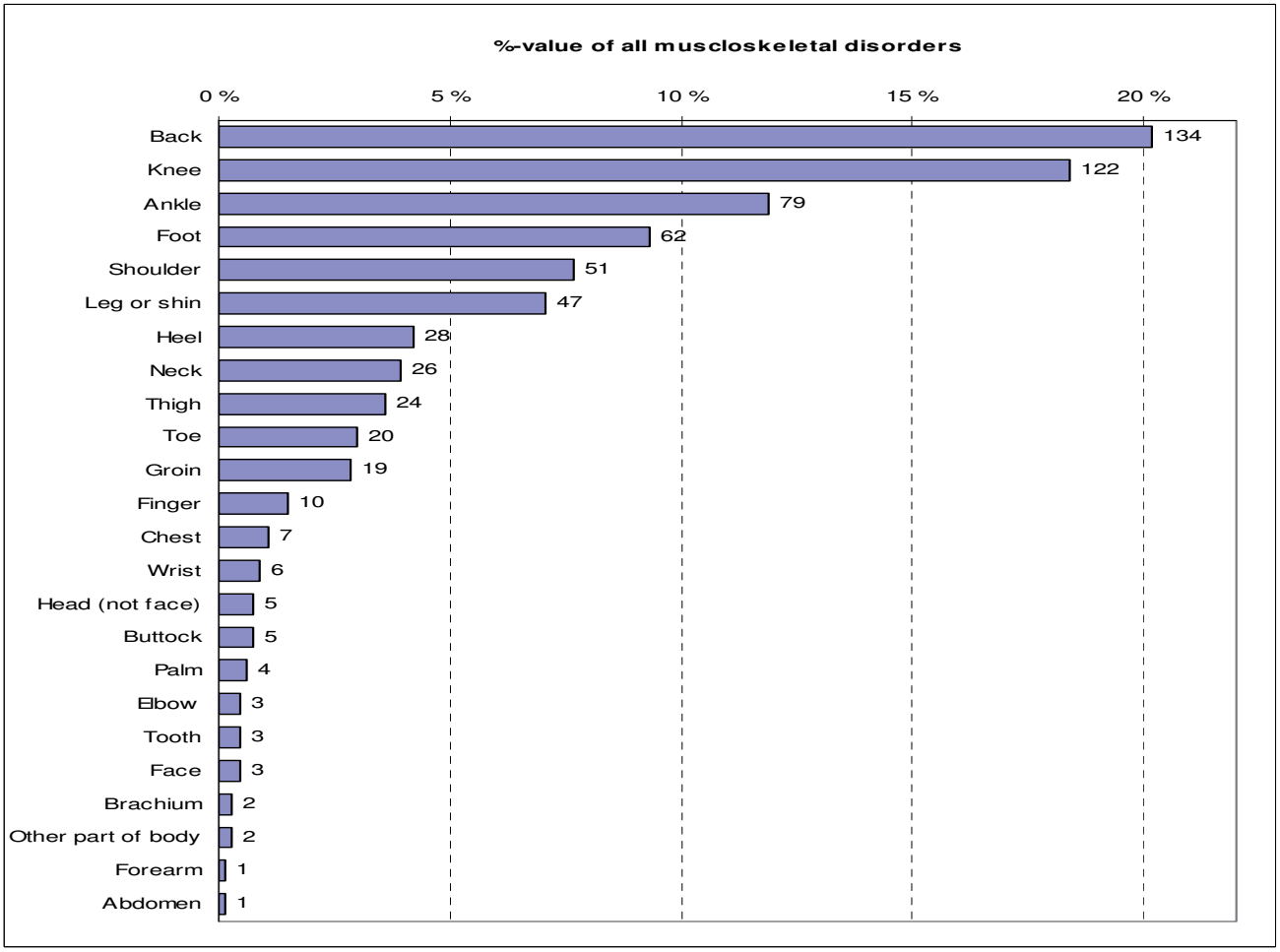

Figure 3
Distribution of musculoskeletal disorders by anatomical location in 955 male conscripts during 6-month military service. Count next to the bar is the absolute number.

Table 3: Proportions of acute and overuse-related musculoskeletal disorders in 955 male conscripts during 6-month military service.

Body part	Acute		Overuse		Total Number
	n	%	n	%	
Back	43	33	89	67	132
Knee	42	35	78	65	120
Ankle	19	24	60	76	79
Foot	5	8	57	92	62
ALL BODY PARTS	146	34	281	66	427

The four most common body parts are shown in the table. In 10 cases the information considering the onset of the disorder remained unclear.

Table 4: Proportions of new and recurrent musculoskeletal disorders in 955 male conscripts during 6-month military service.

Body part	New		Recurrent		Total Number
	n	%	N	%	
Back	74	56	58	44	132
Knee	67	56	53	44	120
Ankle	66	84	13	16	79
Foot	54	87	8	13	62
ALL BODY PARTS	284	66	145	34	429

The four most common body parts are shown in the table. In 8 cases the information regarding recurrence of the disorder remained unclear.

Table 5: Proportions of acute and overuse-related musculoskeletal disorders in 955 male conscripts during 6-month military service.

Associated activity	Acute		Overuse		Total Number
	n	%	N	%	
Combat training in combat gear	59	36	107	64	166
March on foot or by bicycle	8	7	110	93	118
During other physical exercise	29	54	25	46	54
ALL ASSOCIATED ACTIVITIES	146	34	282	66	428

Three most common associated activities are shown in the table. In 9 cases activities associated with musculoskeletal disorder remained unclear.

also common. The high proportion of disorders affecting the low back and the lower limbs is noteworthy due to their commonly chronic nature causing time loss and premature releases from military service.

In the present study, the event-based incidence rate was 3.3 per 1000 person-days, which is slightly lower than in the two previous studies on conscripts [14,16]. Heir and Glomsaker (1996) monitored 6488 Army, Air Force and Navy conscripts during 6–10-wk period of military basic training in Norway and reported an incidence of approximately 4.2 per 1000 person-days for musculoskeletal injuries, including LBP. Rosendal et al. (2003) prospectively followed 330 Danish conscripts for 12 weeks in military basic training and reported an overall injury occurrence rate of 28% and a person-based incidence rate of approximately 3.5 per 1000 person-days. In the present study, complaints causing no time loss, like minor bruises, wounds and blisters not treated in the garrison clinic were not registered by medical staff, which may partly explain the difference in the occurrence rates between the studies. Also, the intensity of military training may be lower after the initial first weeks, which may be seen as lower injury rates during a longer follow-up time [20].

In this study, a peak of MSDs was seen during the basic training stage for conscripts arriving in July, but less clearly for those arriving in January. Since there were no significant differences between the batches considering the basic characteristics, it is suspected that this seasonal variation occurred due to environmental changes. Several explanations for the seasonal variation in the results may exist. Firstly, since the military training programmes for both arrivals were basically the same, winter may be a protective factor, as was also suggested in a previous Finnish conscript study [2]. A difference in strain may occur due to the winter environment when running and marching on foot are replaced by skiing which reduces the shock to the lower limbs. Also, snow, acting like a cushion, may reduce both traumatic and overuse-related MSDs. Knapik and colleagues [21] (2002) reported the same phenomenon indicating that injury incidence among US Army conscripts is higher in the summer than in the fall and suggested that environmental temperature may provide a partial explanation for the finding. In a large civilian study, a higher injury occurrence rate likewise appeared to be associated with higher environmental temperatures [22].

The high proportion of MSDs in the lower limb (61%) is consistent with the findings of several previous studies concerning military recruits [20,23-25] as well as conscripts in mandatory armies [2,14,16]. It seems that the military basic training exerts a load particularly on the lower limbs. Most conscripts are not used to marching long distances over rough terrains with a heavy load, which may be a factor behind overuse injuries [26]. According to a meta-analysis study, the best way to prevent lower limb fatigue fractures is to use shoes incorporating a proper shock absorbing cushion [27]. However, data concerning the use of custom-made or prefabricated insoles for reducing lower limb injuries in military recruits is conflicting [23,28-30]. Other methods proven to prevent physical activity-related injuries in randomised controlled trials include the use of external joint supports, neuromuscular training, controlled use of protective equipment, careful rehabilitation of injuries and gradual increase of physical exercise [23,29,31,32].

The high proportion of sprains, strains and lower limb overuse injuries is in accordance with previous studies [2,14,15,23,33,34]. Heir and Glomsaker (1996) reported similar results in Norwegian conscripts for LBP and knee overuse injuries. Hence, it seems that basic military training especially exposes conscripts to overuse injuries and LBP. In contrast, among the general population, only about 30% of physical activity-related injuries originate from overuse [35]. The observed high proportion of training-related disorders is in agreement with previous studies [30,36].

Considering that at the turn of the millennium a substantial rise (62%) was seen in the number of premature discharges due to MSDs [3], it was not surprising that MSDs and injuries emerged as an important cause for discharge in this study as well (27% of all premature discharges,

Table 2). One explanation for the high occurrence of MSDs may be found in the changes implemented in the Finnish military service training programme in July 1998 which doubled the amount of physical exercise. On the other hand, the rise may be explained by conscripts being prematurely released from military service on minor grounds than before. In this study, 9% of all conscripts during the study year were prematurely discharged, which corresponds to the general level (8–10%) in the Finnish Defence Forces [3].

In the Finnish Defence Forces, the most common single reason behind medical discharges due to MSDs is LBP (21%), and the number of LBP-related discharges started to rise alarmingly in the late 1990s [3]. Chronic LBP is debilitating in military service and results in a notable increase in the use of health services [8]. However, severe low back disorders leading to hospitalisations are still rare in the early adulthood [37]. The present study indicated that a high proportion (44%) of back-related disorders were recurrent conditions and hence potential reasons for untimely discharge from military service. There is growing evidence that low back disorders occur where movement and motor control impairments appear as a result of abnormal tissue loading and pain. The consequences of these changes along with psychological and societal processes are potential factors behind the observed development [38-40]. Conscripts who suffer from chronic LBP before entering military service have a ten-fold higher risk to experience LBP during military service compared to the risk before the service [8]. This finding reflects the fact that basic military training is physically demanding for the back and requires an adequate level of physical fitness.

The mandatory military service in Finland differs from a recruit army system, such as in the United States, with respect to the number of conscripts, their quality and motivation, as well as the scope of the military programme. In a conscription army, the pace and content of military training have to be carefully adjusted to the fitness level of the conscripts. Combined with the short military service (180 days), this renders both the physical and military skill levels among conscripts lower than among their professional counterparts. Therefore, the results presented in this study cannot be directly extrapolated to a recruit army.

The present study had several strengths. First, the definition of MSD was clear and it was similarly understood by both the conscript himself and by the clinic physician or nurse, who treated and diagnosed the MSD and helped to fill the disorder questionnaire. Second, the participation rate was high (99%). Furthermore, the design of the study was a prospective follow-up of two successive batches of conscripts with the aim to provide information on the incidence of MSDs in an army environment during one whole year. The number of premature discharges (90 conscripts, 9%) from the military service during the study period may be considered a limitation of the study, as well as the descriptive nature of the study. In addition, since the threshold for seeking medical care may vary between individuals, some conscripts may have been more inclined to seek professional care than others.

The present study underlines the importance of MSDs as a cause of morbidity and premature discharge from military service in the Finnish Defence Forces. Given that the great majority (80%) of young men complete their military service in Finland, the high occurrence of MSDs in this population has an impact on public health. The current findings challenge the researchers and the military personnel to recognise and identify the risk factors in order to take preventive actions to decrease the number of MSDs among conscripts. Preventive measures during military service should be targeted at decreasing LBP and lower limb overuse injuries, because these represent the majority of MSDs and tend to have a chronic nature. The current best evidence for successful secondary prevention of LBP is provided by psychosocial and cognitive-behavioural interventions, as well as exercises enhancing motor control, flexibility and muscular strength and endurance of the trunk muscles [40-42]. However, as the efficiency of those programmes has not been well established, especially regarding early prevention of recurrence of LBP, more evidence is needed [42,43]. Knowledge of the risk factors and injury mechanism is an essential component for planning intervention programmes. The authors would recommend randomised controlled studies to provide more evidence from interventions before large scale prevention programmes are initiated in a military environment. In conclusion, preventive measures during military service should be targeted at decreasing LBP and lower limb overuse injuries, which are the largest burden among MSDs with tendency towards becoming chronic.

Conclusion

In the present study two successive batches of physically active young conscripts were followed prospectively over a one year period. The observed high prevalence of MSDs in the lower back and lower limbs should be taken into account when planning prevention strategies. Fractures, knee ligament ruptures, dislocations and muscle strains accounted for the highest number of service days lost. Twenty-four (2.5%) out of 955 conscripts were prematurely discharged due to MSDs. Before initiating intervention programmes, risk factors and injury mechanisms leading to injuries and LBP need to be thoroughly assessed.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

HT participated in manuscript writing, data analysis, interpretation and data acquisition. JS was the primary investigator together with JP. She initiated and conceptually designed the study and took part in data processing and manuscript writing. HP participated in study concept and design as well as manuscript reviewing. VMM took part in data analysis and interpretation and gave statistical expertise. He also participated in the study as a significant manuscript reviewer. OO revised the manuscript critically and took part in data analysis and interpretation. He also participated in the study concept and design. PV took part in designing the study and data acquisition. He also revised the manuscript critically. JP was the primary investigator together with JS. He initiated and conceptually designed the study and participated in manuscript writing, data analysis and interpretation. All authors have made substantive intellectual contributions to the study. All authors reviewed the article and gave the final approval of the manuscript.

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Aetiology and risk factors of musculoskeletal disorders in physically active conscripts: a follow-up study in the Finnish Defence Forces

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Abstract

Background: Musculoskeletal disorders (MSDs) are the main reason for morbidity during military training. MSDs commonly result in functional impairment leading to premature discharge from military service and disabilities requiring long-term rehabilitation. The purpose of the study was to examine associations between various risk factors and MSDs with special attention to the physical fitness of the conscripts.

Methods: Two successive cohorts of 18 to 28-year-old male conscripts (*N* = 944, median age 19) were followed for six months. MSDs, including overuse and acute injuries, treated at the garrison clinic were identified and analysed. Associations between MSDs and risk factors were examined by multivariate Cox's proportional hazard models.

Results: During the six-month follow-up of two successive cohorts there were 1629 MSDs and 2879 health clinic visits due to MSDs in 944 persons. The event-based incidence rate for MSD was 10.5 (95% confidence interval (CI): 10.0-11.1) per 1000 person-days. Most MSDs were in the lower extremities (65%) followed by the back (18%). The strongest baseline factors associated with MSDs were poor result in the combined outcome of a 12-minute running test and back lift test (hazard ratio (HR) 2.9; 95% CI: 1.9-4.6), high waist circumference (HR 1.7; 95% CI: 1.3-2.2), high body mass index (HR 1.8; 95% CI: 1.3-2.4), poor result in a 12-minute running test (HR 1.6; 95% CI: 1.2-2.2), earlier musculoskeletal symptoms (HR 1.7; 95% CI: 1.3-2.1) and poor school success (educational level and grades combined; HR 2.0; 95% CI: 1.3-3.0). In addition, risk factors of long-term MSDs (≥10 service days lost due to one or several MSDs) were analysed: poor result in a 12-minute running test, earlier musculoskeletal symptoms, high waist circumference, high body mass index, not belonging to a sports club and poor result in the combined outcome of the 12-minute running test and standing long jump test were strongly associated with long-term MSDs.

Conclusions: The majority of the observed risk factors are modifiable and favourable for future interventions. An appropriate intervention based on the present study would improve both aerobic and muscular fitness prior to conscript training. Attention to appropriate waist circumference and body mass index would strengthen the intervention. Effective results from well-planned randomised controlled studies are needed before initiating large-scale prevention programmes in a military environment.

Background

Musculoskeletal injuries and disorders are the main reason for morbidity and temporary disability in military populations [1,2]. Health clinic visit rates are approximately equal for injuries and illnesses in the military environment, but the morbidity associated with injuries is over five times greater than that associated with illness [1,3,4]. A recently published hospital discharge register-based study emphasises that injuries are a major cause of morbidity in the Finnish Defence Forces [2]. During the 10-year study period, the incidence of traumatic injury hospitalisation was 94 per 1000 conscripts per year. Moreover, musculoskeletal disorders (MSDs) are the second highest reason for premature discharge from military

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service in the Finnish Defence Forces, and their number increased clearly at the turn of the millennium [5]. Military service in Finland is compulsory for all male citizens over 18 years of age, the duration varying from six to twelve months. Given that 80% of young men in Finland complete their service period, the high number of MSDs affects public health [2].

Previous epidemiological studies report that several risk factors are associated with injuries during military training. These include, amongst others: female gender [6-9], Caucasian race [10-12], biomechanical factors such as foot structure and flexibility [1,7,11], previous history of injury, high running mileage, high amount of weekly exercise [3,4,13-17], tobacco use [7,11,18,19] and low levels of physical fitness and activity [3,7,10,14,20-24]. The evidence is contradictory, however, with respect to some factors, including age, foot structure, muscular strength and body composition [3,6,7,11,12,21,24,25]. Older age is associated with a higher risk for injuries in most studies [1,8,11,21,24,26], but conflicting results are also reported [3,25,27]. Despite the large number of injuries, there is a lack of epidemiological data concerning the causes and risk factors for musculoskeletal injuries or disorders during conscription military service [9]. In addition, the study populations have been rather small with a short follow-up time [21,23,26,28]. Professional soldiers in the United States (US) have been the major target of injury research in the army environment [1,3,4,10,11], but these results are not directly comparable with those of a conscription army. The number of conscripts, their quality and motivation, as well as practices and training schedules differ substantially in the professional army.

The purpose of the present prospective six-month follow-up study of two successive arrivals was to examine associations between MSDs and various intrinsic risk factors with special attention to the physical fitness of the conscripts. The general hypothesis is that low levels of physical fitness and detrimental health behaviour factors prior to conscription are associated with MSDs during military training.

Methods

Subjects

The subjects of this study comprised male conscripts (N = 944) from six companies of one brigade (Pori Brigade, Säkylä) in the Finnish Defence Forces. The six companies enrolled into the study were: the anti-tank company, the signal company, the mortar company, the engineer company, the infantry company and the logistic company. In addition, 16 conscripts in the sample were moved to different brigades. During the study period, two arrivals of conscripts started service in the brigade: 359 in July 2006 and 619 in January 2007. The Pori Brigade is a typical Finnish garrison and the chosen companies form a representative sample of conscripts. The baseline characteristics of the companies are presented in Table 1.

The health status of the conscripts was checked during the first two weeks of service by routine medical screenings performed by a physician. Five participants were discharged temporarily (for at least 12 months) and one was discharged permanently from the military service for medical reasons. Because there were only eight women in the study (<1%), they were excluded from the data. In addition, one conscript applied for postponement of the service during the first two weeks and one patient record was missing. Eighteen (<2%) of 962 conscripts refused to participate in the study (Figure 1). All of the remaining conscripts (N = 944) agreed to participate and provided their informed consent before the initiation of the study. The group of participants was nearly the same as in a previous descriptive study by the same authors [29]. The age of the conscripts varied from 18 to 28 years (median 19). All subjects were followed for six months beginning on the first day of service. Conscripts who were discharged from the military after the two-week run-in period were included in the study and discharges were taken into account when calculating exposure times. Approval for the study protocol was obtained from the Ethics Committee of Pirkanmaa Hospital District on 11 April 2006.

Physical training programme

At the beginning of military service, conscripts performed eight weeks of basic training consisting of varying physical activities, including marching, cycling, skiing, orienteering, swimming, drill training and combat training, or other training involving moderate or heavy physical loading. There was an average of 17 hours of military training per week with a gradual increase in intensity. During combat training and marching, conscripts usually carry approximately 26 kg to 36 kg of personal military equipment and, occasionally, an additional 5 kg to 20 kg of team military equipment. In addition, conscripts performed other physical exercises, such as jogging, team sports, and circuit training, for an average of seven hours per week. The basic training period was followed by diverse training programmes depending on the company and service duration. Over the following four months of service, however, the amount of moderate and high-intensity physical training was maintained approximately at the same level in the different companies.

Musculoskeletal disorder registration

The data of the first arrival were collected from July 10th 2006 to January 5th 2007 and for the second arrival from January 8th 2007 to July 6th 2007. A musculoskeletal disorder (MSD) (including overuse and acute injuries) was defined as an event that resulted in physical damage to the body for which the conscript sought medical care

Table 1: Baseline characteristics of 944 male conscripts by company.

Variable	Anti-Tank company	Signal company	Mortar company	Engineer company	Infantry company	Logistic company	Other companies[1]	Missing	P-value[2]
Number of conscripts	249	234	69	215	100	61	16	0 (0%)	-
Age, median, years	19	19	19	19	19	19	19	0 (0%)	0.839[3]
Body mass index, median, kg/m^2	23.5	22.2	23.5	23.5	22.1	22.8	23.1	75 (8%)	0.025[3]
Waist circumference, median, cm	87.0	85.0	89.0	86.4	84.0	85.0	85.3	51 (5%)	0.015[3]
12-minute run test result, median, m	2320	2395	2530	2408	2388	2250	2535	19 (2%)	<0.001[3]
Muscle fitness index (MFI)[5], median, points	7	7	9	7	6	6	9	10 (1%)	0.005[3]
Conscript's physical fitness index (CPFI)[6],median, points	15.25	15.29	16.75	15.58	15.00	14.50	18.18	21 (2%)	<0.001[3]
	Yes	Yes	Yes	Yes	Yes	Yes	Yes		
High level of education[7],%	48%	35%	46%	39%	36%	48%	56%	10 (1%)	0.037[4]
High level of previous physical activity[8],%	31%	28%	43%	39%	17%	18%	50%	10 (1%)	<0.001[4]
Good self-assessed health[9],%	56%	54%	66%	53%	41%	41%	75%	10 (1%)	0.005[4]
Chronic impairment or disability,%	17%	11%	16%	17%	12%	17%	13%	15 (2%)	0.523[4]
Clear musculoskeletal symptoms[10],%	27%	32%	21%	28%	37%	31%	19%	11 (1%)	0.283[4]

[1] Conscript was moved to a different brigade.
[2] P-value for difference between the companies.
[3] P-value was examined by using a Kruskall-Wallis test for median difference.
[4] P-value was examined by using χ^2 statistics for difference.
[5] MFI is the sum of individual muscle fitness test results comprising push-up, sit-up, pull-up, standing long jump and back lift tests (Excellent = 13-15 points, Good = 9-12 points, Fair good = 5-8 points, Poor = 0-4 points).
[6] CPFI = (12 minute running test result (metres) + 100 × MFI)/200, (Excellent [CPFI ≥ 21.00], Good [17.00 ≤ CPFI < 21.00], Fair good [13.00 ≤ CPFI < 17.00], Poor [CPFI < 13.00]).
[7] Graduated or studies in higher education institution.
[8] Sweating exercise at least three times per week during the last month before military entry.
[9] Compared to age-mates.
[10] Symptoms lasting more than seven days in at least one anatomical region during the last month before entering the military.

from the garrison clinic. Heat or cold injuries were not included in the analysis. Only those wounds that were direct consequences of musculoskeletal contusions were considered MSDs. During military service, all conscripts had to use the services of the military healthcare units. The date, anatomical location, type, aetiological circumstances, severity and diagnosis of each MSD were registered in electronic patient records. Because the conscripts may have sought medical care several times due to the same MSD, the total number of health clinic visits exceeded the number of MSDs (Table 2). The health clinic visits were considered to be for the same disorder when the conscript had sustained an MSD of the same type and location during the preceding two weeks or if a physician had marked on the patient files that the reason for the visit was related to the previous MSD.

The type of MSD was categorised as acute if the MSD had a sudden onset involving known trauma. Overuse-related MSDs had a gradual onset without known trauma [30,31]. For instance, overuse conditions of the knee, shin, ankle and foot were categorised as lower limb overuse injuries, whereas sprains, strains, wounds, internal knee ligament ruptures and joint dislocations were typically categorised as acute injuries.

Disorders that occurred during the conscript's leisure time or on the way to vacation or back to garrison were also included. After careful clinical examination, necessary diagnostic tests and radiological graphs, the most accurate diagnosis was selected by a physician according to the 10th Revision of the International Classification of Diseases and Related Health Problems (ICD-10). The type and anatomical location of the MSD was reported according to the diagnosis. The severity of the MSD was categorised according to the number of days of limited duty: 1-3 days denoting minimal, 4-7 days mild, 8-28 moderate MSD and more than 28 days severe MSD [31]. Limited duty involved a physical restriction that prevented the conscript from fully participating in military training events. Release from military service was indicated when a physician determined a conscript unable to continue military training. Releases from military service due to musculoskeletal injuries were registered as severe MSDs.

Assessment of physical fitness

A Cooper's test (12-minute running test) and muscular fitness tests were performed by most (98%) conscripts during their first weeks of military service. A minority of conscripts (2%) were unable to complete their physical fitness tests during the first two weeks due to minor health problems, such as infections or overuse injuries. Muscular fitness tests and the 12-minute run test were performed on different days. Muscular fitness tests included push-ups, sit-ups, pull-ups, the standing long jump and a back-lift test [32]. Instructors of the companies supervised so that each test was performed technically correctly. The recovery time between each muscle test was at least five minutes. For the pull-up, a conscript was required to raise his chin over a bar and then return to the starting point with elbows fully extended. For the standing long jump, a conscript started the jump with legs close to each other and bilateral take-off was assisted by swinging of the upper body and arms. The landing was bilateral and shortest distance expressed in metres from the landing to the starting point was measured. For the sit-up, a conscript was lying on the floor supine with hands behind the neck. The knees were flexed at an angle of 90°, and an assistant supported the ankles. The conscript raised the upper body until his elbows touched the knees and then returned to the starting position where both scapulas touched the floor. For the push-up, a conscript was first required to fully extend his arms while keeping the body straight with tensed trunk muscles. In the second phase, the body was lowered to the down position with an elbow angle of 90°. For the back lift, a conscript lay prone on the floor with hands behind the neck in the starting position and an assistant supported the legs. During the movement, the upper body was lifted until the scapulas were approximately 30 cm higher than in the starting point. Thereafter, the upper body was lowered down back to the starting position. More detailed information about physical fitness tests is presented in Figures 2, 3, 4, 5 and 6.

To calculate the muscle fitness index (MFI), the points from individual muscle fitness test results (push-ups, sit-ups, pull-ups, standing long jump, and back lift) were added together (Excellent = 13-15 points, Good = 9-12 points, Fair good = 5-8 points, Poor = 0-4 points). Poor result in individual muscle fitness test equated to zero points, a fair good result to one point, a good result to two points and an excellent result to three points. A conscript's physical fitness index (CPFI) was calculated using the following formula: (12 min running test result (metres) + 100 × MFI)/200 (Table 1, see footnotes 5 and 6). These formulas are based on standard practice in the Finnish Defence Forces since 1982 [33]. Because excellent results in Cooper's test were uncommon (<4%), the two highest levels, good and excellent, were combined to obtain a group of equal size for comparison. In addition, Cooper's and individual muscle fitness test results were combined into a single variable to explore whether the combined fitness variable, representing co-impairment, would be more strongly associated with the occurrence of MSDs.

Two additional physical fitness tests of motor skill (running a figure of eight and standing on a narrow beam) were performed for study purposes (Figures 7 and 8). In addition, height, weight and waist circumference were measured during the first two weeks of service. Body mass index (BMI) was calculated by dividing weight (kilograms) with the square of height (metres). Waist circumference (WC) as a mark of abdominal obesity and excessive visceral fat [34] was measured with a tape at the midway between the lowest rib and iliac crest after normal exhalation. The cut-off points to describe overweight and obesity for BMI and WC were set according to the World Health Organization [35] (Table 3).

Pre-information questionnaire

A questionnaire was used to determine the conscripts' socio-economic factors (father's occupational group, school success and urbanisation level of the place of residence; Table 4), health (self-assessed health compared to age-mates, chronic disease, medication, previous orthopaedic surgeries and sport injuries, chronic impairment or disability and musculoskeletal pain in seven anatomical regions during the last month; Table 3) and health behaviour (use of alcohol and tobacco, frequency of drunkenness, opinion about physical demands of a soldier, amount of physical exercise, participation in individual aerobic sports, belonging to a sports club, participation in competitive sports, last degree achieved

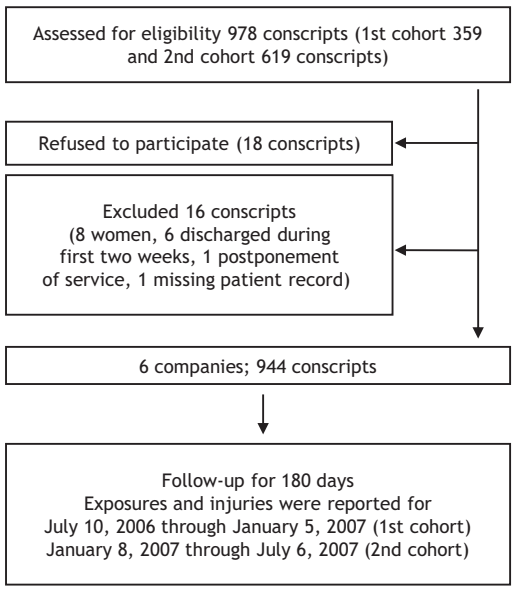

Figure 1 Flow of conscripts through study.

in school sports and self-assessed physical fitness; Table 5) at the baseline of the study just before entry to the military service. The questionnaires were performed during the first week of service.

The school success variable was constructed as a combination of school type attended and grades achieved compared to an intermediate student in the class (Table 4), as follows: Excellent, attended an upper secondary school, polytechnic, or university and reported above average grades; Good, attended upper secondary school, polytechnic, or university and reported average or below average grades, or attended vocational schools and had above average grades; Satisfactory, attended vocational school and reported average or below average grades; Poor, attended only comprehensive school or had permanently interrupted vocational or upper elementary school.

Conscripts entering military service were young healthy men, all of whom had a medical check-up by a clinician during the 12 months before entering into the military. At the baseline, musculoskeletal symptoms during the last month before entry were assessed by a questionnaire. The sum factor of different musculoskeletal symptoms was developed by taking into account the questions about musculoskeletal pain and its severity in seven anatomical locations (neck, shoulder, forearm, low back, low back pain with radiation, hip, knee). Based on this factor, three different musculoskeletal symptoms categories were constructed (Table 3). Conscripts belonging to the 'minimal symptoms' category had symptoms lasting maximally for seven days in one anatomical region. The 'mild symptoms' category included conscripts who had pain in two to six anatomical regions, but the symptoms had not lasted longer than a week. The category of 'clear symptoms at least in one region' comprised the remaining conscripts.

Table 2: Distribution of musculoskeletal disorders by anatomical location in 944 male conscripts during six-month military service.

Body part	Total number (%)	Acute/Overuse,%	Incidence* (95% CI)	Average number of health clinic visits per disorder
Lower extremity	1063 (65%)	26/74	6.9 (6.5-7.3)	1.8
Knee	315 (19%)	32/68	2.0 (1.8-2.3)	2.0
Ankle	192 (12%)	39/61	1.2 (1.1-1.4)	1.7
Foot	195 (12%)	8/92	1.3 (1.1-1.5)	1.9
Shin	103 (6%)	15/85	0.7 (0.5-0.8)	2.5
Back	300 (18%)	19/81	1.9 (1.7-2.2)	1.8
Low back pain	263 (16%)	18/82	1.7 (1.5-1.9)	1.8
Upper extremity	177 (11%)	56/44	1.1 (1.0-1.3)	1.5
Shoulder	87 (5%)	28/72	0.6 (0.5-0.7)	1.6
Head	32 (2%)	100/0	0.2 (0.1-0.3)	1.3
Other parts of body	57 (3%)	43/57	0.4 (0.3-0.5)	1.7
Total	1629 (100%)	30/70	10.5 (10.0-11.1)	1.8

Total number, proportions of acute and overuse-related disorders and their incidence and mean number of health clinic visits per disorder are given according to the anatomical location.

* Event-based incidence expressed as total number per 1000 person-days

Statistical analysis

SPSS 17.0 for Windows software (SPSS Inc., Chicago, IL) was used for statistical analysis. MSD incidence was calculated by dividing the number of conscripts with one or more MSDs treated in the garrison clinic (numerator) for MSD by the total number of conscripts (denominator) and expressed as a percentage. Person-based incidence rate was calculated by dividing the number of conscripts treated in the garrison clinic for MSD by the exposure time. Exposure time for person-based incidence rate was calculated until onset of the conscript's first MSD. Event-based incidence rate was calculated by dividing the total number of MSDs by the exposure time. Exposure time for event-based incidence rate was calculated until the end of follow-up. Time loss due to MSD was allowed for when calculating the exposure time for the event-based incidence rate. The incidences with 95% confidence intervals (CI) were expressed per 1000 person-days. Descriptive statistics were used to analyse the data. To examine differences in the categorical baseline characteristics, the χ^2 statistics was used to test the hypothesis of no difference. Since continuous variables regarding baseline characteristics were not normally distributed, a Kruskall-Wallis test was used to test for a difference between the companies for continuous variables. A P value of < 0.05 was considered statistically significant.

Cox's proportional hazard models were applied to study the prospective associations between baseline characteristics and musculoskeletal disorder incidence (MSDI). The primary outcome was defined as an incidence of any type of MSD. The secondary outcome was defined as an incidence of time loss of at least 10 active service days due to one or several MSDs (hereafter referred to as a long-term MSDI). To examine the associations between risk factors and MSDs, continuous variables relating to physical fitness (Table 6) and body characteristics (Table 3) were converted into categorical variables. In the first phase of the Cox regression, each independent variable was analysed one at a time (univariate). Results were expressed as hazard ratios (HR) and calculated with 95% CIs with age at baseline forced into the model. A multivariate Cox regression was used to identify independent risk factors for MSDI and long-term MSDI and examine interactions between risk factors. Only possibly significant variables (P < 0.20) in the initial univariate-models were included in the multivariate model: company, father's occupational group, urbanisation level of the place of residence, self-assessed health, opinion about physical demands for a soldier, last degree achieved in school sports, belonging to a sports club and self-assessed physical fitness were included in the multivariate model as possible confounders. Smoking status (previous or current regular smoker), poor baseline medical condition (sports injury during the last month before military entry, chronic impairment or disability due to prior musculoskeletal injury, earlier musculoskeletal symptoms, chronic disease), not participating in individual aerobic sports and low physical activity during the previous three months before military entry were entered into the multivariate model as known risk factors. We considered poor school success (educational level and grades combined), participation in competitive sports, height and high frequency of drunkenness before military service as possible risk factors after univariate modelling and entered these variables into the multivariate model although the literature considering these variables as risk factors of MSDs during military training is sparse. In addition, high waist circumference and older age were considered possible risk factors and were therefore included in the multivariate model although results from previous studies are to some extent conflicting. A P value of < 0.05 was considered statistically significant when

STANDING LONG-JUMP TEST

Purpose: To measure explosive force production of the lower limb extensor muscles as well as motor control.

Method: The jump starts with legs close to each other and bilateral takeoff is assisted by swinging of the upper body and arms. The landing is bilateral and shortest distance expressed in metres from the landing to the starting point was measured.

Outcome: The conscript has two attempts and the best result is registered. Result categories: Excellent (≥2,40 m), Good (≥2,20 m), Fair good (≥2,00 m) and Poor (<2,00 m).

Figure 3 Description of standing long jump test. The test is based on practice in the Finnish Defence Forces.

PULL-UP TEST

Purpose: To measure dynamic endurance of flexor muscles in arm and shoulder.

Method: The conscript is required to raise his chin over a bar and then return to the starting point with elbows fully extended.

Outcome: Repeats without time limit. Repeats have to be consecutive and intermission in the starting point is not allowed. Result categories: Excellent (≥14), Good (≥10), Fair good (≥6) and Poor (<6) [repeats].

Figure 2 Description of pull-up test. The test is based on practice in the Finnish Defence Forces.

SIT-UP TEST

Purpose: To measure dynamic endurance of abdominal and hip-flexor muscles.

Method: The conscript is lying on the floor supine with hands behind the neck. The knees are flexed at an angle of 90°, and an assistant supports the ankles (contrary to the picture). The conscript raises upper body until his elbows touches the knees and then returns to the starting position where both scapulas touches the floor.

Outcome: Number of consecutive repeats completed in 60 seconds. Result categories: Excellent (≥48), Good (≥40), Fair good (≥32) and Poor (<32) [repeats].

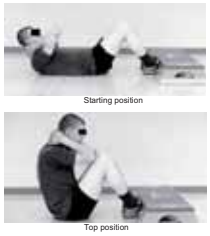

Figure 4 Description of sit-up test. The test is based on practice in the Finnish Defence Forces.

PUSH-UP TEST

Purpose: To assess dynamic strength of the upper body and the ability to stabilise the trunk.

Method: The conscript starts from the lowest face-down position and hands are kept shoulder-wide level. During the push-up, a conscript was first required to fully extend his arms while keeping the body straight with tensed trunk muscles. In the second phase, the body was lowered to the down position with an elbow angle of 90°.

Outcome: Number of consecutive repeats completed in 60 seconds. Result categories: Excellent (≥38), Good (≥30), Fair good (≥22) and Poor (<22) [repeats].

Starting position

Top position

Figure 5 Description of push-up test. The test is based on practice in the Finnish Defence Forces.

interpreting the results from Cox's proportional hazard models.

Results

Incidence of musculoskeletal disorders

During the one-year study period (July 2006-July 2007), a total of 1629 MSDs and 2879 health clinic visits due to MSDs were registered in the garrison clinic. A total of 652 of 944 (69%) conscripts sustained one or more MSDs during the six-month service. Of these, 35% had one, 24% had two, 17% had three, 11% had four, 7% had five and 6% had from six to ten MSDs. A total of 194 (21%) conscripts suffered from long-term MSD (≥10 service days lost due to one or several MSDs). The event-based incidence rate for MSD was 10.5 (95% CI: 10.0-11.1) and the person-based incidence rate was 7.1 (95% CI: 6.6-7.7) per 1000 person-days, respectively. The MSD incidences for first (68%) and second (69%) arrival did not vary statistically significantly ($P = 0.74$).

Type and anatomical location of musculoskeletal disorders

Most MSDs were in the lower extremities (65%) followed by the back (18%), upper extremities including shoulders (11%), head (2%) and other parts of the body (torso excluding back; 3%) (Table 2). The most common types of MSDs were lower limb overuse injuries (48%) and low back pain (16%). Overuse-related MSDs (70%) were more than twice as prevalent as traumatic MSDs (30%; Table 2).

RUNNING A FIGURE OF EIGHT

Purpose: To assess agility, speed and body control during rapid turns.

Method: The conscript runs as fast as possible a figure of eight around two traffic cones placed 10 metres apart with the start/finish line next to one of the cones. The stopwatch is started concurrently with the starting signal and stopped when the subject crosses the start/finish line again.

Outcome: Time in seconds. Result were categorised in quartiles: 1st quartile (<6.03), 2nd quartile (6.03 ≤ time < 6.27), 3rd quartile (6.27 ≤ time ≤ 6.60), 4th quartile (> 6.60).

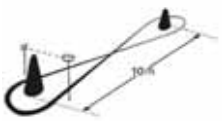

Diagram of the performance of running a figure of eight test.

Figure 7 Description of running a figure of eight test. The test was performed for study purposes.

Severity, immediate causes and associated activities of musculoskeletal disorders

The majority (69%, n = 1119) of disorders were classified as minimal leading to a maximum three-day exemption from military training, while mild MSDs accounted for 20% (n = 328), moderate for 8% (n = 138) and severe for 3% (n = 44) of all cases. Fractures (n = 15), bone stress injuries (foot n = 7, shin n = 5, femur n = 2, calcaneus n = 1; total 15 cases), dislocations (n = 22) and internal knee injuries (n = 25) represented the most severe injuries and accounted for the majority of long-term exemptions from military training. Twenty-eight (3.0% of all) conscripts were released temporarily (for at least six months) from military service due to MSDs after the two-week run-in period.

MSDs occurred mostly (93%) during military training. Some (7%) occurred during vacations and four cases (0.3%) while travelling to vacation or back to the garrison. Of the immediate causes of acute MSDs, falling down (17%) and collision with an object (16%) were most commonly associated with MSDs. The following immediate causes were: tackling or struggling during sports exercise (5%), jumping (5%), malposition of foot during ground contact (4%), traffic accident (4%), slipping (4%) and being compressed between two objects (4%). In 12% of acute MSDs, the immediate cause remained unclear. Marching and running (36%) were the most common activities associated with overuse-related MSDs, followed by carrying and lifting loads (10%) and other organised physical exercise excluding marches and combat training (6%). For 27% of overuse-related MSDs, however, the

BACK LIFT TEST

Purpose: To measure dynamic endurance of back and hip-extensor muscles.

Method: The conscript lies prone on the floor with hands behind the neck in the starting position. An assistant supports the legs (contrary to the picture). During the movement, the upper body is lifted until the scapulas are approximately 30 cm higher than in the starting point. Thereafter, the upper body is lowered down back to the starting position.

Outcome: Number of consecutive repeats completed in 60 seconds. Result categories: Excellent (≥60), Good (≥50), Fair good (≥40) and Poor (<40) [repeats].

Starting position

Top position

Figure 6 Description of back lift test. The test is based on practice in the Finnish Defence Forces.

ONE-LEG STANDING ON A NARROW BEAM

Purpose: To measure efficiency of static postural control while the are of support is reduced.

Method: The narrow beam (1cm wide) is placed on the floor. The person stands on one foot on bar with shoes on, the unsupporting foot off the floor. The conscript can choose which foot to stand on, and is allowed to use his arms to balance.

Outcome: Attempts needed to collect one minute total standing time is counted. The tester stops the watch every time the unsupporting foot touches the floor and restarts the watch when the foot is of the floor again.

Starting position or foul which stops the watch

Performance position

Figure 8 Description of one-leg standing on a narrow beam test. The test was performed for study purposes.

Table 3: Hazard ratios (HR) for musculoskeletal disorder (MSD) incidence and incidence of long-term MSD by health variables at baseline.

Health variable	Category	Total number (% of experienced MSD;% of experienced ≥10 service days lost due to MSDs)	HR for MSD incidence (n = 652) *	HR for MSD incidence (n = 652) **	HR for long-term MSD incidence (≥10 service days lost) (n = 194) *	HR for long-term MSD incidence (≥10 service days lost) (n = 194) **
Body mass index[1] (BMI = (kg)/(m)^2)	Underweight (BMI < 18.5)	44 (66; 20)	1.1 (0.7-1.5)	1.1 (0.7-1.6)	1.1 (0.6-2.2)	1.1 (0.5-2.2)
	Normal (18.5 ≤ BMI < 25.0)	539 (67; 19)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Pre-obese (25.0 ≤ BMI < 30.0)	220 (71; 19)	1.1 (0.9-1.3)	**1.2 (1.0-1.5)**	1.0 (0.7-1.5)	1.1 (0.7-1.6)
	Obese (BMI ≥ 30.0)	66 (82; 33)	**1.7 (1.3-2.3)**	**1.8 (1.3-2.4)**	**2.0 (1.3-3.2)**	**1.9 (1.2-3.2)**
Waist circumference (WC, cm)	Thin (WC < 80)	177 (64; 20)	1.0 (0.8-1.2)	1.0 (0.8-1.2)	1.2 (0.8-1.8)	1.1 (0.7-1.6)
	Normal (80 ≤ WC < 94)	499 (68; 17)	1 (Referent))	1 (Referent)	1 (Referent))	1 (Referent)
	Increased (94 ≤ WC < 102)	126 (74; 23)	1.2 (1.0-1.5)	1.2 (1.0-1.6)	1.4 (0.9-2.1)	1.3 (0.8-2.0)
	High (WC ≥ 102)	91 (79; 32)	**1.6 (1.2-2.0)**	**1.7 (1.3-2.2)**	**2.1 (1.4-3.3)**	**2.2 (1.3-3.5)**
Height (cm)	Shortest quartile (≤176)	184 (71; 24)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Second quartile (177-180)	248 (63; 15)	0.8 (0.7-1.0)	0.9 (0.7-1.2)	**0.6 (0.4-0.9)**	0.7 (0.4-1.1)
	Third quartile (181-184)	212 (71; 20)	1.0 (0.8-1.3)	1.0 (0.8-1.3)	0.8 (0.6-1.3)	0.8 (0.5-1.2)
	Tallest quartile (≥184)	225 (72; 21)	1.0 (0.8-1.3)	1.1 (0.9-1.4)	0.9 (0.6-1.3)	0.8 (0.5-1.3)
Self-assessed health[2]	Good or very good	500 (66; 17)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Average or inferior	434 (72; 24)	**1.3 (1.1-1.6)**	1.0 (0.9-1.3)	**1.6 (1.2-2.1)**	0.9 (0.7-1.3)
Sum factor of musculoskeletal symptoms	Minimal symptoms[3]	305 (62; 14)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Mild symptoms[4]	357 (68; 21)	**1.2 (1.0-1.5)**	**1.4 (1.1-1.7)**	**1.7 (1.1-2.4)**	**1.9 (1.3-2.9)**
	Clear symptoms[5]	271 (78; 28)	**1.8 (1.5-2.2)**	**1.7 (1.3-2.1)**	**2.4 (1.7-3.6)**	**2.6 (1.7-3.9)**
Chronic disease	No	687 (68; 21)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Yes	247 (72; 21)	1.2 (1.0-1.4)	1.1 (0.9-1.3)	1.0 (0.8-1.4)	1.1 (0.8-1.6)
Regular medication	No	834 (69; 21)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Yes	96 (72; 18)	1.1 (0.9-1.4)	1.1 (0.8-1.4)	0.8 (0.5-1.4)	0.7 (0.4-1.3)
Orthopaedic surgery	Never	858 (68; 20)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Yes	74 (73; 27)	1.2 (0.9-1.6)	1.1 (0.8-1.6)	1.3 (0.8-2.1)	1.4 (0.9-2.4)

Table 3: Hazard ratios (HR) for musculoskeletal disorder (MSD) incidence and incidence of long-term MSD by health variables at baseline. (Continued)

Chronic impairment or disability[6]	No	789 (67; 19)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Yes	140 (81; 31)	**1.6 (1.3-2.0)**	**1.4 (1.1-1.7)**	**1.8 (1.3-2.5)**	1.4 (0.9-2.1)
Sports injury during last month	No	842 (67; 20)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Yes	88 (82; 25)	**1.4 (1.1-1.8)**	**1.4 (1.0-1.8)**	1.3 (0.8-2.0)	1.2 (0.7-2.0)

Variable distribution was charted in 944 male conscripts during the first week of military service and MSD outcomes were registered during the following six-month military service. Long-term MSD was defined as an incidence of time loss of at least 10 active service days due to one or several MSDs. Statistically significant findings are indicated with bold type.

* Adjusted for age (univariate).

** Adjusted for age, company, smoking, frequency of drunkenness before military service, baseline medical conditions (sports injury during the last month before military entry, chronic impairment or disability due to prior musculoskeletal injury, earlier musculoskeletal symptoms, chronic disease), school success (educational level and grades combined), father's occupation, opinion about physical demands for a soldier, urbanisation level of the place of residence, self-assessed health, waist circumference, height, participating in individual aerobic sports, last degree achieved in school sports, belonging to a sports club, self-assessed physical fitness, participation in competitive sports and physical activity during the previous three months before entering the military.

[1] Not adjusted by waist circumference since BMI and WC strongly interconnected (χ^2-test, $p < 0.001$).

[2] Compared to age-mates.

[3] 'Minimal symptoms': maximum seven-day lasting symptom in one anatomical region during the last month before entering the military.

[4] 'Mild symptoms': symptoms in two to six anatomical regions, but the symptoms had lasted a maximum of one week during the last month before military entry.

[5] 'Clear symptoms': included the remaining conscripts.

[6] Due to prior musculoskeletal injury.

associated activity remained unclear due to the gradual onset of the MSD.

Risk factors of musculoskeletal disorders

Tables 3, 4, 5 and 6 show the distribution of variables and the hazard ratios of MSDI and long-term MSDI for various health (Table 3), socio-economic (Table 4), health behaviour (Table 5) and physical fitness variables (Table 6) in the univariate and adjusted models.

With regard to *health*, we observed a strong association between obesity and MSDs. A BMI over 30 increased the risk for MSDI (HR 1.8; 95% CI: 1.3-2.4) and long-term MSDI (HR 1.9; 95% CI: 1.2-3.2). In addition, the pre-obese category (25 ≤ BMI < 30) was associated with MSDI, but not with long-term MSDI. Abdominal obesity (WC over 102 cm) was associated with a 1.7-fold risk for MSDI (95% CI: 1.3-2.2) and a 2.2-fold risk for long-term MSDI (95% CI: 1.3-3.5). A low self-assessed health level compared to age-mates was associated with both outcomes in univariate models, but not after further adjustments. Of the baseline medical conditions, the sum factor of musculoskeletal symptoms was the strongest predictor for both outcomes with a dose-response relationship. In addition, chronic impairment or disability due to earlier musculoskeletal injury and earlier sport injuries were associated with MSDI (Table 3).

From the *socio-economic background* variables, a conscript's poor school success was associated with a two-fold risk for MSDI (95% CI: 1.3-3.0) and a 2.2-folded risk for long-term MSDI (95% CI: 1.1-4.5) (Table 4). In addition, father's occupation was associated with MSDI, but not with long-term MSDI. The company of the conscript was clearly associated with both outcome variables. During the 180 days of military service, the MSDI was lowest in the anti-tank and mortar companies and highest in the infantry company (Table 4).

With regard to *health behaviours*, there was a strong association between detrimental health behaviour factors and MSDs based on the univariate analysis, but after further adjustments these associations weakened (Table 5). Smoking, use of alcohol, frequency of drunkenness, physical inactivity, not participating in individual aerobic sports, not belonging to a sports club, low level of achievement in school sports and low self-assessed physical fitness were all associated with the both outcomes in univariate models. In the final model, however, only high frequency of drunkenness, not belonging to a sports club, and on other hand, participating in competitive sports were associated with MSDI. Present or former cigarette smoking and not belonging to a sports club were associated with the long-term MSDI in the final model (Table 5).

High hazard ratios of MSD were observed in those conscripts with low levels of *physical fitness test results* (Table 6). Each fitness test was associated with MSDI or

Table 4: Hazard ratios (HR) for musculoskeletal disorder (MSD) incidence and incidence of long-term MSD by socio-economic variables and company at baseline.

Socioeconomic background & company	Category	Total number (% of experienced MSD;% of experienced ≥10 service days lost due to MSDs)	HR for MSD incidence (n = 652) *	HR for MSD incidence (n = 652) **	HR for long-term MSD incidence (≥10 service days lost) (n = 194) *	HR for long-term MSD incidence (≥10 service days lost) (n = 194) **
Father's occupational group	Not physical	325 (64; 20)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Physical	416 (70; 20)	1.2 (1.0-1.4)	1.1 (0.9-1.4)	1.0 (0.7-1.4)	0.9 (0.6-1.3)
	Unclear or unemployed	185 (74; 24)	**1.3 (1.0-1.6)**	**1.3 (1.1-1.7)**	1.2 (0.8-1.7)	1.1 (0.7-1.7)
School success (combination of school type attended and school success)	Excellent[1]	138 (52; 12)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good[2]	410 (70; 18)	**1.7 (1.3-2.2)**	**1.4 (1.1-1.9)**	1.6 (0.9-2.7)	1.1 (0.6-1.9)
	Satisfactory[3]	319 (72; 24)	**1.9 (1.5-2.5)**	**1.5 (1.1-2.0)**	**2.3 (1.3-3.8)**	1.3 (0.7-2.4)
	Poor[4]	67 (81; 37)	**2.7 (1.9-3.9)**	**2.0 (1.3-3.0)**	**4.2 (2.2-7.7)**	**2.2 (1.1-4.5)**
Urbanisation level of the place of residence	≥10000 inhabitants	552 (70; 20)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	<10000 inhabitants	382 (66; 21)	1.0 (0.8-1.1)	0.9 (0.8-1.1)	1.1 (0.8-1.4)	1.0 (0.7-1.4)
Age	18-19 years	723 (68; 20)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	20-28 years	221 (71; 23)	1.1 (0.9-1.3)	1.1 (0.9-1.3)	1.2 (0.9-1.6)	1.2 (0.8-1.7)
Company	Anti-tank company	249 (61; 16)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Signal company	234 (66; 16)	1.2 (1.0-1.5)	**1.3 (1.0-1.6)**	1.0 (0.7-1.6)	1.1 (0.7-1.8)
	Mortar company	69 (61; 9)	1.0 (0.7-1.4)	1.2 (0.8-1.7)	0.5 (0.2-1.2)	0.8 (0.3-1.9)
	Engineer company	215 (76; 24)	**1.5 (1.2-1.8)**	**1.5 (1.2-2.0)**	**1.6 (1.0-2.3)**	1.5 (0.9-2.4)
	Infantry company	100 (86; 36)	**2.1 (1.6-2.8)**	**1.9 (1.4-2.6)**	**2.6 (1.7-4.1)**	**2.6 (1.6-4.3)**
	Logistic company	61 (77; 34)	**1.7 (1.2-2.4)**	**1.7 (1.2-2.4)**	**2.4 (1.4-4.1)**	**2.2 (1.2-3.9)**
	Other companies[5]	16 (50; 0)	0.8 (0.4-1.7)	1.0 (0.5-2.1)	0.0 (0.0-∞)	0.0 (0.0-∞)

Variable distribution was charted in 944 male conscripts during the first week of military service and MSD outcomes were registered during the following six-month military service. Long-term MSD was defined as an incidence of time loss of at least 10 active service days due to one or several MSDs. Statistically significant findings are indicated with bold type.

* Adjusted for age (univariate).

** Adjusted for age, company, smoking, frequency of drunkenness before military service, baseline medical conditions (sports injury during the last month before military entry, chronic impairment or disability due to prior musculoskeletal injury, earlier musculoskeletal symptoms, chronic disease), school success (educational level and grades combined), father's occupation, opinion about physical demands for a soldier, urbanisation level of the place of residence, self-assessed health, waist circumference, height, participating in individual aerobic sports, last degree achieved in school sports, belonging to a sports club, self-assessed physical fitness, participation in competitive sports and physical activity during the previous three months before entering the military.

[1] Attended upper secondary school, polytechnic or university and reported excellent or good grades.

[2] Other subjects from upper secondary school, polytechnic or university and conscripts from vocational school whose grades were excellent or good.

[3] Respondents with poorer grades in vocational school.

[4] Attended only comprehensive school or had permanently interrupted vocational or upper elementary school.

[5] Conscripts were moved to different brigades.

long-term MSDI in univariate models (Table 6). However, after final adjustments, only the 12-minute running test (Cooper) maintained its significance for both MSDI (HR 1.6; 95% CI: 1.2-2.2) and long-term MSDI (HR 2.5; 95% CI: 1.4-4.5). In addition, the back lift test was associated with MSDI in the final model. Cooper's and individual muscle fitness test results were combined into one variable to explore whether co-impairment in aerobic and muscular fitness would increase the risk for MSDs. Combinations of poor fitness in Cooper's test and standing long jump, push-up and back lift tests proved to be the strongest predictors for both outcomes with a dose-response relationship. Poor results in both Cooper's and standing long jump test were associated with a 1.6-fold risk for MSDI (95% CI: 1.0-1.6) and 3.0-fold risk for long-term MSDI (95% CI: 1.2-7.8). Accordingly, poor results in both Cooper's and push-up test were clear predictors for both outcomes, HR being 1.8 (95% CI: 1.2-2.8) for MSDI and 2.8 (95% CI: 1.2-6.2) for long-term MSDI. In addition, poor results in both Cooper's and back lift test were strongly associated with MSDI (HR 2.9; 95% CI: 1.9-4.6) and long-term MSDI (HR 2.7; 95% CI: 1.2-5.9) (Table 6). Results of the pull-up or sit-up test combined with Cooper's test, however, were not significant for either outcome (data not shown).

Discussion

In the present study, we examined risk factors for MSDs among male conscripts during a six-month military service. The findings indicated that a low level of physical fitness expressed by 12-minute running (Cooper's test) was clearly associated with MSD with a dose-response relationship, confirming the association of low levels of aerobic fitness and subsequent risk of injury [6-8,18,20-24,36,37]. Furthermore, we present new findings that poor results in standing long jump, push-up or back lift tests combined with poor result in Cooper's test are strong predictors for MSDs. In addition, higher WC and BMI, earlier musculoskeletal symptoms, poor school success and company were all clearly associated with MSDs elucidating previously equivocal findings. It was also observed that some military tasks specific to the company involve higher risks for MSDI than other tasks. Good entry-level physical fitness, normal BMI and normal WC were protective factors against MSDI in all companies suggesting that these intrinsic and modifiable risk factors are amenable for prevention programmes.

The main finding of the present study was the association between low physical fitness and MSDs. A number of studies have documented the association of low levels of aerobic fitness and subsequent risk of injury [6-8,18,20-24,36,37], although a conflicting result was reported in a Finnish study of injury hospitalisations [9]. Poor muscular strength and endurance are also reported to be risk factors for injuries during military training, although not as frequently [7,8,23,27]. A civilian study among intercollegiate basketball and track athletes clarified these findings by demonstrating that core stability has an important role in the prevention of lower extremity injuries [38]. The findings of the present study, that poor back lift or push-up test result combined with poor aerobic endurance (Cooper's test) are strong predictors for MSDs, support the importance of core strength and stability to protect against MSDs. Moreover, improved control of the lumbar neutral zone with trunk muscles decreases low back pain among middle-aged men [39], a common MSD in the present study.

The US Army Physical Fitness Test includes a two-mile (3.2 km) run and push-up and sit-up tests. Hence, the finding that MSDs were associated with poor results in standing long jump and back-lift tests is new. In the present study, a combination of Cooper's test and lower extremity muscle fitness (standing long jump test) proved to be a strong predictor for MSDs with a dose-response relationship. The standing long jump requires efficient motor control of the whole body in addition to measuring power production of the lower limb extensor muscles. Moreover, the standing long jump test is a good marker of lower limb dynamic muscle strength [40]. The present finding suggests that in addition to good aerobic endurance, motor control and strength of the lower extremities are important factors of physical fitness in the prevention of MSDs during military training. However, criticisms have been raised with regard to army physical fitness tests because they tend to penalise larger, not just fatter, individuals because body weight acts as a load. Larger individuals receive lower scores than their lighter counterparts, although larger persons perform work-related fitness tasks, such as carrying loads, better in a military environment [41].

Individuals with lower aerobic capacity probably experience greater physiological stress than individuals with better aerobic fitness during long-term military basic training (marching, running, combat training), which may also predispose to MSDs [1,7]. Various hypothetical mechanisms have been presented to explain this association. Conscripts with lower aerobic fitness levels may perceive military training as more difficult and fatigue more rapidly [42]. It has also been proposed that fatigue leads to changes in gait and kinematics in lower extremities [43,44] which may result in musculoskeletal stress in specific body areas and predispose to injuries [45].

Low levels of physical activity are associated with injuries in several military studies [3,7,11,21,37]. In the present study, low physical activity level during the three months prior to entering military service was associated with the risk of MSDI with a dose-response relationship, but only in the univariate models. This may be due to the

Table 5: Hazard ratios (HR) for musculoskeletal disorder (MSD) incidence and incidence of long-term MSD by health behaviour variables at baseline.

Health behaviour	Category	Total number (% of experienced MSD;% of experienced ≥10 service days lost due to MSDs)	HR for MSD incidence (n = 652) *	HR for MSD incidence (n = 652) **	HR for long-term MSD incidence (≥10 service days lost) (n = 194) *	HR for long-term MSD incidence (≥10 service days lost) (n = 194) **
Smoking habits	Never smoked regularly	492 (62; 14)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Has smoked regularly	439 (76; 28)	**1.5 (1.2-1.7)**	1.1 (0.9-1.3)	**2.1 (1.6-2.9)**	**1.5 (1.0-2.1)**
Use of alcohol	<1 time per month	176 (57; 14)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	1-2 times per week	603 (70; 21)	**1.3 (1.0-1.6)**	1.2 (0.9-1.5)	1.5 (1.0-2.2)	1.3 (0.8-2.1)
	≥3 times per week	154 (78; 25)	**1.7 (1.3-2.2)**	1.3 (1.0-1.9)	**1.8 (1.1-3.0)**	1.0 (0.5-1.9)
Frequency of drunkenness before military service	<1 time per week	723 (66; 19)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	≥1 time per week	211 (77; 27)	**1.4 (1.2-1.7)**	**1.3 (1.1-1.6)**	**1.6 (1.2-2.2)**	1.3 (0.9-1.8)
Agrees that soldier needs good physical fitness	Yes	598 (67; 19)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	No	336 (71; 23)	1.1 (1.0-1.3)	1.0 (0.8-1.2)	1.2 (0.9-1.6)	1.0 (0.7-1.3)
Sweating exercise (Brisk leisure time sport)	≥3 times per week	287 (62; 13)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	1-2 times per week	282 (72; 21)	**1.3 (1.1-1.6)**	1.2 (0.9-1.5)	**1.7 (1.1-2.5)**	1.2 (0.7-2.0)
	Only leisured exercise	183 (69; 24)	**1.4 (1.1-1.8)**	1.2 (0.9-1.6)	**2.1 (1.4-3.2)**	1.4 (0.8-2.3)
	No physical exercise	182 (75; 29)	**1.6 (1.3-2.0)**	1.2 (0.9-1.6)	**2.5 (1.7-3.9)**	1.3 (0.7-2.3)
Participates in individual aerobic sports	Yes, at least sometimes	638 (67; 18)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	No	293 (73; 26)	**1.2 (1.0-1.5)**	1.1 (0.9-1.3)	**1.6 (1.2-2.1)**	1.3 (0.9-1.8)
Belongs to a sports club	Yes, an active member	148 (64; 10)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	No	782 (70; 23)	**1.3 (1.0-1.6)**	**1.5 (1.1-2.0)**	**2.6 (1.5-4.4)**	**2.9 (1.4-5.8)**

Table 5: Hazard ratios (HR) for musculoskeletal disorder (MSD) incidence and incidence of long-term MSD by health behaviour variables at baseline. (Continued)

Participates in competitive sports	Yes	138 (71; 16)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	No	794 (68; 21)	1.0 (0.8-1.2)	**0.7 (0.5-0.9)**	1.5 (0.9-2.3)	0.6 (0.3-1.1)
Last degree achieved in school sports	Very good or excellent	436 (67; 19)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good	301 (66; 20)	1.0 (0.9-1.2)	1.0 (0.8-1.2)	1.1 (0.8-1.5)	1.0 (0.7-1.4)
	Poor or fair	196 (76; 27)	**1.3 (1.1-1.6)**	1.0 (0.8-1.2)	**1.6 (1.1-2.3)**	0.8 (0.5-1.3)
Self-assessed physical fitness [1]	Good or very good	217 (65; 14)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Average or inferior	717 (70; 23)	**1.3 (1.1-1.6)**	1.0 (0.8-1.2)	**1.8 (1.2-2.6)**	1.1 (0.7-1.8)

Variable distribution was charted in 944 male conscripts during the first week of military service and MSD outcomes were registered during the following six-month military service. Long-term MSD was defined as an incidence of time loss of at least 10 active service days due to one or several MSDs. Statistically significant findings are indicated with bold type.
* Adjusted for age (univariate).
** Adjusted for age, company, smoking, frequency of drunkenness before military service, baseline medical conditions (sports injury during the last month before military entry, chronic impairment or disability due to prior musculoskeletal injury, earlier musculoskeletal symptoms, chronic disease), school success (educational level and grades combined), father's occupation, opinion about physical demands for a soldier, urbanisation level of the place of residence, self-assessed health, waist circumference, height, participating in individual aerobic sports, last degree achieved in school sports, belonging to a sports club, self-assessed physical fitness, participation in competitive sports and physical activity during the previous three months before entering the military.
[1] Compared to age-mates.

fact that results in the final model were adjusted by other physical activity-related variables. Physical activity level before entry into the military service in particular, is associated with overuse injuries [10,20,23,36,46] suggesting that untrained conscripts overload their musculoskeletal structures and tissues more often than their active counterparts during military training.

Among young civilians, high exposure to competitive sports participation is associated with a higher risk of injuries [47,48], consistent with the findings of the present study. In previous military studies, however, participation in competitive sports was not associated with MSDs [6,21]. High running mileage is an evident risk factor for injuries based on several military [1,3,11,14-17] and civilian studies [49-51], indicating that as the total amount of exercise increases, the injuries decrease first, until a point is reached at which injuries increase disproportionately with changes in physical fitness [49].

In the present study, abdominal obesity and high BMI were associated with a higher risk for MSDI and long-term MSDI compared to smaller WC and normal BMI. In earlier studies, higher BMI was linked to an increased risk of injury during military service [6,9,26,46], although contradictory results indicating no association between BMI and injuries [24,50], and an association of lower BMI with injuries [21] are also reported. Mattila and colleagues [40] demonstrated that a high proportion of body fat measured by dual-energy x-ray absorptiometry (DEXA) is clearly associated with poor running performance and muscle strength among conscripts and proposed a stricter entry level BMI for Finnish conscripts. Morbidly obese persons might be temporarily discharged from the army in Finland, mainly on the basis of their subjective perception of being able to cope with military service [40]. Severely obese persons do not meet military entrance standards [7] in professional armies, which may partly explain the equivocal results from different studies.

Among the lifestyle characteristics, smoking, alcohol intake and frequency of drunkenness were clearly associated with MSDs in univariate models, but after further adjustments the associations weakened. The present finding that high frequency of drunkenness prior to the beginning of military service is a risk factor for MSDs has, to our knowledge, not been reported before. Risk taking behaviour and cognitive deficits are more common among smokers, which may partly explain the altered risk for MSDs in adjusted models [1,52]. Moreover, smoking and alcohol intake are strongly associated with each other among young men [53,54] which is consistent with the present data. This interaction attenuated the association

Table 6: Hazard ratios (HR) for musculoskeletal disorder (MSD) incidence and incidence of long-term MSD by physical fitness test variables at baseline.

Physical fitness test result	Category	Total number (% of experienced MSD;% of experienced ≥10 service days lost due to MSDs)	HR for MSD incidence (n = 652) *	HR for MSD incidence (n = 652) **	HR for long-term MSD incidence (≥10 service days lost) (n = 194) *	HR for long-term MSD incidence (≥10 service days lost) (n = 194) **
Running a figure of eight (three attempts, best time [seconds])	Fastest quartile (<6.03)	211 (64; 16)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Mid 50% (6.03-6.60)	431 (69; 19)	1.2 (1.0-1.5)	1.3 (1.0-1.6)	1.3 (0.8-1.9)	1.2 (0.8-1.9)
	Slowest quartile (>6.60)	215 (71; 22)	**1.3 (1.0-1.6)**	1.2 (0.9-1.7)	1.4 (0.9-2.2)	1.2 (0.7-2.2)
One-leg standing on a narrow beam (attempts needed to one minute total standing time)	Best quartile (1)	201 (63; 17)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Mid 50% (2-6)	439 (71; 18)	1.1 (0.9-1.4)	1.1 (0.9-1.3)	1.1 (0.7-1.6)	0.9 (0.6-1.4)
	Poorest quartile (≥7)	221 (69; 25)	1.2 (0.9-1.5)	1.0 (0.7-1.2)	**1.5 (1.0-2.3)**	1.1 (0.7--1.8)
Cooper's test (12-minute running test)	Excellent (≥3000 m) Good (≥2600 m)	36 (67; 13) 214 (62; 13)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Fair good (≥2200 m)	435 (69; 20)	**1.2 (1.0-1.5)**	1.2 (0.9-1.5)	**1.5 (1.0-2.2)**	**1.6 (1.0-2.7)**
	Poor (<2200 m)	240 (76; 28)	**1.7 (1.4-2.1)**	**1.6 (1.2-2.2)**	**2.3 (1.5-3.5)**	**2.5 (1.4-4.5)**
Pull-up test (consecutive repeats without time limit)	Excellent (≥14)	107 (65; 14)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥10)	140 (66; 16)	1.0 (0.7-1.4)	0.8 (0.5-1.1)	1.2 (0.6-2.2)	0.8 (0.4-1.8)
	Fair good (≥6)	266 (70; 18)	1.2 (0.9-1.5)	0.8 (0.6-1.2)	1.3 (0.7-2.3)	1.0 (0.5-1.9)
	Poor (<6)	421 (71; 25)	1.3 (1.0-1.7)	0.8 (0.6-1.2)	**2.0 (1.2-3.4)**	1.1 (0.6--2.2)
Standing long jump test (two attempts, best result)	Excellent (≥2,40 m)	141 (62; 13)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥2,20 m)	251 (69; 20)	1.3 (1.0-1.7)	1.2 (0.9-1.6)	1.6 (0.9-2.7)	1.1 (0.6-1.9)
	Fair good (≥2,00 m)	311 (69; 20)	**1.3 (1.0-1.7)**	1.2 (0.9-1.6)	1.6 (1.0-2.7)	1.0 (0.6-1.8)
	Poor (<2,00 m)	231 (74; 26)	**1.6 (1.2-2.0)**	1.4 (1.0-1.9)	**2.3 (1.4-3.8)**	1.4 (0.7-2.6)
Sit-up test (repeats per 60 seconds)	Excellent (≥48)	122 (64; 16)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)

Table 6: Hazard ratios (HR) for musculoskeletal disorder (MSD) incidence and incidence of long-term MSD by physical fitness test variables at baseline. (Continued)

	Good (≥40)	221 (71; 17)	1.2 (0.9-1.6)	1.0 (0.8-1.4)	1.0 (0.6-1.8)	0.8 (0.4-1.5)
	Fair good (≥32)	328 (70; 22)	1.3 (1.0-1.7)	1.0 (0.7-1.3)	1.4 (0.9-2.3)	0.8 (0.5-1.5)
	Poor (<32)	263 (70; 24)	**1.4 (1.0-1.8)**	0.9 (0.7-1.3)	1.6 (1.0-2.6)	0.7 (0.4-1.4)
Push-up test (repeats per 60 seconds)	Excellent (≥38)	283 (70; 18)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥30)	216 (64; 16)	1.0 (0.8-1.2)	0.8 (0.7-1.1)	0.9 (0.6-1.4)	0.7 (0.4-1.1)
	Fair good (≥22)	263 (68; 21)	1.0 (0.9-1.3)	0.8 (0.6-1.0)	1.2 (0.8-1.8)	0.7 (0.4-1.1)
	Poor (<22)	172 (76; 30)	**1.4 (1.1-1.8)**	1.0 (0.7-1.3)	**2.0 (1.4-3.0)**	1.0 (0.6-1.8)
Back lift test (repeats per 60 seconds)	Excellent (≥60)	450 (65; 18)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥50)	195 (68; 20)	1.1 (0.9-1.4)	1.0 (0.8-1.3)	1.1 (0.8-1.6)	0.9 (0.6-1.4)
	Fair good (≥40)	197 (73; 20)	**1.2 (1.0-1.5)**	1.1 (0.9-1.4)	1.2 (0.8-1.7)	0.8 (0.5-1.3)
	Poor (<40)	92 (83; 32)	**1.8 (1.4-2.3)**	**1.5 (1.1-2.0)**	**2.0 (1.3-3.1)**	1.2 (0.7-2.0)
Conscript's muscle fitness index[1]	Excellent (13-15 points)	94 (61; 12)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (9-12 points)	249 (66; 17)	1.3 (0.9-1.7)	1.2 (0.8-1.6)	1.5 (0.8-2.9)	1.2 (0.5-2.5)
	Fair good (5-8 points)	336 (72; 22)	**1.5 (1.1-2.0)**	1.2 (0.9-1.8)	**2.0 (1.1-3.8)**	1.2 (0.5-2.5)
	Poor (0-4 points)	255 (71; 25)	**1.6 (1.2-2.2)**	1.1 (0.8-1.7)	**2.6 (1.3-4.8)**	1.1 (0.5-2.7)
Conscript's physical fitness index[2]	Excellent (≥21,00)	37 (59; 8)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (17.00-20.99)	270 (66; 16)	1.3 (0.8-2.0)	0.9 (0-6-1.4)	2.1 (0.6-6.6)	1.1 (0.3-3.7)
	Fair good (13.00-16.99)	420 (69; 21)	1.5 (1.0-2.4)	1.0 (0.6-1.6)	2.8 (0.9-9.0)	1.2 (0.3-4.1)
	Poor (<13.00)	196 (77; 28)	**2.0 (1.3-3.2)**	1.2 (0.7-2.0)	**4.4 (1.4-14.0)**	1.6 (0.4-5.8)
Combination of Cooper's and standing long jump test	Excellent[3]	77 (58; 9)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good[4]	335 (65; 19)	1.3 (0.9-1.8)	1.1 (0.8-1.6)	**2.2 (1.0-4.9)**	1.5 (0.6-3.3)
	Fair good[5]	394 (72; 20)	**1.6 (1.2-2.2)**	**1.5 (1.0-2.1)**	**2.5 (1.2-5.4)**	1.8 (0.8-4.1)
	Poor[6]	117 (79; 33)	**2.1 (1.5-3.0)**	**1.6 (1.0-2.6)**	**4.8 (2.2-10.8)**	**3.0 (1.2-7.8)**
Combination of Cooper's and push-up test	Excellent[3]	135 (64; 13)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good[4]	361 (67; 17)	1.2 (0.9-1.5)	1.1 (0.8-1.4)	1.3 (0.8-2.2)	1.3 (0.7-2.4)
	Fair good[5]	336 (70; 23)	**1.3 (1.0-1.7)**	1.0 (0.7-1.4)	**1.9 (1.1-3.1)**	1.4 (0.7-2.8)
	Poor[6]	91 (82; 36)	**2.3 (1.7-3.1)**	**1.8 (1.2-2.8)**	**3.6 (2.0-6.5)**	**2.8 (1.2-6.2)**

Table 6: Hazard ratios (HR) for musculoskeletal disorder (MSD) incidence and incidence of long-term MSD by physical fitness test variables at baseline. (Continued)

Combination of Cooper's and back lift test	Excellent[3]	171 (60; 12)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good[4]	437 (68; 20)	**1.3 (1.0-1.6)**	**1.3 (1.0-1.7)**	**1.8 (1.1-2.9)**	1.7 (1.0-3.0)
	Fair good[5]	272 (74; 22)	**1.5 (1.2-2.0)**	**1.4 (1.0-1.9)**	**2.0 (1.2-3.3)**	1.5 (0.8-2.8)
	Poor[6]	43 (91; 42)	**3.6 (2.5-5.2)**	**2.9 (1.9-4.6)**	**5.0 (2.6-9.3)**	**2.7 (1.2-5.9)**

Variable distribution was charted in 944 male conscripts during the first two weeks of military service and MSD outcomes were registered during the following six-month military service. Long-term MSD was defined as an incidence of time loss of at least 10 active service days due to one or several MSDs. Statistically significant findings are indicated with bold type.

* Adjusted for age (univariate).

** Adjusted for age, company, smoking, frequency of drunkenness before military service, baseline medical conditions (sports injury during the last month before military entry, chronic impairment or disability due to prior musculoskeletal injury, earlier musculoskeletal symptoms, chronic disease), school success (educational level and grades combined), father's occupation, opinion about physical demands for a soldier, urbanisation level of the place of residence, self-assessed health, waist circumference, height, participating in individual aerobic sports, last degree achieved in school sports, belonging to a sports club, self-assessed physical fitness, participation in competitive sports and physical activity during the previous three months before entering the military.

[1] Muscle fitness index (MFI) is the sum of individual muscle fitness test results including push-up, sit-up, pull-up, standing long jump and back muscle tests.

[2] Conscript's physical fitness index (CPFI) = (12 min running test result (m) + 100 × MFI)/200.

[3] Excellent or good result in Cooper's test and excellent result in standing long jump/push-up/back lift tests.

[4] Excellent result in standing long jump/push-up/back lift test and fair good or poor result in Cooper's test, or excellent result in Cooper's test and good, fair good, or poor result in standing long jump standing long jump/push-up/back lift test, or good result in Cooper's test and good or fair good result in standing long jump/push-up/back lift test, or fair good result in Cooper's test and good result in standing long jump test.

[5] Poorer results than aforementioned, except the combination of poor results in both tests.

[6] Poor result in Cooper's test and poor result in standing long jump/push-up/back lift tests.

between MSDs and predictive variables when both variables were placed in the same model. Altarac and colleagues [19] reported that cigarette smoking is associated with exercise-related injuries sustained during basic military training. After controlling for other factors, the adjusted odds ratio for smokers experiencing an exercise-related injury during basic military training was approximately 1.5-fold compared to non-smokers. Similar findings have also been reported in other military studies [3,11,18,25,28,37]. Although among young smokers, the aerobic capacity is similar to non-smokers [7], smoking may be associated with MSDs in many other ways. Smoking causes a deficit in bone density [55]. This effect may be detected even in young healthy persons [56]. Several studies have concluded that smoking hampers wound and fracture healing and impairs fibroblast function [57,58]. Overuse injuries are known to result from repetitive microtrauma leading to inflammation and local tissue damage [59]. There is no clear evidence, however, of the association between smoking and bone fractures among military recruits, because the underlying mechanisms are thought to depend on long-term exposure [19]. Overall, alcohol and smoking are probably indicators for risk-taking behaviour rather than causal risk factors for MSDs among the young during military training.

The finding of the present study that lower school success, a combination of educational level and grades in school, was associated with MSDs is concordant with some previous studies [12,60]. These studies reported lower educational level as a risk factor for foot injuries [12] and military discharge [60], but in general the association of poor school success and MSDs has not been investigated in the army setting. Lower grade of mental ability, however, is reported to be associated with acute musculoskeletal injuries [61] and severe low back pain [62] among young men.

It is well established that previous injury history is associated with a higher risk of injury during basic military training [3,11,14,46]. In the present study, chronic impairment or disability due to earlier musculoskeletal injury and prior sports injury during the month before military entry were also associated with a higher risk for MSD. On the other hand, a past training injury may be a marker of past physical activity [20]. Musculoskeletal symptoms during the three months before military entry were strongly associated with MSDs in the present study. This predictive association is not generally investigated in the army environment, but musculoskeletal complaints are associated with a higher risk for premature discharge from military service [28].

The results of civilian [63] and military [3,7,13,14,17] studies suggest that modification of running distance, frequency and duration may be effective toward preventing lower extremity injuries. A recent study by Finestone and Milgrom [17] reported a promising 60% decrease in stress fractures by reducing cumulative marching and by assuring a minimum sleep regimen in the Israeli army. Similar findings were reported in a previous study of soldiers in the US Army [4]. Both studies reported that these changes in military training did not lower the soldiers' combat readiness or physical fitness test results. The key element in military weight-bearing training to avoid overuse related MSDs is to gradually increase the distance, frequency and duration of training [3,13,14,23]. A study of the Singaporean army, however, demonstrated that a formal pre-training conditioning programme may be more effective toward reducing attrition than training with a gradual increase in pace, which extended the basic military training by one month [64]. Similar findings from the US Army showed that pre-conditioning of low-fit recruits resulted in lower attrition and a tendency towards lower injury risk [65]. In the Finnish Defence Forces, as well as in other mandatory armies in Nordic countries, the proportion of conscripts with low physical fitness and obesity has increased dramatically over recent decades. This phenomenon may cause serious health problems in the future. In addition, the phenomenon forces military training programmes to adapt to these changes in mandatory armies [32,40].

A recently published randomised controlled trial from the Danish conscription army revealed that an exercise programme enhancing muscular strength, coordination, and flexibility based on intrinsic risk factors identified in previous studies was not effective in reducing the incidence of lower extremity overuse injuries [66]. This study was the first randomised, placebo-controlled study investigating the preventive effect of concurrent exercise programmes on overuse injuries in the military environment. The intervention was speculated to be more effective in situations with a more gradual increase in load [66].

The present study has several strengths. First, the definition of MSD is clear. Moreover, the data regarding MSDs was collected using electronic patient files, which guaranteed a high coverage of MSDs because all patients who entered the garrison clinic were recorded in the computerised system. Second, the participation rate was high (98%). Furthermore, the design of the study was a prospective follow-up of two successive cohorts of conscripts with the aim of providing information on the risk factors of MSDs in an army environment during one entire year. The study limitations arise from the fact that, after the initial eight weeks of basic training, training programmes diverged depending on the company. Although the physical training was maintained at approximately the same level in different companies, the military training tasks were different. The presented associations between risk factors and MSDs were, however, adjusted by the company. In addition, because the threshold for seeking medical care may vary between individuals, some conscripts may have been more inclined to seek professional care than others.

The present study provides a wide spectrum of modifiable risk factors for MSDs. Although association does not indicate causality, increased knowledge of the risk factors and injury mechanisms is an essential component when planning intervention programmes. An appropriate intervention based on the results of the present study would be to increase both aerobic and muscular fitness prior to conscript training. Attention to appropriate waist circumference and BMI would strengthen the intervention programme. Well-planned randomised controlled studies are needed to provide more evidence from effective interventions before large-scale prevention programmes are initiated in a military environment.

Conclusions

The findings of the present study provide a reliable insight into the intrinsic risk factors for MSDs. This study showed that a low cardiorespiratory fitness level expressed by poor results in a 12-minute running test at entry into the military service is strongly associated with MSD in a dose-response manner. Furthermore, we found that co-impairments in cardiorespiratory and muscular fitness (i.e., poor results in Cooper's test combined with a poor result in standing long jump, push-up or back lift tests) are the strongest predictors for MSDs. In addition, abdominal obesity, high BMI, earlier musculoskeletal symptoms, poor school success and physically demanding military training tasks are clearly associated with MSDs. The majority of the observed risk factors are modifiable and favourable for future interventions. The present results suggest that a good result (≥2600 m) in the 12-minute running test is a desirable goal in a pre-training programme before entering military service.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

HT participated in manuscript writing, data analysis, interpretation and data acquisition. JS was the primary investigator together with JP. They initiated and conceptually designed the study and participated in data processing and manuscript writing. HP participated in study concept and design as well as manuscript reviewing.

VMM took part in data analysis and interpretation and provided statistical expertise. He also participated in the study as a significant manuscript reviewer. OO took part in data analysis and interpretation. He also revised the manuscript critically and participated in the study concept and design. PV took part in designing the study and data acquisition. He also revised the manuscript critically. All authors have made substantive intellectual contributions to the study. All authors reviewed and approved the final manuscript.

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Clinical Study

Predictors of low back pain in physically active conscripts with special emphasis on muscular fitness

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Abstract

BACKGROUND CONTEXT: Association between low physical fitness and low back pain (LBP) is contradictory in previous studies.

PURPOSE: The objective of the present prospective cohort study was to investigate the predictive associations of various intrinsic risk factors in young conscripts for LBP, with special attention to physical fitness.

STUDY DESIGN: A prospective cohort study.

PATIENT SAMPLE: A representative sample of Finnish male conscripts. In Finland, military service is compulsory for male citizens and 90% of young men enter into the service.

OUTCOME MEASURES: Incidence of LBP and recurrent LBP prompting a visit at the garrison health clinic during 6-month military training.

METHODS: Four successive cohorts of 18- to 28-year-old male conscripts (N=982) were followed for 6 months. Conscripts with incidence of LBP were identified and treated at the garrison clinic. Predictive associations between intrinsic risk factors and LBP were examined using multivariate Cox proportional hazard models.

RESULTS: The cumulative incidence of LBP was 16%, the incidence rate being 1.2 (95% confidence interval [CI], 1.0–1.4) per 1,000 person-days. Conscripts with low educational level had increased risk for incidence of LBP (hazard ratio [HR], 1.6; 95% CI, 1.1–2.3). Conscripts with low dynamic trunk muscle endurance and low aerobic endurance simultaneously (ie, having coimpairment) at baseline also had an increased risk for incidence of LBP. The strongest risk factor was coimpairment of trunk muscular endurance in tests of back lift and push-up (HR, 2.8; 95% CI, 1.4–5.9).

CONCLUSIONS: The increased risk for LBP was observed among young men who had a low educational level and poor fitness level in both muscular and aerobic performance.

Keywords: Low back pain; Risk factors; Trunk muscle endurance; Physical fitness; Military training

Introduction

High prevalence of low back pain (LBP) is reported among adolescents and young adults in civil [1–4] and military populations [5–8]. Low back pain afflicts approximately 50% of people aged 20 years [9–11], one-fifth of adolescents experiencing moderate to severe LBP [12]. The prevalence and incidence of LBP increase with age

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EVIDENCE & METHODS

Context
The association between poor physical fitness and low back pain is often assumed. This article aimed to assess this potential relationship via a prospective cohort study.

Contribution
The authors found an increased risk for reported low back pain among young males in military training who had lower levels of education and pre-induction physical fitness.

Implication
The strengths of this study include the prospective design and a sample based on a universal conscription population that included 90% of young men in Finland. It is unclear how the fitness of young Finns compares with other countries; however, the well-defined epidemics of obesity and sedentary behavior in North American youth should raise concerns that this phenomenon may be a widespread public health concern.

—*The Editors*

[9,13–15]. Furthermore, LBP during young adulthood predicts LBP later in life [2,16,17].

Leboeuf-Yde and Kyvik [10] suggested over a decade ago that research on the causes, risk indicators, and prevention of LBP should be focused on young population because of early onset of LBP. Considering health behavior, a consistent, although weak, link exists between smoking and LBP [18–21], whereas alcohol intake does not seem to be associated with LBP [22]. Among body characteristics, obesity was modestly associated particularly with chronic LBP and seeking care for LBP in a recent systematic meta-analysis [23].

Wedderkopp et al. [24] reported that high levels of physical activity in childhood protect against LBP in early adolescence, but this is controversial [4,9,19,25]. On the other hand, participation in competitive sports predisposes one to LBP [9,12,26,27], particularly in women [28]. Thus, there appears to be a U-shaped association between physical activity and risk of LBP [4,29]. Physical activity before entering the military may not lower the risk for LBP during military service [7,30], but findings are conflicting [31].

Longitudinal population studies on the relation between physical fitness and the risk of LBP were systematically reviewed for the first time by Hamberg-van Reenen et al. [32]. The major question was whether poor fitness in muscular endurance and strength or reduced spinal mobility (ie, flexibility) was a predictor of LBP. The results from best-evidence analyses were inconclusive for all evaluated fitness factors and the risk for LBP. Thus, the role of physical fitness as a risk factor for LBP in population level [32–34] as well as in occupational [35–38] and military settings [7,30,31,39–41] is unclear.

The literature of risk indicators of LBP during military training is sparse, although LBP is the leading cause of musculoskeletal disability discharge in conscription [42] and professional armies [43,44]. In addition, LBP is the second most common reason to seek health care [45], causing a loss of billions of dollars annually [46].

The present 6-month prospective follow-up study of four successive cohorts evaluated the predictive associations between LBP and various intrinsic risk factors with special attention to the physical fitness of the conscripts. We hypothesized that low levels of physical fitness and health damaging behavior at the beginning of military service are associated with an increased incidence of LBP during military training.

Methods

Subjects

Subjects comprised male conscripts (N=1,513) from four companies of one brigade (Pori Brigade, Säkylä) in the Finnish Defence Forces. Military service in Finland is compulsory for male citizens, and annually about 90% of 19-year-old men enter into the service. The anti-tank, signal, mortar, and engineer companies were enrolled in the study. During the study period, four cohorts of conscripts began service in the brigade (Figure). The Pori Brigade is a typical Finnish garrison, and the selected companies form a representative sample of male conscripts. Baseline characteristics of the companies are presented in Table 1.

Twenty-four conscripts (less than 2%) refused to participate in the study (Figure). The remaining conscripts (N=1,489) agreed to participate and provided informed consent before initiation of the study. Because there were only 36 women who volunteered for military service and participated in the study (2.4%), their data were excluded from the analysis. Low back pain during the month before military entry was assessed based on the answers to four questions included in a preinformation questionnaire. The questions charted period prevalence of LBP with and without radiation and its ill effects on everyday life at baseline. Data for conscripts who reported at least 1 day of LBP or disability in everyday activities because of LBP (n=396) during the month before military entry were excluded from the analyses to ensure that previous LBP did not bias the results. In addition, 33 conscripts who did not respond to the preinformation questionnaire were excluded (Figure). Conscripts entering military service were young healthy men, all of whom had a medical checkup by a clinician during the 12 months before entering the military.

The health status of the conscripts was rechecked at baseline during the first 2 weeks (run-in period) by routine medical screenings performed by a physician. Twenty-nine

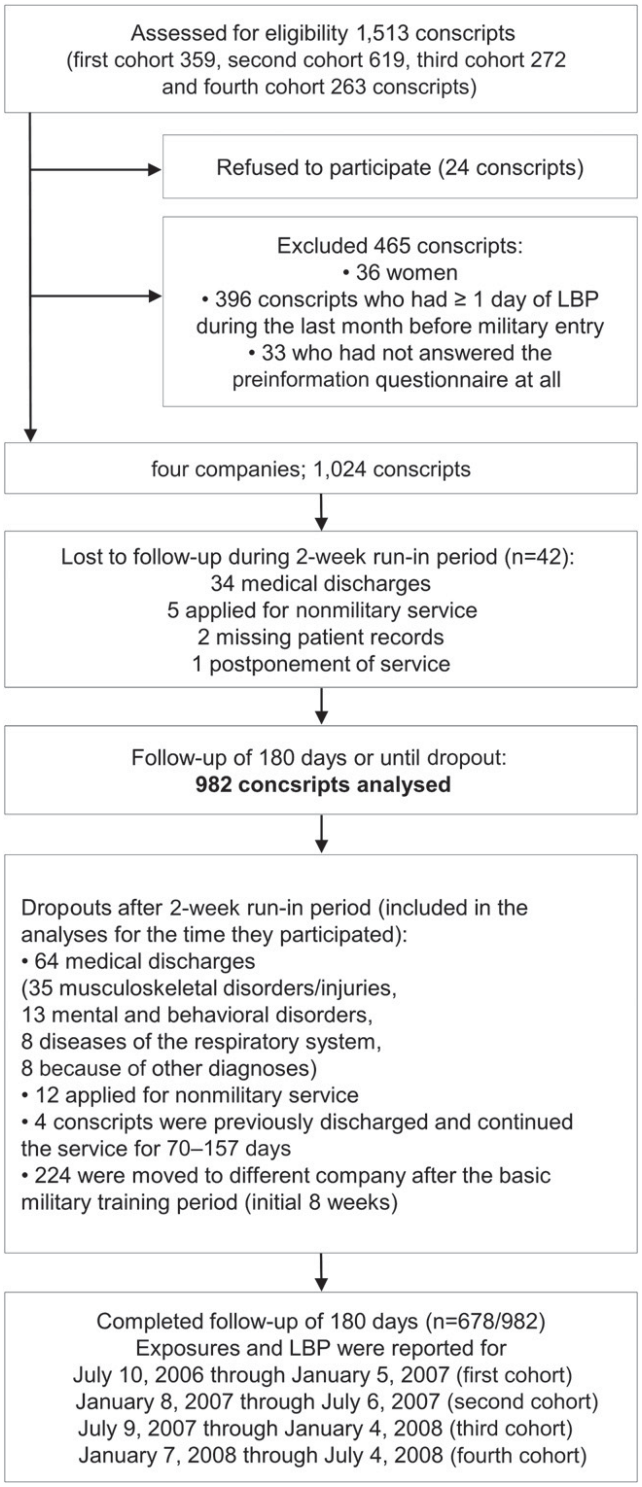

Figure. Flow of conscripts through the study.

participants were discharged temporarily (6 months or more) and five were discharged permanently from the military for medical reasons. During the first 2 weeks, five conscripts applied for nonmilitary service, two patient records were missing, and one conscript applied for postponement of service, leaving 982 conscripts for present analysis (Figure). Conscript age varied from 18 to 28 years (median 19). All subjects were planned to be followed for 6 months beginning on the first day of service but some dropout from the military or changed company (Figure). Approval for the study protocol was obtained from the Ethics Committee of Pirkanmaa Hospital District on April 11, 2006.

Low back pain registration

The data were collected from July 10, 2006 to July 4, 2008 (Figure). Low back pain included the following *International Classification of Diseases, Tenth Revision* diagnoses: M54 (dorsalgia), M54.5 (LBP), M41 (scoliosis), M54.9 (dorsalgia, unspecified), and M54.3 (sciatica). The anatomical location of the afflicted body part was confirmed by the study physician (HT) based on computerized patient records. Upper back pain was excluded from the outcome definition.

During military service, all conscripts are required to use military health care services. The date, severity, and diagnosis of each LBP were registered in the electronic patient records. Because the conscripts may have sought medical care several times for the same episode of LBP, the total number of health clinic visits exceeded the number of LBP.

In addition to active service hours, LBP occurring during the conscript's leisure time or on the way to or from the garrison for leave was included in the study. Low back pain severity was categorized according to the number of days of limited duty: 1–3 days denoting minimal LBP; 4–7 days, mild LBP; 8–28 days, moderate LBP; and more than 28 days, severe LBP [47]. Limited duty involved a physical restriction that prevented the conscript from fully participating in military training events. Discharge from military service was indicated when a physician determined a conscript unable to continue military training.

Physical training during military service

Conscripts spent an average of 17 hours per week on military physical training, including marching, cycling, skiing, orienteering, swimming, drill training, and combat training with a gradual increase in intensity. In addition, conscripts performed other physical exercises, such as jogging and team sports for an average of 7 hours per week.

Assessment of physical fitness and preinformation questionnaire

A Cooper test (12-minute running test) and the muscular fitness tests were performed by most (97%) conscripts during their first 2 weeks of military service. A small minority of conscripts (3%) was unable to complete their physical fitness tests because of minor health problems, such as respiratory infections or overuse injuries. Muscular fitness tests and the 12-minute run test were performed on different days. Muscular fitness tests included push-ups, sit-ups, pull-ups, the standing long jump, and a back lift test.

Table 1
Baseline characteristics of 982 male conscripts by company

Variable	Anti-tank	Signal	Mortar	Engineer	Missing (%)	p Value*
Number of conscripts	191	368	253	170	0 (0)	—
Age, median, (y)	19	19	19	19	0 (0)	.755†
BMI, median, kg/m^2	23.5	22.6	23.3	23.5	83 (8)	.035†
Waist circumference, median, cm	86.3	84.6	86.0	86.0	60 (6)	.017†
12-Minute run test result, median, m	2,320	2,340	2,505	2,415	22 (2)	<.001†
CPFI‡, median, points	15.35	15.03	17.08	15.94	23 (2)	<.001†
Hometown population ≥10,000 persons, %	61	66	57	54	2 (0)	.028§
High level of education¶, %	53	40	50	42	0 (0)	.007§
High level of previous physical activity‖, %	34	26	43	36	0 (0)	<.001§
Good self-assessed health#,%	62	53	65	54	0 (0)	.015§
Chronic impairment or disability, %	17	14	14	15	3 (0)	.786§
Regular medication, %	11	13	10	8	4 (0)	.307§
Clear musculoskeletal symptoms**, %	18	22	15	19	0 (0)	.145§
Previous or current regular smoker, %	39	40	38	54	2 (0)	.007§
Use of alcohol ≥3 times per week, %	14	17	12	17	1 (0)	.314§

BMI, body mass index; CPFI, Conscript's physical fitness index.
* p Value for difference between the companies.
† p Value was calculated using a Kruskal-Wallis test for median difference.
‡ CPFI=(12-minute running test result (m)+100×muscle fitness test points)/200, (Excellent [CPFI ≥21.00], Good [17.00≤CPFI<21.00], Fair good [13.00≤CPFI<17.00], Poor [CPFI<13.00]).
§ p Value was calculated using $\chi 2$ statistics for difference.
¶ Graduated or studies in higher education institution.
‖ Sweating exercise at least three times per week during the last month before entering the military.
\# Compared with age-mates.
** Symptoms lasting more than 7 days in at least one anatomical region other than back during the last month before entering the military.

Instructors of the companies supervised the conscripts to ensure technically correct performance of each test. The recovery time between each muscle test was at least 5 minutes. More detailed information about the physical fitness tests was presented in previous studies [48,49]. These tests assessed general physical fitness of the conscripts rather than specifically spine fitness.

A poor result in an individual muscle fitness test equated to 0 points, a fair result to 1 point, a good result to 2 points, and an excellent result to 3 points. A conscript's physical fitness index was calculated using the following formula: (12-minute running test result [m]+100×muscle fitness points)/200. This formula and the result categories of physical fitness have been based on standard practice in the Finnish Defence Forces since 1982 [50]. Because excellent results in the Cooper test were uncommon (less than 4%), the two highest levels, good and excellent, were combined to obtain a group of equal size for comparison. Individual muscle fitness test results were combined into a single variable to explore whether the combined fitness variable, representing coimpairment, is more strongly associated with LBP. Coimpairment was defined as a poor result in both measured fitness tests according to the standard result categories [50].

Conscripts with poor physical fitness are not able to perform military tasks as required in combat field operations [51]. In the Finnish Defence Forces among the conscripts who have poor physical fitness, the objective in physical training is to improve their physical fitness during following 6 months of service. For the conscripts who have poor aerobic fitness in the beginning of the service, the training target is to achieve a test result of 2,400 to 2,600 meters in 12-minute running before the end of the service [52]. Considering aerobic fitness, the minimum level able to perform battle field activities is estimated to be about 42 mL/kg/min, which corresponds the 12-minute running test result of about 2,400 meters [51,53]. Considering muscle fitness, the minimum objective is to achieve good muscle fitness level before the end of the military service. This level is estimated to correspond the minimum combat field requirements for muscle fitness. These requirements include ability to perform heavy lifting, digging, and long marches on foot with 25 to 65 kg carriage [49,51].

In addition, height, weight, and waist circumference were measured during the first 2 weeks of service. Body mass index (BMI) was calculated by dividing weight (kg) by the square of height (m). Waist circumference as a mark of abdominal obesity and excessive visceral fat [54] was measured with a tape midway between the lowest rib and iliac crest after normal exhalation. The cutoff points to determine overweight and obesity for BMI as well as waist circumference were set according to the World Health Organization [55].

A questionnaire was used to determine the conscripts' socioeconomic factors (father's occupational group, level of education, school degrees and urbanization level of the place of residence), health (self-assessed health compared with age-mates, chronic disease, medication, previous orthopedic surgeries and sport injuries, chronic impairment or disability, and musculoskeletal pain in six anatomical

regions during the previous month), and health behavior (use of alcohol and tobacco, frequency of drunkenness, opinion about physical demands of a soldier, amount of physical exercise, participation in individual aerobic sports, belonging to a sports club, participation in competitive sports, last degree achieved in school sports, and self-assessed physical fitness) at the baseline of the study. The questionnaires were administered during the first week of service.

Statistical analysis

For statistical analysis, SPSS 18.0 for Windows software (SPSS Inc., Chicago, IL, USA) was used. Incidence of LBP was calculated by dividing the number of conscripts treated for LBP in the garrison clinic by the total number of conscripts, and expressed as a percentage. Incidence rate was calculated by dividing the number of conscripts treated for LBP in the garrison clinic by the exposure time, and expressed per 1,000 person-days. Exposure time was calculated as the time from entering military service until onset of the conscript's first LBP. To examine differences in the baseline characteristics between companies, the χ^2 statistic and a Kruskal-Wallis test was used to test the hypothesis of no difference.

Cox proportional hazard models were applied to study prospective associations between baseline characteristics and LBP incidence. Primary outcome was defined as an incidence of LBP treated at the garrison clinic. Secondary outcome was defined as at least three health clinic visits because of LBP or the time loss of at least five active service days because of LBP (hereafter referred to as a recurrent LBP). Continuous variables relating to physical fitness and body characteristics were converted to categorical variables to examine associations between risk factors and outcomes when the relationship was not linear.

In the first phase of the Cox regression, each independent variable was analyzed one at a time. Results are expressed as hazard ratios and calculated with 95% confidence intervals with age at baseline forced into the model. A multivariate Cox regression was used to identify independent risk factors for LBP and recurrent LBP and examine the interactions between risk factors. Only possibly significant variables ($p<.20$) in the initial age-adjusted models were included in the multivariate model. Older age, smoking status, poor baseline medical condition (sports injury during the last month before entering the military, chronic impairment or disability because of prior musculoskeletal injury, previous orthopedic surgeries, sum factor of musculoskeletal symptoms in anatomical regions other than the back during the last month before entering the military, chronic disease, and regular medication), low educational level, and low school degrees were entered into the multivariate model as known or possible risk factors. We considered participation in individual aerobic sports, company, and father's occupational group as effect modifiers and entered these variables into the multivariate model. A p value of less than .05 was considered statistically significant when interpreting the results of the Cox proportional hazard models.

Results

Low back pain incidence

During the study period, a total of 286 health clinic visits because of LBP were registered in the garrison clinic. A total of 155 of 982 (16%) conscripts suffered from LBP during the 6 months' follow-up time. Of those, 27% (n=42) had recurrent LBP (three or more health clinic visits or five or more active service days lost because of LBP). The LBP incidence rate was 1.2 (95% confidence interval, 1.0–1.4) per 1,000 person-days. Low back pain incidence for the first (17%), second (16%), third (17%), and fourth (13%) arrival did not vary significantly (p=.56).

Low back pain severity and associated activities

Most (75%) LBP was classified as minimal, leading to a maximum 3-day exemption from military training, whereas mild LBP accounted for 15%, moderate for 7%, and severe for 3% of all cases. Thirty-five (3.6%) conscripts were discharged from military service because of musculoskeletal injuries or disorders after the 2-week run-in period. Of them, five (14%) had a diagnosis relating to LBP (M54.5 LBP, n=3; M54 dorsalgia, n=2). Low back pain occurred mostly (92%) during military training. Some (8%) occurred during vacations and one case (0.6%) occurred while the conscript was traveling to vacation or back to the garrison.

Risk factors of LBP

Tables 2–5 show the distribution of variables and the hazard ratios of incidence of LBP and recurrent LBP for various socioeconomic (Table 2), health (Table 3), health behavior (Table 4), and physical fitness variables (Table 5) in the age-adjusted and multivariate-adjusted models.

From the socioeconomic background variables, lower level of education (only comprehensive or vocational school) compared with higher education (secondary school graduates, polytechnic, and university students) was associated with both incidence and recurrence of LBP even after multivariate adjustments. Low school degrees were associated with LBP but not with recurrent LBP. In addition, company was associated with LBP, risk being lowest in the mortar company and highest in the engineer company (Table 2).

With regard to health, baseline health problems were associated with incidence of LBP in age-adjusted model. After further adjustments, former sports injury and musculoskeletal symptoms in anatomical regions other than

Table 2
Hazard ratios for LBP incidence and incidence of recurrent LBP by socioeconomic variables at baseline

Socioeconomic background and company	Category	Total number (% of experienced LBP, % of experienced recurrent* LBP)	HR for LBP incidence (n=155)†	Adjusted HR for LBP incidence (n=155)‡	HR for recurrent* LBP incidence (n=42)†	Adjusted HR for recurrent* LBP incidence (n=42)‡
Father's occupation	Not physical	341 (13, 3)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Physical	405 (17, 4)	1.4 (0.9–2.0)	1.2 (0.8–1.9)	1.3 (0.6–2.8)	1.1 (0.5–2.4)
	Unemployed or retired	200 (18, 7)	1.5 (1.0–2.4)	1.4 (0.9–2.2)	2.0 (0.9–4.5)	1.6 (0.7–3.6)
Level of education	High§	448 (12, 2)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Lower¶	534 (19, 6)	**1.9 (1.3–2.3)**	**1.6 (1.1–2.3)**	**3.2 (1.5–6.6)**	**2.8 (1.2–6.3)**
Degrees achieved in school	High	346 (12, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Low or average	636 (18, 5)	**1.6 (1.1–2.3)**	**1.5 (1.0–2.2)**	0.8 (0.5–1.5)	0.8 (0.4–1.6)
Urbanization level of the place of residence	Countryside	162 (12, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Small population center	224 (17, 6)	1.5 (0.9–2.5)	1.1 (0.6–2.0)	1.7 (0.7–4.4)	1.6 (0.6–4.2)
	Midsize town or city	384 (15, 3)	1.2 (0.7–2.0)	1.0 (0.6–1.7)	0.8 (0.3–2.1)	0.7 (0.2–1.9)
	Bigger city	210 (18, 5)	1.3 (0.8–2.3)	1.2 (0.7–2.0)	1.4 (0.5–3.8)	1.2 (0.4–3.5)
Age (y)	18–20	928 (15, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	21–28	54 (26, 2)	**2.1 (1.2–3.7)**	1.8 (1.0–3.4)	0.5 (0.1–3.3)	0.5 (0.1–3.8)
Company	Anti-tank company	191 (15, 3)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Signal company	368 (18, 6)	1.3 (0.9–2.1)	1.4 (0.9–2.3)	2.5 (1.0–6.6)	**3.0 (1.0–8.7)**
	Mortar company	253 (8, 1)	0.8 (0.5–1.4)	1.0 (0.5–1.8)	0.6 (0.1–2.5)	0.8 (0.2–3.6)
	Engineer company	170 (24, 7)	**1.8 (1.1–2.9)**	**2.0 (1.2–3.3)**	2.8 (1.0–7.9)	**3.5 (1.1–11.0)**

HR, hazard ratio; LBP, low back pain.

Variable distribution was charted in 982 male conscripts during the first week of military service, and LBP outcomes were registered during the following 6-month military service.

Statistically significant findings are indicated in bold type.

* Three or more health clinic visits or five or more active service days lost because of LBP.

† Adjusted for age.

‡ Adjusted for age, company, smoking, baseline medical conditions (sports injury, sum factor of earlier musculoskeletal symptoms, regular medication, chronic impairment or disability because of prior musculoskeletal injury, and orthopedic surgery), educational level, school degree level, father's occupation, and participating in individual aerobic sports (12 adjusting variables).

§ Secondary school graduates, polytechnic, and university students.

¶ Only comprehensive or vocational school.

the back remained predictive of LBP. High BMI increased the risk for recurrent LBP in the multivariate model (Table 3).

With regard to health behaviors, health-damaging behavior was not related to incidence of LBP. Smoking was associated with LBP in the age-adjusted model, but after final adjustments, the association weakened. Similarly, previous physical activity was not associated with LBP (Table 4).

With regard to physical fitness (Table 5), single test items of poor fitness showed no predictive associations with incidence or recurrence of LBP with the exception of poor fitness in push-up predicting incidence of LBP, which, however, diminished after multivariable adjustments. Contrary to that, predictive associations between coimpairments of fitness with LBP were more systematic. Highest risk for both incidence and recurrence of LBP were detected among conscripts with poor level of fitness both in push-up and back lift test, back lift and Cooper test, as well as push-up and Cooper test (Table 5). Coimpairment in sit-up and push-up predicted incidence of LBP but not recurrence.

Discussion

In the present study, risk factors for LBP were examined among male conscripts during 6-month military service. The cumulative incidence of LBP prompting at least one visit to a garrison clinic during 6-month military service was 16%, consistent with previously published figures for young military [7,30,56] and civilian populations [9,19]. The key finding of the present study was the strong predictive association of coimpairments in fitness for LBP in previously healthy conscripts. The hypothesis that coimpairment in physical fitness is a predictor of LBP was based on the previous study investigating risk factors of musculoskeletal disorders during military training [48]. Furthermore, conscripts with low education level had high risk for both incidence and recurrence of LBP. Given that 90% of young men in Finland enter military service, the present results might have an impact also outside military environment among young men who engage in an intensive physical training program.

Conscripts with coimpairment in push-up and back lift tests had the highest risk for both incidence and recurrence

Table 3
Hazard ratios for LBP incidence and incidence of recurrent LBP by health variables at baseline

Health variable	Category	Total number (% of experienced LBP, % of experienced recurrent* LBP)	HR for LBP incidence (n=155)†	Adjusted HR for LBP incidence (n=155)‡	HR for recurrent* LBP incidence (n=42)†	Adjusted HR for recurrent* LBP incidence (n=42)‡
Body mass index, BMI=(kg)/(m)^2	Underweight (BMI<18.5)	43 (7, 0)	0.4 (0.1–1.4)	0.2 (0.0–1.3)	NA	NA
	Normal (18.5≤BMI<25.0)	570 (17, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Pre-obese (25.0≤BMI<30.0)	220 (15, 3)	0.9 (0.6–1.4)	0.9 (0.6–1.3)	0.8 (0.3–1.7)	0.7 (0.3–1.8)
	Obese (BMI ≥30.0)	66 (23, 9)	1.4 (0.8–2.4)	1.4 (0.8–2.4)	2.1 (0.9–5.3)	**2.6 (1.0–6.6)**
WC, cm	Thin (WC <80)	198 (12, 4)	0.8 (0.5–1.3)	0.8 (0.5–1.4)	1.1 (0.4–2.5)	1.2 (0.5–3.0)
	Normal (80 ≤WC<94)	521 (17, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Increased (94 ≤WC<102)	121 (21, 6)	1.4 (0.9–2.2)	1.3 (0.8–2.0)	1.7 (0.7–4.0)	1.7 (0.7–4.5)
	High (WC≥102)	82 (17, 6)	1.1 (0.6–2.0)	1.3 (0.7–2.4)	1.8 (0.7–4.8)	2.8 (1.0–7.9)
Height, cm	Shortest quartile (≤176)	233 (16, 6)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Second quartile (177–180)	228 (18, 5)	1.1 (0.7–1.7)	1.2 (0.7–1.8)	0.8 (0.4–1.8)	0.9 (0.4–2.1)
	Third quartile (181–185)	242 (15, 3)	1.0 (0.6–1.6)	0.9 (0.5–1.4)	0.5 (0.2–1.3)	0.6 (0.2–1.5)
	Tallest quartile (≥185)	196 (16, 3)	0.9 (0.6–1.5)	1.1 (0.7–1.8)	0.5 (0.2–1.3)	0.6 (0.2–1.7)
Self-assessed health§	Good or very good	570 (15, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Average or inferior	412 (17, 5)	1.4 (1.0–1.9)	1.1 (0.8–1.6)	1.5 (0.8–2.7)	1.3 (0.7–2.5)
Chronic disease	No	717 (15, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Yes	265 (18, 5)	1.2 (0.9–1.7)	1.2 (0.8–1.7)	1.4 (0.7–2.7)	1.6 (0.8–3.2)
Regular medication	No	873 (15, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Yes	105 (20, 4)	1.4 (0.9–2.2)	1.4 (0.9–2.3)	1.0 (0.3–2.7)	1.0 (0.4–3.0)
Orthopedic surgery	Never	900 (15, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Yes	82 (26, 5)	**1.8 (1.1–2.8)**	1.6 (0.9–2.6)	1.2 (0.4–3.5)	1.3 (0.4–4.2)
Chronic impairment or disability¶	No	835 (15, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Yes	144 (23, 4)	**1.7 (1.2–2.5)**	1.4 (0.9–2.2)	1.0 (0.4–2.3)	0.8 (0.3–2.2)
Sports injury during last month	No	897 (15, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Yes	81 (23, 7)	**1.7 (1.1–2.8)**	**1.7 (1.0–2.8)**	2.0 (0.9–4.8)	2.5 (1.0–6.4)
Sum factor of other musculoskeletal symptoms	Minimal symptoms‖	421 (13, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Mild symptoms#	375 (16, 5)	1.4 (1.0–2.0)	1.3 (0.9–2.0)	1.3 (0.7–2.7)	1.4 (0.6–2.8)
	Clear symptoms**	186 (22, 5)	**2.0 (1.3–3.0)**	**1.6 (1.0–2.5)**	1.6 (0.7–3.6)	1.4 (0.6–3.2)

HR, hazard ratio; LBP, low back pain; WC, waist circumference; BMI, body mass index; NA, not applicable.

Variable distribution was charted in 982 male conscripts during the first week of military service, and LBP outcomes were registered during the following 6-month military service.

Statistically significant findings are indicated in bold type.

* Three or more health clinic visits or five or more active service days lost because of LBP.

† Adjusted for age.

‡ Adjusted for age, company, smoking, baseline medical conditions (sports injury, sum factor of earlier musculoskeletal symptoms, regular medication, chronic impairment or disability because of prior musculoskeletal injury, and orthopedic surgery), educational level, school degree level, father's occupation, and participating in individual aerobic sports (12 adjusting variables).

§ Compared with age-mates.

¶ Because of prior musculoskeletal injury.

‖ "Minimal symptoms": maximum 7-day lasting symptom in one anatomical region during the last month before military entry.

\# "Mild symptoms": symptoms in two to six anatomical regions, but the symptoms had lasted 1 week maximum during the last month before military entry.

** "Clear symptoms": included the remaining conscripts.

of LBP (Table 5) even after multiple adjustments made for possible confounding socioeconomic, health, and health behavior variables. To our knowledge, similar findings have not been reported among young populations. Coimpairment of the trunk extensor and flexor muscles may be an indicator of compromised spinal stability. Improved control of the lumbar neutral zone with trunk muscles has decreased LBP among middle-aged men [57]. Core stability as a subset of motor control [58] also has an important role in the prevention of lower extremity injuries [59].

Good trunk muscle endurance is presumed to decrease the loss of motor control because of fatigue in repeated submaximal trunk motion and thus decreases the risk for back injury [60]. However, former findings on trunk muscle endurance and incidence of LBP are extremely controversial [32,35,61,62] although current recommendations are to increase physical activity to prevent LBP [63,64]. Good

Table 4
Hazard ratios for LBP incidence and incidence of recurrent LBP by health behavior variables at baseline

Health behavior	Category	Total number (% of experienced LBP, % of experienced recurrent* LBP)	HR for LBP incidence (n=155)†	Adjusted HR for LBP incidence (n=155)‡	HR for recurrent* LBP incidence (n=42)†	Adjusted HR for recurrent* LBP incidence (n=42)‡
Smoking habits	Never regularly	571 (13, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Has smoked regularly	409 (20, 5)	**1.7 (1.3–2.4)**	1.1 (0.8–1.6)	1.5 (0.8–2.7)	1.0 (0.5–1.9)
Use of alcohol	<1 Time per month	187 (14, 5)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	1–2 Times per week	645 (16, 4)	1.0 (0.7–1.5)	0.8 (0.5–1.2)	0.8 (0.4–1.7)	0.7 (0.3–1.6)
	≥3 Times per week	149 (15, 3)	1.0 (0.7–1.5)	0.6 (0.3–1.2)	0.5 (0.2–1.6)	0.3 (0.1–1.0)
Frequency of drunkenness before military service	<1 Time per week	777 (16, 5)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	≥1 Time per week	204 (16, 3)	1.0 (0.7–1.5)	0.7 (0.5–1.1)	0.6 (0.3–1.5)	0.4 (0.2–1.1)
Agrees that soldier needs good physical fitness	Yes	671 (16, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	No	311 (15, 5)	1.0 (0.7–1.4)	1.0 (0.7–1.4)	1.3 (0.7–2.4)	1.2 (0.6–2.4)
Sweating exercise (brisk leisure time sport)	≥3 Times per week	331 (15, 5)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	1–2 Times per week	300 (14, 3)	0.9 (0.6–1.4)	0.7 (0.5–1.1)	0.7 (0.3–1.7)	0.6 (0.2–1.4)
	Only leisured exercise	167 (18, 5)	1.4 (0.9–2.2)	1.3 (0.8–2.1)	1.1 (0.5–2.7)	1.0 (0.4–2.3)
	No physical exercise	184 (18, 5)	1.4 (0.9–2.2)	1.0 (0.6–1.7)	1.2 (0.5–2.6)	0.9 (0.4–2.3)
Participates in individual aerobic sports	Yes, at least sometimes	689 (15, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	No	290 (18, 6)	1.3 (0.9–1.8)	1.1 (0.7–1.5)	1.5 (0.8–2.7)	1.1 (0.6–2.2)
Belongs to a sports club	Yes, an active member	156 (14, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	No	820 (16, 4)	1.2 (0.8–1.9)	1.1 (0.7–1.8)	1.2 (0.5–3.0)	1.3 (0.5–3.1)
Participates in competitive sports	Yes	139 (16, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	No	842 (17, 4)	1.0 (0.7–1.6)	1.1 (0.7–1.7)	1.3 (0.5–3.4)	1.5 (0.5–4.3)
Last degree in school sports	Good or excellent	798 (15, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Poor or fair	182 (16, 5)	1.1 (0.8–1.7)	0.8 (0.5–1.3)	1.4 (0.7–2.9)	1.2 (0.5–2.7)
Self-assessed physical fitness§	Good or very good	254 (13, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Average or inferior	728 (17, 5)	1.4 (1.0–2.1)	1.3 (0.8–1.9)	1.4 (0.7–2.9)	1.3 (0.6–2.8)

HR, hazard ratio; LBP, low back pain.

Variable distribution was charted in 982 male conscripts during the first week of military service, and LBP outcomes were registered during the following 6-month military service.

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† Adjusted for age.

‡ Adjusted for age, company, smoking, baseline medical conditions (sports injury, sum factor of earlier musculoskeletal symptoms, regular medication, chronic impairment or disability because of prior musculoskeletal injury, and orthopedic surgery), educational level, school degree level, father's occupation, and participating in individual aerobic sports (12 adjusting variables).

§ Compared with age-mates.

isometric muscle endurance of the back extensors [62], abdominal, and lumbar muscles [65] were negatively associated with LBP among the young. Several studies in adults [34,36,66,67] indicate that a low static endurance capacity of back extensor muscles is a risk factor for LBP, but a systematic review [32] claimed the findings to be controversial. Furthermore, the systematic review reported strong evidence for the absence of a relation between any dynamic trunk muscle endurance tests and risk of LBP. This controversy between studies is probably based on heterogeneity considering physical fitness tests, outcome measures, follow-up, and adjustment for confounders. Studies reporting low static back extensor endurance capacity as a risk factor for future LBP [34,66,67] were conducted among middle-aged working populations between 126 and 1,789 participants with follow-up times from 9 to 30 months. Whereas, study samples were small with less than 200 participants [68–70] or response rates insufficient [38] in studies finding no association between back extensor endurance and risk of LBP possibly explaining discrepancy between studies. Furthermore, earlier studies have not explored the association between coimpairment of physical fitness and risk of LBP.

Combinations of poor trunk muscular performance (push-up and back lift) and poor aerobic capacity (Cooper test) significantly increased the risk of LBP (Table 5). Conscripts with lower aerobic endurance levels may perceive military training as more difficult and fatigue more rapidly [71]. It has also been proposed that fatigue leads to changes in gait and kinematics in lower extremities [72,73], which may result in poor motor control performance and predispose to musculoskeletal disorders [74].

In general, the association of low educational level and LBP has not been investigated in the military setting among

Table 5
Hazard ratios for LBP incidence and incidence of recurrent LBP by physical fitness test variables at baseline

Physical fitness test result	Category	Total number (% of experienced LBP, % of experienced recurrent* LBP)	HR for LBP incidence (n=155)†	Adjusted HR for LBP incidence (n=155)‡	HR for recurrent* LBP incidence (n=42)†	Adjusted HR for recurrent* LBP incidence (n=42)‡
Cooper test (12-minute running test)	Excellent (≥3,000 m)	39 (13, 3)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥2,600 m)	252 (13, 3)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Fair (≥2,200 m)	427 (19, 4)	**1.6 (1.1–2.4)**	1.5 (1.0–2.3)	1.4 (0.6–3.1)	1.3 (0.5–3.1)
	Poor (<2,200 m)	242 (15, 6)	1.4 (0.9–2.2)	1.3 (0.8–2.1)	2.2 (1.0–5.1)	2.0 (0.8–5.2)
Pull-up test (consecutive repeats without time limit)	Excellent (≥14)	121 (12, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥10)	162 (19, 6)	1.7 (0.9–3.1)	1.6 (0.8–3.1)	1.4 (0.5–4.1)	1.3 (0.4–4.0)
	Fair (≥6)	273 (17, 3)	1.4 (0.8–2.5)	1.3 (0.7–2.5)	0.8 (0.3–2.4)	0.6 (0.2–1.9)
	Poor (<6)	413 (15, 4)	1.3 (0.7–2.2)	1.2 (0.7–2.3)	1.1 (0.4–2.9)	0.9 (0.3–2.6)
Standing long jump test (two attempts, best result observed)	Excellent (≥240 m)	171 (17, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥220 m)	255 (15, 4)	0.9 (0.5–1.4)	0.9 (0.5–1.5)	1.0 (0.4–2.6)	0.9 (0.3–2.3)
	Fair (≥200 m)	312 (17, 5)	1.0 (0.6–1.5)	1.1 (0.7–1.7)	1.2 (0.5–2.9)	1.3 (0.5–3.3)
	Poor (<200 m)	231 (14, 4)	0.9 (0.5–1.5)	0.9 (0.5–1.5)	1.0 (0.4–2.7)	0.9 (0.3–2.5)
Sit-up test (repeats/60 s)	Excellent (≥48)	175 (12, 3)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥40)	225 (16, 4)	1.4 (0.8–2.4)	1.5 (0.8–2.8)	1.5 (0.5–4.4)	1.7 (0.5–5.7)
	Fair (≥32)	316 (16, 5)	1.5 (0.9–2.5)	1.4 (0.8–2.4)	1.8 (0.6–4.9)	2.0 (0.6–6.1)
	Poor (<32)	253 (18, 5)	1.6 (1.0–2.7)	1.7 (0.9–3.0)	1.8 (0.6–5.2)	2.0 (0.6–6.5)
Push-up test (repeats/60 s)	Excellent (≥38)	344 (13, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥30)	220 (17, 3)	1.4 (0.9–2.2)	1.3 (0.8–2.1)	0.8 (0.3–2.1)	0.8 (0.3–2.1)
	Fair (≥22)	237 (16, 4)	1.4 (0.9–2.1)	1.2 (0.8–1.9)	1.1 (0.5–2.6)	0.9 (0.4–2.2)
	Poor (<22)	168 (20, 7)	**1.8 (1.1–2.8)**	1.6 (1.0–2.6)	1.8 (0.8–4.1)	1.6 (0.7–3.9)
Back-lift test (repeats/60 s)	Excellent (≥60)	499 (13, 3)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good (≥50)	189 (19, 7)	1.4 (0.9–2.1)	1.2 (0.8–1.9)	**2.2 (1.0–4.5)**	2.1 (1.0–4.7)
	Fair (≥40)	196 (17, 4)	1.2 (0.8–1.9)	1.2 (0.7–1.8)	1.1 (0.4–2.6)	1.0 (0.4–2.5)
	Poor (<40)	85 (21, 6)	1.6 (1.0–2.8)	1.6 (0.9–2.8)	2.0 (0.7–5.4)	1.5 (0.5–4.3)
Combination of push-up and Cooper test	Excellent§	178 (11, 3)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good¶	379 (16, 4)	1.5 (0.9–2.5)	1.4 (0.8–2.3)	1.3 (0.5–3.7)	1.4 (0.5–4.6)
	Fair‖	305 (17, 4)	**1.7 (1.0–2.9)**	1.5 (0.8–2.5)	1.6 (0.6–4.5)	1.4 (0.4–4.5)
	Poor#	97 (22, 9)	**2.4 (1.3–4.4)**	**2.1 (1.1–4.2)**	**3.7 (1.3–11.2)**	**3.8 (1.1–13.9)**
Combination of back lift and Cooper test	Excellent§	219 (12, 3)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good¶	435 (15, 4)	1.3 (0.9–2.1)	1.3 (0.8–2.1)	1.2 (0.5–2.8)	1.2 (0.5–3.3)
	Fair‖	262 (19, 5)	**1.6 (1.0–2.6)**	1.5 (0.9–2.5)	1.6 (0.6–4.0)	1.4 (0.5–3.9)
	Poor#	43 (32, 12)	**2.4 (1.1–4.9)**	**2.4 (1.1–5.4)**	**4.4 (1.4–13.8)**	**4.0 (1.1–14.7)**
Combination of sit-up and push-up test	Excellent§	142 (11, 3)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good¶	280 (15, 4)	1.5 (0.8–2.7)	1.5 (0.8–2.8)	1.4 (0.5–4.5)	1.7 (0.5–6.3)
	Fair‖	440 (17, 4)	**1.8 (1.0–3.1)**	1.6 (0.9–3.0)	1.6 (0.5–4.8)	1.7 (0.5–5.9)
	Poor#	107 (21, 7)	**2.4 (1.3–4.7)**	**2.2 (1.1–4.5)**	2.7 (0.8–9.3)	2.9 (0.7-12.2)
Combination of push-up and back lift test	Excellent§	268 (12, 4)	1 (Referent)	1 (Referent)	1 (Referent)	1 (Referent)
	Good¶	315 (16, 4)	1.4 (0.9–2.2)	1.4 (0.8–2.2)	1.0 (0.4–2.4)	1.2 (0.5–2.8)
	Fair‖	347 (17, 4)	1.4 (0.9–2.2)	1.3 (0.8–2.0)	1.1 (0.5–2.4)	0.9 (0.4–2.2)
	Poor#	39 (28, 13)	**2.7 (1.4–5.5)**	**2.8 (1.4–5.9)**	**4.2 (1.4–12.3)**	**4.3 (1.3–13.9)**

HR, hazard ratio; LBP, low back pain.

Variable distribution was charted in 982 male conscripts during the first 2 weeks of military service, and LBP outcomes were registered during the following 6-month military service.

Statistically significant findings are indicated in bold type.

* Three or more health clinic visits or five or more active service days lost because of LBP.

† Adjusted for age.

‡ Adjusted for age, company, smoking, baseline medical conditions (sports injury, sum factor of earlier musculoskeletal symptoms, regular medication, chronic impairment or disability because of prior musculoskeletal injury, and orthopedic surgery), educational level, school degree level, father's occupation, and participating in individual aerobic sports (12 adjusting variables).

§ Excellent results in both tests.

¶ Excellent result in sit-up/push-up/back lift tests and good or fair and good result in the combined test, or good results in both tests.

‖ Poorer results than aforementioned, except the combination of poor results in both tests.

\# Poor results in both tests.

the young. Higher levels of intellectual capacity and type of education, however, are reported to protect against severe LBP [6,75]. The present findings of the predictive value of a low level of education for recurrent LBP support previous findings. The ability to cope with minor LBP during military training might depend on educational background and intellectual capacity [75].

Earlier musculoskeletal symptoms and sport injuries were associated with LBP. The present results are consistent with those of a previous study of young conscripts [75,76], indicating that the roots of LBP are multifactorial, and LBP is not unrelated to other health problems, even in young persons. Conscripts entering military service were young healthy men, who had a medical checkup by a clinician during the 12 months before entering the military. Because conscripts with LBP at baseline were excluded from the data and an additional medical screening at baseline was performed by a physician, we assume that previous LBP did not bias the results.

High BMI and abdominal obesity were marginally ($p<.10$) associated with recurrent LBP in the multivariate model, which is in consonance with a recent meta-analysis reporting an association between obesity and chronic LBP [23]. Greater body weight [77] has been linked to an increased risk for LBP during military service, but findings are contradictory among Israeli recruits [56]. Severely obese persons do not meet military entrance standards in professional armies [78], which may partly explain the equivocal results of different studies. The association between BMI and LBP is unlikely to be causal [35,79].

Smoking was associated with LBP, consistent with previous findings [18,20,21,28,35]. In the multivariate model, however, the association diminished. The link between smoking and LBP seems to be weak, although persistent [18,19,21,28], and the causality of the association has not been proved, even in large epidemiological studies [21,80]. Because 95% of conscripts were between 18 and 20 years of age, it was not possible to investigate the effect of age on LBP thoroughly, but older age was associated with LBP before multivariate adjustments, consistent with findings among professional soldiers [39,44].

The present study has several strengths. First, the definition of LBP is clear and defined by *International Classification of Diseases, Tenth Revision* codes set by an independent physician in the garrison clinic. The study physician (HT) verified the accuracy of the codes by reviewing the patient records. Second, LBP data were collected from computerized patient files, guaranteeing a high coverage of LBP because all patients who entered the garrison clinic were recorded in the computerized system. Third, the participation rate was high (98%). Fourth, the military environment provides highly standardized conditions for investigating the effect of individual risk factors: conscripts trained in the same area, ate same food, and lived in the same barracks with nearly equal daily military programs, opportunity for rest and sleep [6,78]. Given that 90% of young men in Finland enter military service, and the participation rate in the present study was high, the present results might have an impact also outside military environment among young men who engage in an intensive physical training program with different physical fitness, body characteristics, health behavior, and socioeconomic backgrounds.

Our study has some limitations. First, although the compulsory military service concerns all Finnish male citizens, approximately 15% of conscripts are exempted from duty after physician examinations at call-up or at the first week of military service because of minimum physical and mental requirements established for military service [81]. Second, another 7% of all eligible men choose to perform nonmilitary service [82]. Third, considering physical fitness tests, the test protocol assessed general physical fitness of the conscripts rather than specifically spine fitness, which can be considered as a limitation of the study. Fourth, the findings cannot be generalized to young women because no more than 3% of the conscripts were women and were excluded from the study. A fifth limitation was the fact that after the initial 8 weeks of basic training, training programs diverged depending on the company, and although the physical training in different companies was maintained at the same level, the military training tasks were different. The associations between risk factors and LBP were, however, adjusted by company. In addition, because the threshold for seeking medical care may vary between individuals, some conscripts may have been more inclined to seek professional care than others demonstrating a situation where motivation for compulsory military service has an effect on the present results. However, motivation plays a significant role also in working populations, and thus, the role of motivation should not be overestimated when comparing present results with other studies conducted outside military environment.

In conclusion, the strongest risk factors for LBP were low educational level and coimpairments in physical fitness tests measuring aerobic capacity (12-minute running test) and trunk muscular endurance (sit-up, push-up, back lift tests). Lower educational level and coimpairments of physical fitness were also predictors for recurrent LBP. Mechanisms underlying the effects of educational status on the risk for LBP warrant further investigation. Low back pain is associated with other health problems as well, indicating the potentially multifactorial background of LBP. The present findings reflect the fact that basic military training is physically demanding for the back and requires adequate physical fitness. Poor entry-level fitness both in aerobic and trunk muscle endurance before military entry is a modifiable risk factor of LBP and amenable to prevention programs. The present results support the current understanding on the importance of efficient motor control and spinal stability to prevent LBP [57,83,84]. To distinguish conscripts at increased risk for LBP during military service that may benefit from targeted intervention programs, we suggest screening for

low fitness in dual combinations of aerobic and dynamic trunk muscle endurance tests, that is, sit-up, push-up, back lift, and 12-minute running test.

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RESEARCH ARTICLE Open Access

Low physical fitness is a strong predictor of health problems among young men: a follow-up study of 1411 male conscripts

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Abstract

Background: Military service in Finland is compulsory for male citizens and annually about 90% of 19-year-old men enter into the service. Approximately 15% of them are discharged due to medical reasons constituting a group of young men who are at risk of being marginalised in society. The purpose of the study was to evaluate predictive associations between medical discharge from the compulsory military service and various intrinsic risk factors, including socio-economic, health, health behavior, and physical fitness outcomes.

Methods: We followed four successive cohorts of conscripts who formed a representative sample of Finnish young men (18-28 years old, median age 19 yrs) for 6 months. To exclude injuries and illnesses originating before the onset of service, conscripts discharged from the service at the medical screenings during the 2-week run-in period were excluded from the analyses. Data regarding medical discharge were charted from computerised patient records. Predictive associations between medical discharge and intrinsic risk factors were examined using multivariate Cox's proportional hazard models.

Results: Of 1411 participants, 9.4% (n = 133) were discharged prematurely for medical reasons, mainly musculoskeletal (44%, n = 59) and mental and behavioral (29%, n = 39) disorders. Low levels of physical fitness assessed with a 12-min running test (hazard ratio [HR] 3.3; 95% confidence interval [CI]: 1.7-6.4), poor school success (HR 4.6; 95% CI: 2.0-11.0), poor self-assessed health (HR 2.8; 95% CI: 1.6-5.2), and not belonging to a sports club (HR 4.9; 95% CI: 1.2-11.6) were most strongly associated with medical discharge in a graded manner. The present results highlight the need for an improved pre-enlistment examination and provide a new means of identifying young persons with a high risk for discharge.

Conclusions: The majority of the observed risk factors are modifiable. Thus preventive measures and programs could be implemented. The findings suggest that increasing both aerobic and muscular fitness is a desirable goal in a pre-training program before entering military service. Attention to appropriate waist circumference and strategies addressing psychological well-being may strengthen the preventive program. Optimally the effectiveness of these programs should be tested in randomized controlled intervention studies.

Keywords: epidemiology, exercise, fitness testing, sporting injuries

Background

Military service in Finland is compulsory for all male citizens over 18 years of age and the duration varies from 6 to 12 months. The last stage to easily contact an entire age cohort of young males in Finland is at the time of military call-up at 18 years of age. Therefore, a call-up with a medical examination offers a unique opportunity to identify those persons requiring special attention [1]. Approximately 13% to 15% of Finnish conscripts (3500-4000 persons annually) are prematurely discharged from military service for medical reasons [2]. Given that 90% of young men in Finland enter into military service, the high number of medical-related discharges is a public health concern [3].

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It is important for military forces to identify persons unsuitable for service as early as possible [4,5], preferably at call-up before entering the service [1]. Early discharge from compulsory military service is a major drain of financial resources and time [6,7]. For the young individual, early discharge during military service can cause financial, emotional, and physical harm [1,8]. Moreover, severe injuries may result in functional impairment that leads to disabilities requiring long-term rehabilitation [9].

Knapik and colleagues [6] reported that lower performance in army physical fitness tests, lower educational level, and injuries accounting for time lost from service are risk factors for discharge in United States Army recruits, consistent with previous findings [8,10,11]. Other risk factors for discharge identified foremost in professional armies include: female sex [4,6,12], older age [7,12], Caucasian race [6,8], tobacco smoking [5,10,13,14], no history of competitive exercise [7], recurrent back pain prior to entering the service [4], history of depression [4,15,16], misconduct [5,12], lack of motivation [15], pre-service injuries [17,18] especially those with incomplete recovery [7,14], poor self-rated physical fitness on arrival [7,14], and low pre-service physical activity [12,14]. Physical and mental problems often overlap, leading to premature discharge from military service [12,18]. Moreover, some researchers have suggested that it is better to focus on overall discharge when examining the value of screening methods [4,5].

The findings from recruit armies are not directly comparable with those of a conscription army. The number of recruits, their quality and motivation, as well as practices and training regimens differ substantially between conscription and hired armies [8,9]. A recent Finnish study focusing mainly on psychological risk factors concluded that men prematurely discharged from compulsory military service require psychosocial support due to the accumulation of mental and social problems [19]. They are at risk of being marginalised in society at a time when they are at the threshold of adulthood [1,20]. In addition to Finnish studies [1,16,19], only one study has investigated risk factors for premature discharge in a conscription army. In Sweden, Larsson et al. [14] found a strong association between musculoskeletal injuries or complaints and discharge. These findings cannot be generalised, because less than 6% of young men complete their military service in Sweden [19].

The purpose of the present 6-month prospective follow-up study of four successive cohorts conscripted in the Finnish army was to evaluate predictive associations between medical discharge of the conscripts and various intrinsic risk factors, including socio-economic, health, health behaviour, and physical fitness outcomes. We hypothesized that low levels of physical fitness and health-damaging behaviour at the beginning of military service are associated with an increased incidence of premature discharge from military training.

Methods

Subjects

The subjects of the study comprised male conscripts (N = 1513) from four companies of one brigade (Pori Brigade, Säkylä) in the Finnish Defence Forces. The companies enrolled into the study were anti-tank, signal, mortar and engineer companies. During the study period, four cohorts of conscripts started service in the brigade (Figure 1). The Pori Brigade is a typical Finnish garrison and the selected companies form a representative sample of conscripts. The conscripts of each age-cohort are randomly assigned into the companies. The baseline characteristics of the companies are presented in Table 1.

Twenty-four conscripts (< 2%) refused to participate in the study (Figure 1). All of the remaining conscripts (N = 1489) agreed to participate and provided their informed consent before initiation of the study. Because there were only 36 women who volunteered military service and participated in the study (2.4%), their data was excluded from the analysis. Conscripts entering military service were young healthy men, all of whom had a medical check-up by a clinician during the 12 months before entering into the military. The health status of the conscripts was rechecked at baseline using routine medical screenings performed by a physician. To exclude injuries and illnesses originating before the onset of military service, conscripts discharged from the service at the medical screenings during the 2-week run-in period were excluded from the analyses leaving 1411 conscripts included in the analyses (Figure 1).

The age of the conscripts ranged from 18 to 28 years (median 19). All subjects were planned to be followed for 6 months beginning on the first day of service, but some dropped-out from the military or changed company (Figure 1) and this was taken into account when calculating exposure times. Approval for the study protocol was obtained from the Ethics Committee of Pirkanmaa Hospital District on 11 April 2006.

Physical training program

At the beginning of military service, all conscripts performed 8 weeks of basic training consisting of varying physical activities including marching, cycling, skiing, orienteering, swimming, drill training and combat training, or other training. There was an average of 17 hours of military actions per week with a gradual increase in intensity. Most of this time was low-to-moderate intensity activity. Instructors of the companies supervised that the intensity of training was low-to-moderate level. The rest breaks were organized in such manner that all conscripts managed to perform physical training regularly. In addition,

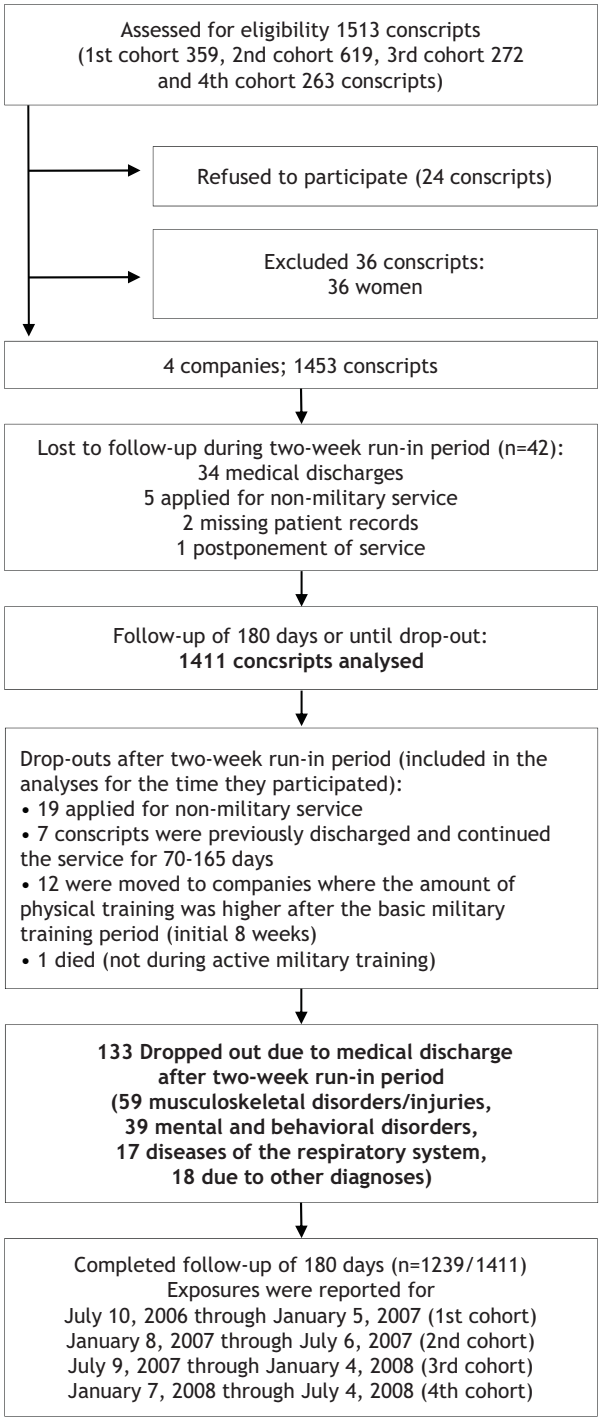

Figure 1 Flow of conscripts through the study.

conscripts performed other physical exercises such as jogging, team sports, and circuit training, for an average of 7 hours per week.

The two month basic training period was followed by a specific military training program depending on the company and service duration. During this 4-month period of service, the amount and intensity of physical training was maintained at approximately the same level in different companies.

Discharge registration and outcome definition

The data were collected from July 10, 2006 to July 4, 2008 (Figure 1). Data regarding medical discharge were charted from computerised patient records. During military service, all conscripts were required to use the services of the military healthcare units. In addition, we received separate discharge statistics from the Pori Brigade and cross-checked this data with the patient records to ensure that the data were complete. Discharges were divided into four main categories according to International Statistical Classification of Diseases and Related Health Problems (10th Revision): musculoskeletal disorders and injuries (M- and S-diagnoses), mental and behavioural disorders (F-diagnoses), respiratory diseases (J-diagnoses), and other diagnoses (Table 2). Discharge from military service was indicated when a physician determined a conscript unable to continue military training.

Assessment of physical fitness

A Cooper's test (12-min running test) and muscular fitness tests were performed by most (97%) conscripts during their first 2 weeks of military service. A minority of conscripts (3%) were unable to complete their physical fitness tests due to minor health problems, such as infection or overuse injury. Muscular fitness tests included push-ups, sit-ups, pull-ups, the standing long jump, and a back-lift test. Instructors of the companies supervised the conscripts to ensure technically correct performance of each test. More detailed information about the physical fitness tests was presented in our previous study [9].

A poor result in an individual muscle fitness test equated to 0 points, a fair result to 1 point, a good result to 2 points, and an excellent result to 3 points. A conscript's physical fitness index (CPFI) was calculated using the following formula: (12-min running test result [metres] + 100 × Muscle fitness test points)/200. The formula is based on standard practice in the Finnish Defence Forces since 1982 [21]. Because excellent results in the Cooper's test were uncommon (< 4%), the two highest levels, good and excellent, were combined to obtain a group of equal size for comparison between different fitness categories. Individual muscle fitness test results were combined into a single variable to explore whether the combined fitness variable, representing co-impairment, would be more strongly associated with premature discharge. In addition, height, weight, and waist circumference were measured during the first 2 weeks of service. Body mass index (BMI) was calculated by dividing weight (kilograms) by the square of height (meters). Waist circumference, as a mark

Table 1 Baseline characteristics of 1411 male conscripts by company

Variable	Anti-tank	Signal	Mortar	Engineer	Missing	P-value[1]
Number of conscripts	263	540	363	245	0 (0%)	-
Age, median, years (SD)	19 (0.79)	19 (1.18)	19 (0.78)	19 (0.93)	0 (0%)	0.422 [2]
Body mass index, median, kg/m^2 (SD)	23.4 (3.95)	22.6 (3.81)	23.3 (4.17)	23.6 (3.99)	139 (10%)	0.003 [2]
Waist circumference, median, cm (SD)	87.0 (10.2)	84.9 (9.69)	85.6 (10.5)	87.0 (9.72)	101 (7%)	0.001 [2]
12-minute run test result, median, m (SD)	2310 (338)	2308 (341)	2500 (302)	2400 (303)	42 (3%)	< 0.001 [2]
Conscript's physical fitness index (CPFI)[4], median, points (SD)	15.05 (3.05)	14.75 (3.29)	17.00 (3.10)	15.50 (3.09)	46 (3%)	< 0.001 [2]
Hometown population ≥ 10,000 persons,%	59%	66%	59%	57%	24 (2%)	0.044 [3]
High level of education[5],%	48%	38%	49%	35%	22 (2%)	< 0.001 [3]
High level of previous physical activity[6],%	31%	24%	42%	36%	23 (2%)	< 0.001 [3]
Good self-assessed health[7],%	57%	47%	61%	51%	22 (2%)	< 0.001 [3]
Chronic impairment or disability,%	17%	15%	16%	17%	27 (2%)	0.802 [3]
Regular medication, %	10%	13%	11%	8%	26 (2%)	0.220 [3]
Clear musculoskeletal symptoms[8],%	28%	32%	26%	27%	23 (2%)	0.339 [3]
Previous or current regular smoker, %	43%	47%	44%	57%	26 (2%)	0.004 [3]
Use of alcohol ≥ 3 times per week, %	16%	19%	15%	20%	23 (2%)	0.318 [3]

SD = standard deviation.

[1] P-value for difference between the companies.

[2] P-value was calculated using a Kruskal-Wallis test for median difference.

[3] P-value was calculated using $\chi 2$ statistics for difference.

[4] CPFI = (12-min running test result (metres) + 100 × muscle fitness test points)/200, [Excellent (CPFI ≥ 21.00), Good (17.00 ≤ CPFI < 21.00), Fair (13.00 ≤ CPFI < 17.00), Poor (CPFI < 13.00)].

[5] Graduated or studies in higher education institution.

[6] Sweating exercise at least three times per week during the last month before entering the military.

[7] Compared to age-mates.

[8] Symptoms lasting more than 7 days in at least one anatomical region during the last month before entering the military.

of abdominal obesity and excessive visceral fat [22], was measured with a tape at the midway between the lowest rib and iliac crest after normal exhalation. The cut-off points to describe overweight and obesity for BMI and waist circumference were set according to the World Health Organisation [23].

Pre-information questionnaire

Subjects were administered a pre-information questionnaire during the first week of military service. Questions charted conscripts' *socio-economic factors* (Table 3), *health* (Table 4), and *health behaviour* (Table 5) at the baseline of the study. The socio-economic factors included education, urbanization level of the place of residence, educational level, degrees achieved in school, and father's occupational group. Health factors included previous sports injuries and orthopedic surgeries, medication, chronic disease, chronic impairment or disability, self-assessed health compared to age mates, and musculoskeletal pain in six anatomical regions during the last month. Health behaviour was assessed with questions on the use of alcohol and tobacco, frequency of drunkenness, amount of physical exercise, prior sporting activities, belonging to a sports club, participation in competitive sports, highest level achieved in school sports, self-assessed physical fitness, and opinion about the physical demands of a soldier.

Statistical analysis

SPSS 17.0 for Windows software (SPSS Inc., Chicago, IL) was used for statistical analysis. Medical discharge incidence was calculated by dividing the number of discharged conscripts by the total number of conscripts and expressed as a percentage. Incidence rate was calculated by dividing the number of discharged conscripts by the exposure time. Exposure time was calculated until the end of the follow-up. The incidence with 95% confidence interval (CI) was expressed per 1000 person-days.

Cox's proportional hazard models were applied to study the prospective associations between baseline characteristics and discharge incidence. The outcome was defined as an incidence of premature discharge due to medical reasons. In the first phase of the Cox regression, each independent variable was analyzed one at a time. Results are expressed as hazard ratios (HR) and calculated with 95% CIs with age at baseline forced into the model.

Table 2 Numbers and reasons for early medical discharge from military service after the 2-week run-in period in 1411 male conscripts during a 6-month military training period

Number	Diagnosis
Musculoskeletal disorders & injuries	
25	Overuse injury of the limb
9	Low back pain
8	Internal injury of the knee joint
4	Dislocations
3	Fracture of neck of femur
2	Other chest pain due to earlier fracture
2	Fracture of humerus
1	Fracture of carpal bones
1	Injury of the extensor muscle and tendon of a finger
1	Fracture of shaft of femur
1	Sprain of collateral ligament of knee
1	Sprain of wrist
1	Tendinopathies
Total 59 conscripts, 44% of all discharges	
Mental and behavioural disorders	
21	Adjustment disorders
9	Depressive episodes
7	Anxiety disorders
2	Personality disorders
Total 39 conscripts, 29% of all discharges	
Diseases of the respiratory system	
9	Acute upper respiratory infection
6	Asthma
1	Chronic pansinusitis
1	Chlamydial pneumonia
Total 17 conscripts, 13% of all discharges	
Dermatological diseases	
1	Atopic dermatitis
1	Erysipelas
1	Allergic urticaria
1	Pilonidal cyst without abscess
Total 4 conscripts, 3% of all discharges	
Cardiovascular disorders	
1	Tachycardia
1	Subarachnoid haemorrhage
Total 2 conscripts, 2% of all discharges	
Gastrointestinal diseases	
1	Ulcerative colitis
1	Volvulus
Total 2 conscripts, 2% of all discharges	
Other reasons	
1	Hematuria
1	Postviral fatigue syndrome

Table 2 Numbers and reasons for early medical discharge from military service after the 2-week run-in period in 1411 male conscripts during a 6-month military training period *(Continued)*

1	Allergy unspecified
1	Noise effects on inner ear
1	Precordial pain
1	Malaise and fatigue
1	Congenital pes planus
1	Coma unspecified
1	Acute atopic conjunctivitis
1	Juvenile rheumatoid arthritis
Total 10 conscripts, 8% of all discharges	

Table 3 Hazard ratios (HR) for early medical discharge from military service by socioeconomic variables at baseline

Socioeconomic background & company	Category	Total number (% of discharged)	HR for discharge (n = 133) *	HR for discharge (n = 133) **
Father's occupation	Not physical	488 (8)	1 (Referent)	1 (Referent)
	Physical	590 (10)	1.2 (0.8-1.9)	1.0 (0.7-1.6)
	Unclear or unemployed	261 (10)	1.3 (0.8-2.2)	1.2 (0.7-2.0)
School success (educational level and grades combined)	Excellent [1]	218 (4)	1 (Referent)	1 (Referent)
	Good [2]	608 (8)	**2.2 (1.0-4.7)**	2.0 (0.9-4.2)
	Satisfactory [3]	467 (11)	**3.2 (1.5-6.7)**	**2.5 (1.2-5.5)**
	Poor [4]	96 (22)	**6.4 (2.8-14.5)**	**4.6 (2.0-11.0)**
Level of education	High [5]	589 (6)	1 (Referent)	1 (Referent)
	Lower [6]	800 (12)	**2.0 (1.4-3.0)**	1.3 (0.7-2.4)
Degrees achieved in school	High	466 (6)	1 (Referent)	1 (Referent)
	Low or average	922 (11)	**1.7 (1.1-2.5)**	0.8 (0.5-1.4)
Urbanisation level of the place of residence	< 10000 inhabitants	537 (7)	1 (Referent)	1 (Referent)
	≥ 10000 inhabitants	850 (11)	1.4 (1.0-2.0)	1.4 (1.0-2.1)
Age	18-19 years	1052 (8)	1 (Referent)	1 (Referent)
	20-28 years	359 (13)	**1.6 (1.1-2.3)**	1.4 (0.9-2.0)
Company	Anti-tank company	263 (7)	1 (Referent)	1 (Referent)
	Signal company	540 (10)	1.5 (0.9-2.6)	1.2 (0.7-2.1)
	Mortar company	363 (11)	1.7 (1.0-2.9)	1.7 (0.9-3.0)
	Engineer company	245 (9)	1.2 (0.6-2.3)	1.1 (0.6-2.1)

Variable distribution was charted in 1411 male conscripts during the first week of military service and discharge outcomes were registered during the following 6-month military service. Statistically significant findings are indicated with bold type.

[1] Attended upper secondary school, polytechnic, or university and reported excellent or good grades.

[2] Other subjects from upper secondary school, polytechnic, or university and conscripts from vocational school whose grades were excellent or good.

[3] Respondents with poorer grades in vocational school.

[4] Attended only comprehensive school or had permanently interrupted vocational or upper elementary school.

[5] Secondary school graduates, polytechnic, and university students

[6] Only comprehensive or vocational school

* Adjusted for age (univariate)

** Adjusted for age, company, smoking (previous or current smoker), alcohol intake, baseline medical conditions (sports injury during last month, sum factor of earlier musculoskeletal symptoms during the last month before entering the military, chronic impairment or disability due to prior musculoskeletal injury, chronic disease, regular medication), school success (educational level and grades combined), urbanisation level of the place of residence, participating in ball games, last degree achieved in school sports, physical activity during the previous 3 months before entering the military, self-assessed health, belonging to a sports club and participation in competitive sports (17 adjusting variables).

Table 4 Hazard ratios (HR) for early medical discharge from military service by health variables at baseline

Health variable	Category	Total number (% of discharged)	HR for discharge (n = 133) *	HR for discharge (n = 133) **
Body mass index	Underweight (BMI < 18.5)	56 (7)	1.4 (0.5-3.9)	1.3 (0.5-3.8)
(BMI = (kg)/(m)^2)	Normal (18.5 ≤ BMI < 25.0)	812 (5)	1 (Referent)	1 (Referent)
	Pre-obese (25.0 ≤ BMI < 30.0)	300 (6)	1.1 (0.6-1.9)	1.1 (0.6-2.0)
	Obese (BMI ≥ 30.0)	104 (9)	1.7 (0.8-3.4)	1.7 (0.8-3.6)
Waist circumference	Thin (WC < 80)	271 (7)	1.5 (0.9-2.6)	1.2 (0.7-2.2)
(WC, cm)	Normal (80 ≤ WC < 94)	739 (5)	1 (Referent)	1 (Referent)
	Increased (94 ≤ WC < 102)	178 (6)	1.1 (0.5-2.2)	0.9 (0.4-1.9)
	High (WC ≥ 102)	122 (12)	**2.5 (1.4-4.5)**	**2.4 (1.3-4.6)**
Height (cm)	Shortest tertile (≤ 177 cm)	392 (6)	1.3 (0.7-2.3)	1.3 (0.7-2.3)
	Middle tertile (178-183 cm)	477 (6)	1.2 (0.7-2.2)	1.2 (0.7-2.2)
	Tallest tertile (≥ 184 cm)	403 (5)	1 (Referent)	1 (Referent)
Self-assessed health [1]	Good or very good	743 (5)	1 (Referent)	1 (Referent)
	Average	558 (12)	**2.4 (1.6-3.5)**	**1.7 (1.1-2.6)**
	Inferior	88 (26)	**5.7 (3.4-9.5)**	**2.8 (1.6-5.2)**
Chronic disease	No	1012 (8)	1 (Referent)	1 (Referent)
	Yes	377 (14)	**1.8 (1.3-2.6)**	**1.6 (1.1-2.3)**
Regular medication	No	1235 (9)	1 (Referent)	1 (Referent)
	Yes	150 (15)	**1.8 (1.2-2.8)**	1.3 (0.8-2.2)
Orthopaedic surgery	Never	1273 (10)	1 (Referent)	1 (Referent)
	Yes	114 (7)	0.7 (0.3-1.4)	0.8 (0.4-1.7)
Chronic impairment	No	1165 (9)	1 (Referent)	1 (Referent)
or disability [2]	Yes	219 (13)	**1.5 (1.0-2.3)**	1.1 (0.7-1.8)
Sports injury during	No	1254 (9)	1 (Referent)	1 (Referent)
last month	Yes	130 (15)	**1.7 (1.0-2.7)**	**1.7 (1.0-2.9)**
Sum factor of other	Minimal symptoms [3]	440 (6)	1 (Referent)	1 (Referent)
musculoskeletal	Mild symptoms [4]	548 (9)	1.5 (0.9-2.4)	1.3 (0.8-2.2)
symptoms	Clear symptoms [5]	400 (13)	**2.3 (1.4-3.6)**	1.6 (1.0-2.9)

Variable distribution was charted in 1411 male conscripts during the first week of military service and discharge outcomes were registered during the following 6-month military service. Statistically significant findings are indicated with bold type.

[1] Compared to age-mates

[2] Due to prior musculoskeletal injury.

[3] 'Minimal symptoms': maximum 7-day lasting symptom in one anatomical region during the last month before military entry.

[4] 'Mild symptoms': symptoms in 2 to 6 anatomical regions but the symptoms had lasted a week maximum during the last month before military entry.

[5] 'Clear symptoms': included the remaining conscripts.

* Adjusted for age (univariate)

** Adjusted for age, company, smoking (previous or current smoker), alcohol intake, baseline medical conditions (sports injury during last month, sum factor of earlier musculoskeletal symptoms during the last month before entering the military, chronic impairment or disability due to prior musculoskeletal injury, chronic disease, regular medication), school success (educational level and grades combined), urbanisation level of the place of residence, participating in ball games, last degree achieved in school sports, physical activity during the previous 3 months before entering the military, self-assessed health, belonging to a sports club and participation in competitive sports (17 adjusting variables).

Table 5 Hazard ratios (HR) for early medical discharge from military service by health behaviour variables at baseline

Health behaviour	Category	Total number (% of discharged)	HR for discharge (n = 133) *	HR for discharge (n = 133) **
Smoking habits	Never smoked regularly	735 (7)	1 (Referent)	1 (Referent)
	Has smoked regularly	650 (12)	**1.6 (1.2-2.3)**	1.3 (0.8-1.9)
Use of alcohol	< 1 time per month	254 (13)	1 (Referent)	1 (Referent)
	1-2 times per week	894 (8)	**0.6 (0.4-0.9)**	**0.5 (0.3-0.8)**
	≥ 3 times per week	240 (11)	0.8 (0.5-1.4)	**0.5 (0.3-1.0)**
Frequency of drunkenness before military service	< 1 time per week	1075 (9)	1 (Referent)	1 (Referent)
	≥ 1 time per week	313 (12)	1.4 (1.0-2.1)	1.1 (0.7-1.8)
Agrees that soldier needs good physical fitness	Yes	902 (9)	1 (Referent)	1 (Referent)
	No	487 (9)	1.1 (0.7-1.5)	0.8 (0.5-1.1)
Sweating exercise (Brisk leisure time sport)	≥ 3 times per week	438 (6)	1 (Referent)	1 (Referent)
	1-2 times per week	415 (8)	1.4 (0.8-3.8)	0.9 (0.5-1.6)
	Only leisured exercise	257 (12)	**2.2 (1.3-3.8)**	1.2 (0.7-2.1)
	No physical exercise	278 (15)	**2.7 (1.7-4.5)**	1.2 (0.7-2.2)
Participates in individual aerobic sports	Yes, at least sometimes	954 (9)	1 (Referent)	1 (Referent)
	No	431 (10)	1.2 (0.8-1.7)	0.9 (0.6-1.3)
Belongs to a sports club	Yes, active member	206 (2)	1 (Referent)	1 (Referent)
	No, but former member	802 (9)	**4.9 (1.8-13.4)**	**3.7 (1.5-16.0)**
	No, never member	375 (14)	**7.4 (2.7-20.4)**	**4.9 (1.2-11.6)**
Participates in competitive sports	Yes	180 (4)	1 (Referent)	1 (Referent)
	No	1206 (10)	**2.7 (1.3-5.8)**	1.0 (0.4-2.5)
Last degree in school Sports	Good or excellent	1101 (8)	1 (Referent)	1 (Referent)
	Poor or fair	286 (14)	**1.8 (1.2-2.5)**	0.9 (0.5-1.4)
Participates in ball games	Yes	950 (8)	1 (Referent)	1 (Referent)
	No	438 (13)	**1.7 (1.2-2.4)**	1.2 (0.8-1.8)

Variable distribution was charted in 1411 male conscripts during the first week of military service and discharge outcomes were registered during the following 6-month military service. Statistically significant findings are indicated with bold type.

* Adjusted for age (univariate)

** Adjusted for age, company, smoking (previous or current smoker), alcohol intake, baseline medical conditions (sports injury during last month, sum factor of earlier musculoskeletal symptoms during the last month before entering the military, chronic impairment or disability due to prior musculoskeletal injury, chronic disease, regular medication), school success (educational level and grades combined), urbanisation level of the place of residence, participating in ball games, last degree achieved in school sports, physical activity during the previous 3 months before entering the military, self-assessed health, belonging to a sports club and participation in competitive sports (17 adjusting variables).

A multivariate Cox regression was used to identify independent risk factors for discharge and examine interactions between risk factors. In the data analysis, based on the previous literature, conceptually compatible and logical risk factors were chosen for multivariate-models. Only possibly significant explanatory variables ($P < 0.20$) in the initial age-adjusted models were included for the multivariate models: Higher age, company, smoking status (previous or current regular smoker), high alcohol intake, poor baseline medical condition (sports injury during last month, sum factor of earlier musculoskeletal symptoms during the last month before entering the military, chronic impairment or disability due to prior musculoskeletal injury, chronic disease, regular medication), poor school success (educational level and grades combined) and poor self-assessed health, were entered into the model as known or possible risk factors. Prior physical activity during the previous three months before

entering the military, participating in ball games, last degree achieved in school sports, belonging to a sports club, participation in competitive sports and urbanisation level of the home residence were considered as effect modifiers and entered into the multivariate model. A *P* value of less than 0.05 was considered statistically significant when interpreting the results from Cox's proportional hazard models.

Results

Incidence and reasons for discharge

Of the 1411 participants, 9.4% (n = 133) sustained a premature medical discharge after the 2-week run-in period during the 6-month service. The mean follow-up time per conscript was 166 days. The incidence rate for discharge was 0.57 (95% CI: 0.48-0.67) per 1000 person-days. The discharge incidence for the first (8%), second (8%), third (16%), and fourth (10%) cohorts was significantly different among cohorts (P = 0.002). In addition, there was a trend towards more medical discharges among arrivals entering the military in July (11%) than in January (8%; P = 0.058). The most common reasons for discharge were musculoskeletal injuries and disorders (44%, n = 59), followed by mental and behavioural disorders (29%, n = 39) (Table 2). For discharged conscripts, the mean time in military service (± SD) was 65 ± 37 days.

Tables 3, 4, 5, and 6 show the distribution of variables and the hazard ratios of medical discharge for various *socioeconomic* (Table 3), *health* (Table 4), *health behaviour* (Table 5), and *physical fitness* variables (Table 6) in the age-adjusted and multivariate models.

From the *socioeconomic background* variables (Table 3), a conscript's poor school success (educational level and degrees combined) was the strongest risk factor. After adjustment in multivariate analyses, poor school success was associated with a 4.6-fold higher risk for discharge (95% CI: 2.0-11.0) compared to excellent school success with a graded relationship. Older age was associated with discharge in the age-adjusted model, but was not significant in multivariate model.

With regard to *health* (Table 4), we observed low self-assessed health to be the strongest risk indicator in a graded manner (HR 2.8; 95% CI: 1.6-5.2) after adjustments in multivariate analyses. Waist circumference over 102 cm was clearly associated with discharge compared to normal waist circumference. In addition, chronic diseases and former sport injuries were associated with discharge.

From the *health behaviour* variables (Table 5), never belonging to a sports club was a strong risk indicator for discharge (HR = 4.9; 95% CI: 1.2-11.6). Conscripts who used alcohol more than once a month seemed to have lower risk for discharge compared to conscripts who drank alcohol less frequently. Smoking and lack of participation in leisure time sports before entering military service were associated with discharge in the age-adjusted model, but these associations weakened in the multivariate analyses.

With regard to *physical fitness* (Table 6), we observed a clear association between low physical fitness and discharge. In the age-adjusted analysis, all the army physical fitness tests were associated with premature discharge. After adjustment in the multivariate analyses, the strongest association was between a poor result in the 12-min running test and discharge (HR = 3.3; 95% CI: 1.7-6.4). In addition, a poor result in the push-up test nearly doubled the risk for discharge. When combining individual fitness test results, co-impairment in 12-min running and push-up or pull-up tests was the strongest risk indicator. In addition, co-impairments in sit-ups, push-ups, pull-ups, and standing long jump test were associated with discharge.

There were some associations for risk factors specific for mental or musculoskeletal discharge categories (Table 7). Low self-assessed health was associated especially with discharge for mental reasons (HR = 7.8; 95% CI: 2.7-22.4). Use of alcohol more than once per month was associated with a lower risk for discharge due to mental reasons. Co-impairment in the sit-up and push-up tests was associated especially with discharge for musculoskeletal reasons. Older age was associated with discharge for mental reasons. There was a trend towards poor school success being associated with discharge for mental reasons.

Discussion

Low levels of physical fitness, poor school success, poor self-assessed health, and high waist circumference were associated with premature discharge from military service in a graded manner. Conscripts that never belonged to a sports club were at higher risk of discharge compared to former club members and especially present active members. Of the 1411 participants, 9.4% (n = 133) sustained premature medical discharge during the 6-month service. The most common reasons for discharge were musculoskeletal (44%, n = 59) injuries, followed by mental and behavioural disorders (29%, n = 39). The hypothesis that co-impairment in physical fitness is a predictor of medical discharge was based on our previous study investigating risk factors of musculoskeletal disorders during military training [9].

Santtila and colleagues [24] reported that conscripts' aerobic fitness has decreased 12% during the years 1979-2004 and mean body mass has increased 4.4 kg during the years 1993-2004. Moreover, the proportion of conscripts with low physical ability leading to problems meeting minimum physical requirements set for military service has increased dramatically: The number of

Table 6 Hazard ratios (HR) for early medical discharge from military service by physical fitness test variables at baseline

Physical fitness test result	Category	Total number (% of discharged)	HR for discharge (n = 133) *	HR for discharge (n = 133) **
Cooper's test (12-minute running test)	Excellent (≥ 3000 m)	51 (6)		
			} 1 (Referent)	} 1 (Referent)
	Good (≥ 2600 m)	330 (4)		
	Fair (≥ 2200 m)	630 (6)	1.5 (0.8-2.8)	1.4 (0.8-2.7)
	Poor (< 2200 m)	358 (14)	**3.7 (2.1-6.7)**	**3.3 (1.7-6.4)**
Pull-up test (consecutive repeats without time limit)	Excellent (≥ 14)	158 (5)	1 (Referent)	1 (Referent)
	Good (≥ 10)	221 (8)	1.6 (0.7-3.6)	1.8 (0.7-4.5)
	Fair (≥ 6)	391 (5)	1.0 (0.5-2.4)	1.0 (0.4-2.5)
	Poor (< 6)	608 (11)	**2.2 (1.1-4.6)**	2.0 (0.9-4.6)
Standing long jump test (two attemps, best result observed)	Excellent (≥ 2, 40 m)	241 (5)	1 (Referent)	1 (Referent)
	Good (≥ 2, 20 m)	363 (8)	1.6 (0.8-3.0)	1.5 (0.8-3.0)
	Fair (≥ 2, 00 m)	442 (6)	1.2 (0.6-2.3)	1.0 (0.5-2.0)
	Poor (< 2, 00 m)	332 (11)	**2.3 (1.2-4.2)**	1.7 (0.9-3.3)
Sit-up test (repeats per 60 seconds)	Excellent (≥ 48)	221 (5)	1 (Referent)	1 (Referent)
	Good (≥ 40)	319 (4)	0.9 (0.4-2.1)	0.7 (0.3-1.7)
	Fair (≥ 32)	459 (9)	2.0 (1.0-3.9)	1.4 (0.7-3.0)
	Poor (< 32)	379 (12)	**2.8 (1.4-5.5)**	1.9 (0.9-4.0)
Push-up test (repeats per 60 seconds)	Excellent (≥ 38)	450 (6)	1 (Referent)	1 (Referent)
	Good (≥ 30)	312 (5)	1.0 (0.5-1.8)	0.9 (0.5-1.6)
	Fair (≥ 22)	350 (7)	1.3 (0.8-2.3)	1.0 (0.6-1.9)
	Poor (< 22)	266 (15)	**2.7 (1.7-4.5)**	**1.8 (1.0-3.2)**
Back lift test (repeats per 60 seconds)	Excellent (≥ 60)	660 (6)	1 (Referent)	1 (Referent)
	Good (≥ 50)	284 (10)	1.7 (1.1-2.8)	1.2 (0.7-1.9)
	Fair (≥ 40)	291 (7)	1.2 (0.7-2.0)	0.9 (0.5-1.5)
	Poor (< 40)	143 (13)	**2.2 (1.3-3.9)**	1.3 (0.7-2.4)
Conscript's physical fitness index [1]	Excellent (≥ 21.00)	69 (3)	1 (Referent)	1 (Referent)
	Good (17.00-20.99)	409 (6)	2.0 (0.5-8.4)	1.4 (0.3-5.9)
	Fair (13.00-16.99)	590 (6)	2.1 (0.5-8.7)	1.1 (0.2-4.7)
	Poor (< 13.00)	297 (14)	**5.1 (1.2-21.2)**	2.5 (0.6-11.1)
Co-impairment in Cooper's and push-up tests	No	1219 (6)	1 (Referent)	1 (Referent)
	Yes, poor results in both tests	146 (18)	**3.1 (2.0-4.8)**	**2.6 (1.6-4.3)**
Co-impairment in Cooper's and pull-up tests	No	1365 (7)	1 (Referent)	1 (Referent)
	Yes, poor results in both tests	272 (15)	**2.8 (1.9-4.1)**	**2.7 (1.7-4.3)**
Co-impairment in sit-up and pull-up tests	No	1107 (6)	1 (Referent)	1 (Referent)
	Yes, poor results in both tests	271 (15)	**2.6 (1.8-3.8)**	**2.2 (1.4-3.4)**
Co-impairment in push-up and standing long jump tests	No	1241 (7)	1 (Referent)	1 (Referent)
	Yes, poor results in both tests	137 (19)	**3.1 (2.0-4.8)**	**2.5 (1.5-4.1)**

Table 6 Hazard ratios (HR) for early medical discharge from military service by physical fitness test variables at baseline *(Continued)*

Co-impairment in sit-up and push-up tests	No	1215 (7)	1 (Referent)	1 (Referent)
	Yes, poor results in both tests	163 (18)	**3.0 (2.0-4.6)**	**2.6 (1.6-4.1)**

Variable distribution was charted in 1411 male conscripts during the first week of military service and discharge outcomes were registered during the following 6-month military service. Statistically significant findings are indicated with bold type.

[1] Conscript's physical fitness index (CPFI) = (12-min running test result (m) + 100 × muscle fitness test points)/200.

* Adjusted for age (univariate)

** Adjusted for age, company, smoking (previous or current smoker), alcohol intake, baseline medical conditions (sports injury during last month, sum factor of earlier musculoskeletal symptoms during the last month before entering the military, chronic impairment or disability due to prior musculoskeletal injury, chronic disease, regular medication), school success (educational level and grades combined), urbanisation level of the place of residence, participating in ball games, last degree achieved in school sports, physical activity during the previous 3 months before entering the military, self-assessed health, belonging to a sports club and participation in competitive sports (17 adjusting variables).

Table 7 Hazard ratios (HR) for early medical discharge stratified by musculoskeletal and mental reason categories

Variable	Category	Total number (% of discharged[§])	HR for discharge[§] (n = 133) *	HR for discharge[§] (n = 133)
Discharge due to musculoskeletal reasons				
Urbanisation level of the place of residence	< 10000 inhabitants	537 (3)	1 (Referent)	1 (Referent) [†]
	≥ 10000 inhabitants	850 (5)	**1.9 (1.1-3-4)**	**2.3 (1.3-4.4)** [†]
Chronic disease	No	1012 (4)	1 (Referent)	1 (Referent) [†]
	Yes	377 (6)	1.6 (1.0-2.8)	**1.8 (1.0-3.2)** [†]
Co-impairment in sit-up and push-up test	No	1215 (3)	1 (Referent)	1 (Referent) [†]
	Yes, poor results in both tests	163 (7)	**2.6 (1.4-5.1)**	**2.4 (1.2-4.7)** [†]
Discharge due to mental reasons				
Age	18-19 years	1052 (2)	1 (Referent)	1 (Referent) [‡]
	20-28 years	359 (5)	**2.9 (1.5-5.4)**	**2.7 (1.4-5.3)** [‡]
Self-assessed health [1]	Good or very good	743 (1)	1 (Referent)	1 (Referent) [‡]
	Average	558 (3)	**3.0 (1.3-6.9)**	2.1 (0.9-5.4) [‡]
	Inferior	88 (15)	**15.4 (6.4-37.2)**	**7.8 (2.7-22.4)** [‡]
Use of alcohol	< 1 time per month	254 (5)	1 (Referent)	1 (Referent) [‡]
	1-2 times per week	894 (1)	**0.3 (0.1-0.7)**	**0.3 (0.1-0.6)** [‡]
	≥ 3 times per week	240 (5)	1.1 (0.5-2.5)	0.6 (0.3-1.4) [‡]

Variable distribution was charted in 1411 male conscripts during the first two weeks of military service and discharge outcomes were registered during the following 6-month military service. Statistically significant findings are indicated with bold type.

[§] Discharge due to musculoskeletal or mental reasons

[1] Compared to age-mates

* Adjusted for age (univariate)

[†] Adjusted for age, company, father's occupational group, smoking (previous or current smoker), frequency of drunkenness, baseline medical conditions (sum factor of earlier musculoskeletal symptoms during the last month before entering the military, chronic disease), school success (educational level and grades combined), urbanisation level of the place of residence, participating in ball games, last degree achieved in school sports, physical activity during the previous 3 months before entering the military, self-assessed health, belonging to a sports club and participation in competitive sports (15 adjusting variables).

[‡] Adjusted for age, alcohol intake, baseline medical conditions (sum factor of earlier musculoskeletal symptoms during the last month before entering the military, chronic impairment or disability) school success (educational level and grades combined), participating in ball games, last degree achieved in school sports, physical activity during the previous 3 months before entering the military, self-assessed health and participation in competitive sports (10 adjusting variables).

conscripts with a poor result (< 2200 m) in Cooper's test increased 5.6-fold between 1980 and 2004 [24]. Poor muscle fitness and aerobic capacity [9,25-28] and obesity [9,25,29] are risk factors for musculoskeletal injuries and disorders among conscripts. Conscripts' tasks requiring both strength and aerobic capacity, such as loaded marching, may be further negatively affected by obesity [24], demonstrating a situation where several components may play an important role in the aetiology of musculoskeletal injury. In the present study, high waist circumference was independently associated with premature discharge compared to normal waist circumference, whereas BMI was not. This was probably due to the fact that BMI does not distinguish lean mass from fat tissue [30].

One of the reasons for the current study was that at the turn of the millennium, there was a substantial rise (62%) in the number of premature discharges in the Finnish army due to musculoskeletal injuries [31]. Most likely, this was due to the 100% increase in physical exercise in the Finnish military service program in July 1998. At that time, 8% to 10% of the conscripts were prematurely discharged from the Finnish Defence Forces. In a recent study, we found that co-impairments in cardiorespiratory and muscular fitness (i.e., poor results in Cooper's test combined with a poor result in standing long jump, push-up or back lift tests) were highly associated with musculoskeletal injuries and disorders, showing a dose-response relationship. Similarly, abdominal obesity and high BMI were clearly associated with the outcome [9].

Belonging to a sports club is strongly associated with leisure time physical activity, which seems to lower the risk for discharge [12,14]. Sports clubs may also enhance health in ways other than through physical fitness. Koski [32] reported that 81% of Finnish youth sports clubs declare that healthy lifestyle is one of their main goals. Moreover, sports clubs offer informal education on teamwork, interaction skills, and assessing values [33]. Other factors associated with benefits acquired in sports clubs may be that in sports clubs children and adolescents learn to obey rules and follow the instructions of coaches, skills that probably help conscripts to adapt to the discipline required for compulsory military service.

The present results indicated that poor self-assessed health predicted discharge especially for mental health reasons. Similar findings have been reported among Swedish conscripts [14] and US Air Force recruits [34]. Multimaki et al. [1] also found that mental health service use was strongly associated with medical discharge at call-up. In a recent Finnish study, psychosocial problems were more prevalent among men who interrupted their service compared with those exempted from service at call-up [19]. This can be explained by the fact that somatic diseases can be identified more easily than psychosocial problems at call-up. Based on the present findings, direct questions about mental and physical well-being can be used to distinguish persons with an elevated risk for discharge before the onset of military training. Moreover, mental reasons leading to discharge tend to be long-term and debilitating. Only every seventh conscript discharged due to mental reasons performs military service in a 5-year follow-up after the discharge [16].

Our results showed that conscripts who used alcohol more than once a month had a lower risk for premature discharge, especially for mental health issues. This may be due to anxiolytic effects of alcohol during vacations from military service. Andreasson et al. [35] supported this hypothesis and concluded that conscripts who were never anxious or never felt insecure used more alcohol than their counterparts. In contrast, however, Ristkari et al. [36] reported that a high level of alcohol use was associated with poor coping and resiliency strategies among young men at military call-up [36] and excessive alcohol use is associated with discharge at call-up [1]. Another possible explanation for our contradictory finding might be that regular use of alcohol is seen as normal behaviour for conscripts during vacations and this improves affinity among conscripts who use alcohol [37].

The present study has several strengths. First, the definition of premature discharge due to medical reasons was clear and defined by ICD-10 codes set by an independent physician in the garrison clinic. Second, the garrison clinic computerised patient records were cross-checked with the discharge data of the Finnish Defence Forces, guaranteeing a high coverage of discharges. Third, the participation rate was high (98%). Fourth, the military environment provides highly standardised conditions for investigating the effect of individual risk factors: conscripts underwent daily military programs that were nearly equal, providing equal opportunity for rest and sleep [26]. Given that 90% of young men in Finland enter military service, the present results regarding musculoskeletal injuries and disorders might have an impact also outside military environment among young males who engage in an intensive physical training program with different physical fitness, body characteristics, health behaviour, and socioeconomic backgrounds.

Our study has also limitations. First, although the compulsory military service concerns all Finnish male citizens, approximately 15% of conscripts are exempted from duty after physician examinations at call-up or during the first week of military service due to minimum physical and mental requirements established for military service [2]. Second, approximately 7% of all eligible men choose to perform non-military service in Finland [38]. Third, although the information of waist circumference

length was available in 93% of conscripts, it was missing in over 30% of discharged conscripts because they were exempted from active service due to flu or musculoskeletal injuries when the waist circumference was measured. Hence the variable was not entered into the adjusted model which is a limitation of the study. Fourth, the findings can be generalized to young men only because no more than 3% of the conscripts were females and they were excluded from the study. A fifth limitation was the fact that after the initial 8 weeks of basic training, the training programs became more divergent due to the more specialised military service in each company. This also caused drop-out of some participants due to a company change. On the other hand, all conscripts were followed up for the first 8 weeks of service and results were adjusted by company.

Conclusion

In Finland, 13% to 15% (3500-4000 persons) of young men who enter the military service are prematurely discharged annually from compulsory military service. In the present study, low levels of aerobic and muscular fitness and poor school success were associated with premature discharge from military service in a graded manner. We also found that poor self-assessed health was especially associated with discharges due to mental health reasons. These findings highlight the need for an improved pre-enlistment examination. The new interesting finding was that conscripts who had never been a member of a sports club had an elevated risk for premature discharge. For the conscript, a premature discharge during military service can cause financial, emotional, and physical harm requiring long-term rehabilitation. Discharged conscripts are at risk of being marginalised in society at a time when they are at the threshold of adulthood [1,19]. Especially mental health reasons leading to discharge are associated with poor income, retirement, divorced or single status, and a criminal record [39,40] in a follow-up of 10 to 23 years after compulsory military service. Preventive measures and programs are clearly needed and, optimally, should be tested in controlled intervention studies. The present findings suggest that increasing both aerobic and muscular fitness is a desirable goal in a pre-training program before entering military service. Attention to appropriate waist circumference and strategies addressing psychological well-being may strengthen the preventive program.

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Authors' contributions

HT wrote the first draft of the manuscript together with AJMH. HT and AJMH also participated in data analysis, interpretation and data acquisition. JHS was the primary investigator together with JP. JHS initiated and conceptually designed the study and took part in data processing and manuscript reviewing. HP participated in study concept and design as well as manuscript reviewing. JP initiated and conceptually designed the study and participated in manuscript writing, data analysis and interpretation. All authors have made substantive intellectual contributions to the study. All authors reviewed the article and gave the final approval of the manuscript.

Competing interests

The authors declare that they have no competing interests.

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RESEARCH ARTICLE Open Access

Neuromuscular training with injury prevention counselling to decrease the risk of acute musculoskeletal injury in young men during military service: a population-based, randomised study

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Abstract

Background: The rapidly increasing number of activity-induced musculoskeletal injuries among adolescents and young adults is currently a true public health burden. The objective of this study was to investigate whether a neuromuscular training programme with injury prevention counselling is effective in preventing acute musculoskeletal injuries in young men during military service.

Methods: The trial design was a population-based, randomised study. Two successive cohorts of male conscripts in four companies of one brigade in the Finnish Defence Forces were first followed prospectively for one 6-month term to determine the baseline incidence of injury. After this period, two new successive cohorts in the same four companies were randomised into two groups and followed prospectively for 6 months. Military service is compulsory for about 90% of 19-year-old Finnish men annually, who comprised the cohort in this study. This randomised, controlled trial included 968 conscripts comprising 501 conscripts in the intervention group and 467 conscripts in the control group. A neuromuscular training programme was used to enhance conscripts' motor skills and body control, and an educational injury prevention programme was used to increase knowledge and awareness of acute musculoskeletal injuries. The main outcome measures were acute injuries of the lower and upper limbs.

Results: In the intervention groups, the risk for acute ankle injury decreased significantly compared to control groups (adjusted hazards ratio (HR) = 0.34, 95% confidence interval (95% CI) = 0.15 to 0.78, $P = 0.011$). This risk decline was observed in conscripts with low as well as moderate to high baseline fitness levels. In the latter group of conscripts, the risk of upper-extremity injuries also decreased significantly (adjusted HR = 0.37, 95% CI 0.14 to 0.99, $P = 0.047$). In addition, the intervention groups tended to have less time loss due to injuries (adjusted HR = 0.55, 95% CI 0.29 to 1.04).

Conclusions: A neuromuscular training and injury prevention counselling programme was effective in preventing acute ankle and upper-extremity injuries in young male army conscripts. A similar programme could be useful for all young individuals by initiating a regular exercise routine.

Trial registration: ClinicalTrials.gov identifier number NCT00595816.

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Background

Current public health recommendations strongly suggest regular physical activity to improve cardiovascular health and reduce the risk of chronic diseases [1,2]. The risk of musculoskeletal injury also increases, however, with an increase in physical activity. The rapidly increasing number of activity-induced injuries among adolescents and young adults is currently considered a true public health burden [3,4].

Because of their anatomic location, the ankle and knee joints are subjected to tremendous force during exercise and physical activity. Thus, it is not surprising that they are the most common sites for injuries, usually accounting for 50% to 60% of all sports injuries [5,6]. Acute injuries of the limbs, especially those affecting the ankle, knee and shoulder joints, may also have long-term consequences. Ankle injuries recur easily [7-9], and severe knee injuries often lead to early osteoarthritis [10,11].

Several studies have demonstrated that a neuromuscular training programme can reduce the risk of ankle and knee injuries in athletes [12-22]. To our knowledge, the possibility of preventing injuries in a general population, such as in young individuals with various physical fitness levels, has not been assessed. Therefore, the aim of the present study was to investigate whether a systematic neuromuscular training and injury prevention counselling programme could reduce the risk of acute injury in young Finnish men.

Methods

Sample size

On the basis of previous studies of physical activity-related injuries [4,23], the incidence of acute lower-limb injuries was estimated to be 0.6 injuries per person-year. The power calculations were based on a negative binomial model with an assumption of overdispersion parameter of 1.50. Thus, a minimum 33% reduction in the incidence of lower-limb injuries, from 0.6 injuries per person-year in the control group to 0.4 injuries per person-year in the intervention group, would be detected with the sample size of 500 persons per group. The statistical power level was set to 0.80, and the statistical significance level was set at 0.05.

Participants and randomisation

The participants of this study comprised male conscripts from four companies of one brigade (Pori Brigade, Säkylä, Finland) in the Finnish Defence Forces. The Pori Brigade is a typical Finnish garrison, and the chosen companies formed a representative sample of conscripts. Annually, the conscripts of each age cohort are randomly assigned into the companies.

The four companies enrolled into the study were the anti-tank company, the signal company, the mortar company and the engineer company. Military service in Finland is compulsory, and annually about 90% of 19-year-old men enter into the service. The service period varies from 6 to 12 months.

During the study, four cohorts of conscripts started service in the brigade: 359 in July 2006, 619 in January 2007, 522 in July 2007 and 557 in January 2008 (a total of 2,057 conscripts). The first two successive cohorts were followed prospectively for one term (6 months) to assess the baseline incidence of injuries (prestudy period) and to find out possible differences in the risk of acute injury in the participating companies. After this step, the four companies were randomised into two groups (two intervention companies and two control companies), and their two new successive cohorts were followed prospectively for one term, providing the data for the intervention.

Eighteen conscripts during the prestudy period and fourteen during the study period refused to participate in the study. Therefore, 2,025 conscripts (98%) agreed to participate and provided their informed consent prior to the initiation of the study. Details of the flow of participants during the randomised intervention are shown in Figure 1.

The health status of conscripts was checked during the first 2 weeks of the study (run-in period) by routine medical screenings performed by a physician. During the intervention, 61 participants were lost to follow-up for medical reasons: 14 were permanently discharged from military service, and 47 were temporarily discharged for at least 6 months. Because there were only 28 women in the study (3%), their data were excluded from the analysis. Seven conscripts applied for nonmilitary service during the 2-week run-in period, and they were also excluded. Additionally, two conscripts were lost to follow-up because of a missing patient record, and one conscript applied for postponement of service during the run-in period.

Thus, during the intervention (study period), there were 501 and 467 conscripts in the intervention and control groups, respectively, eligible for analyses. Corresponding figures for the prestudy period were 508 and 436. The ages of the conscripts ranged from 18 to 28 years (median and mean age 19 years). The baseline characteristics of the study subjects in the four companies were stratified into two study periods, and these are presented in Table 1. There were some statistically significant differences between the companies, and thus these variables were adjusted in the statistical models.

Using the company as the unit of randomisation with a computer-generated randomisation programme, an

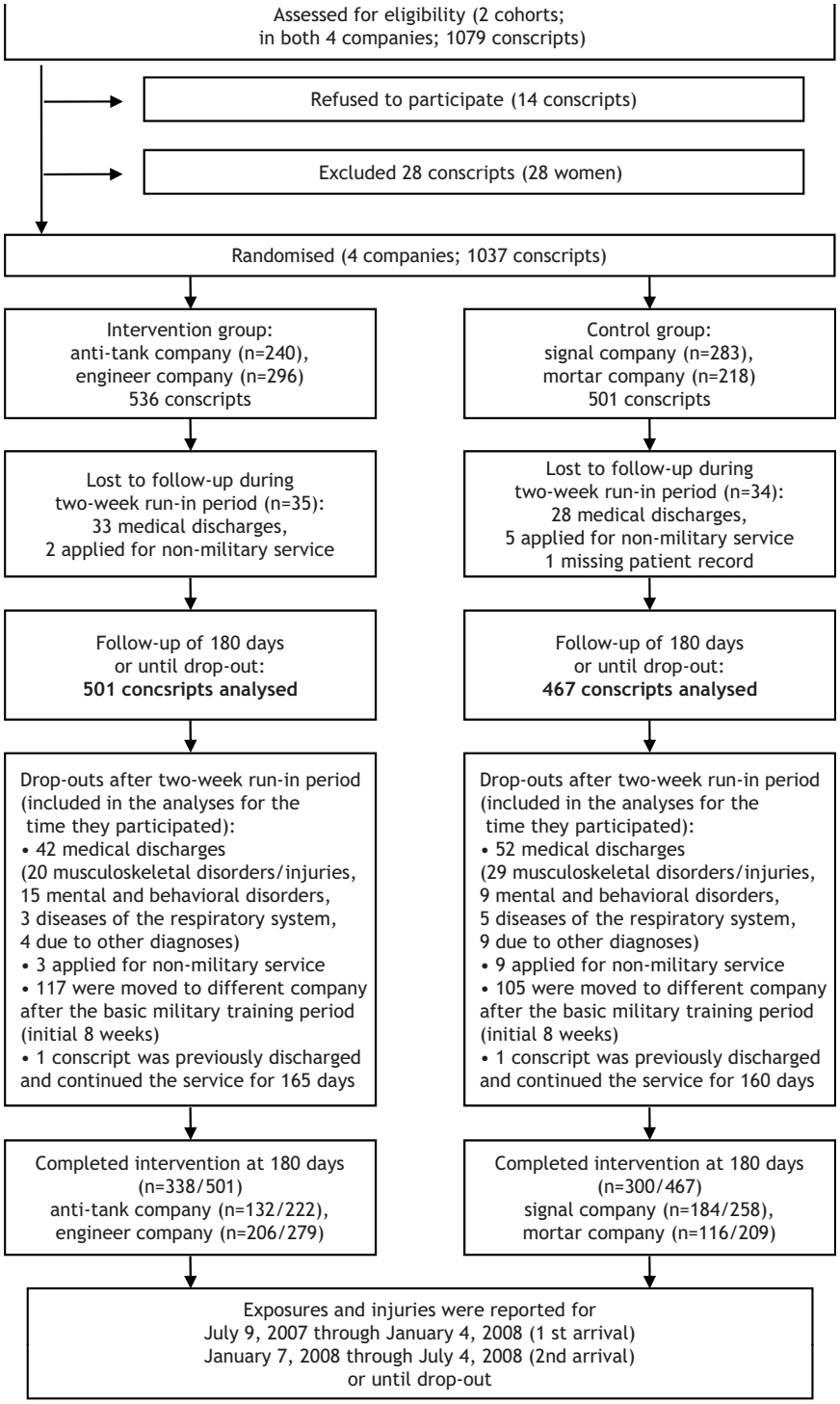

Figure 1 Flowchart of companies and participants through the study during the randomised intervention.

independent statistician who had no information about the study subjects performed the randomisation of companies into the intervention and control groups for the July 2007 and January 2008 cohorts. Companies allocated to the intervention group were informed about the upcoming programme for preventing injuries. Companies in the control group followed the usual regimen of the Finnish army.

All subjects were followed for 6 months starting from the first day of service. If a conscript changed his

Table 1 Baseline characteristics of 1,912 male conscripts by company and study period

Variable	Prestudy period				Study period intervention groups		Study period control group		Missing data	*P* value[a]
	Anti-tank company	Engineer company	Signal company	Mortar company	Anti-tank company	Engineer company	Signal company	Mortar company		
Number of conscripts	263	245	282	154	222	279	258	209	0 (0%)	-
Median age, yr	19	19	19	19	19	19	19	19	0 (0%)	0.054[b]
Median body mass index, kg/m^2	23.4	23.6	22.5	22.7	23.6	23.3	22.8	23.7	175 (9%)	0.011[b]
Median waist circumference, cm	87.0	87.0	85.0	84.5	85.0	86.0	84.0	86.1	139 (7%)	0.005[b]
Median 12-minute running test result, m	2,310	2,400	2,340	2,515	2,350	2,420	2,300	2,470	51 (3%)	0.614[b]
Median muscle fitness index[d], points	7	7	7	8	7	6	6	10	37 (2%)	0.019[b]
Median conscript physical fitness index (CPFI)[e], points	15.05	15.50	15.03	16.75	15.75	15.25	14.60	17.05	58 (3%)	0.153[b]
Conscript's hometown population ≥10,000, %	59	57	64	54	66	57	68	63	25 (1%)	0.100[c]
High level of preceding physical activity[f], %	31	36	26	32	24	26	21	49	24 (1%)	0.011[c]
Good self-assessed health[g], %	57	51	54	50	54	53	41	70	23 (1%)	0.942[c]
Chronic impairment or disability, %	17	17	11	17	11	18	19	16	30 (2%)	0.277[c]
Past orthopaedic surgery, %	8	9	7	9	9	10	11	7	25 (1%)	0.802[c]
No musculoskeletal symptoms[h], %	28	27	32	28	34	34	31	25	25 (1%)	0.143[c]
Previous or current regular smoker, %	43	57	47	40	53	58	47	46	27 (1%)	0.003[c]
Use of alcohol at least three times per week, %	16	20	15	16	24	23	23	14	24 (1%)	0.010[c]

[a]*P* value for difference between the study group and study year; [b]*P* value was calculated by using a Kruskal-Wallis test for median difference; [c]*P* value was calculated by using χ^2 statistics for significant differences; [d]Muscle fitness index is the sum of individual muscle fitness test results comprising pushups, situps, pullups, the standing long jump and the back-lift test (excellent = 13 to 15 points, good = 9 to 12 points, fair to good = 5 to 8 points, and poor = 0 to 4 points); [e]CPFI = (12-minute running test result (measured in meters) + 100 × muscle fitness index) ÷ 200; scoring was excellent = CPFI ≥21.00), good = 17.00 ≤ CPFI < 21.00, fair to good = 13.00 ≤ CPFI < 17.00, and poor = CPFI < 13.00; [f]sweating exercise at least three times per week during the past month before entry into the military; [g]compared to age cohort; [h]symptoms lasting more than 7 days in at least one anatomical region during the past month before entering the military.

company during the study, he was followed until the change took place, and this change was taken into account when calculating exposure times. Approval for the study protocol was obtained from the Ethics Committee of Pirkanmaa Hospital District (reference R07076). The clinical trial identification number is NCT00595816.

Preinformation questionnaire

Subjects were administered a preinformation questionnaire during the first week of military service. Questions charted conscripts' socioeconomic factors, health and health behaviour at the baseline of the study. The socioeconomic factors included education level, urbanisation level of the place of residence, school success (educational level and grades combined) and father's occupational group. Health factors included previous sports injuries and orthopaedic surgeries, medications, chronic disease, chronic impairment or disability, self-assessed health compared to age mates and musculoskeletal pain in seven anatomical regions during the past month. Health behaviour was assessed on the basis of answers to questions about the use of alcohol and tobacco, frequency of drunkenness, amount of physical exercise, prior sporting activities, belonging to a sports club, participation in competitive sports, highest level achieved in school sports, self-assessed physical fitness and opinion about the physical demands on a soldier.

Assessment of baseline physical fitness

A Cooper's test (12-minute running test) and muscular fitness tests were performed by most conscripts (97%) during their first 2 weeks of military service. A minority of conscripts (3%) were unable to complete their physical fitness tests because of minor health problems, such as infection or overuse injury. Muscular fitness tests and the 12-minute running test were performed on different days. Muscular fitness tests included pushups, situps, pullups, the standing long jump and a back-lift test [24]. A conscript's physical fitness index (CPFI) was calculated

using the following formula: (12-minute running test result (measured in metres) + 100 × muscle fitness index) ÷ 200 (Table 1, footnotes d and e). The formula is based on standard practice in the Finnish Defence Forces since 1982 [25]. In addition, height, weight and waist circumference were measured during the first weeks of service. Body mass index (BMI) was calculated by dividing weight (in kilograms) by height (in meters squared). Waist circumference as a mark of abdominal obesity and excessive visceral fat [26] was measured using a tape measure midway between the lowest rib and the iliac crest after normal exhalation. The cutoff points for overweight and obesity on the basis of BMI and waist circumference were set according to the guidelines of the World Health Organisation [27].

Basic physical training programme

At the beginning of military service, all conscripts performed 8 weeks of basic training, which consisted of various physical activities, including marching, cycling, skiing, orienteering, swimming, drill training and combat training or other training. Each week there were an average of 17 hours of military actions, with a gradual increase in intensity. During most of this time, the activity level was low to moderate in intensity. In addition, conscripts performed other physical exercises, such as jogging, team sports and circuit training for an average of 7 hours per week.

The 2-month basic training period was followed by 4-months specific military training programme, depending on the company and service duration. During this 6-month period of service, the amount and intensity of physical training was maintained at approximately the same level in different companies.

Intervention programme

The intervention included neuromuscular training and injury prevention counselling with cognitive-behavioural learning goals. This programme was included in addition to the above-noted basic training. The main aim of this programme was to decrease the number of musculoskeletal injuries during military service. Implementation of the intervention was planned together with the personnel of the brigade as well as with conscripts in leading positions. Two educated female instructors outside the brigade, one of whom had completed military service, were responsible for conducting the implementation of the intervention.

Neuromuscular training

The neuromuscular training programme was designed to enhance conscripts' movement control and agility, as well as to increase the stability of the trunk, knee and ankle. The focus of each of the nine exercises (see Figure 2) was on the use of proper technique, such as good posture, maintenance of core stability or positioning of the hips, knees and ankles, especially "knee over toe" position. Conscripts worked in pairs and were instructed to evaluate each other's technique and to provide feedback during training. The exercises and their repetitions are listed in Table 2 in the order of the exercises from one to nine. Two exercises (exercises 1 and 2) improved balance and posture, one exercise (exercise 4) improved coordination and agility, three exercises (exercises 2, 4 and 8) improved control of the lumbar neutral zone, two exercises (exercises 3 and 5) improved core (trunk) stability and endurance of the trunk muscles, one exercise (exercise 7) improved eccentric muscular work of the hamstring muscles, two exercises (exercises 6 and 8) improved the extensibility of the lower-extremity muscles and one exercise (exercise 9) improved the mobility of the thoracic spine. Exercises performed in upright positions (exercises 1, 2, 4, 6 and 8) followed the exercise principle of a closed kinetic chain [28].

During the first 8 weeks of basic training, neuromuscular training was conducted three times weekly as part of normal compulsory service in the intervention companies. The conscripts trained inside in small groups (approximately 40 men per group) led by the two instructors mentioned above. One exercise session lasted from 30 to 45 minutes and included the above-described nine exercises at moderate intensity. At the beginning of training, the emphasis was on correct performance of the technique, and later the challenge level for balance and coordination, the number of repetitions and the exercise load were increased. Each conscript was provided with a training book named "FIRE", which included the rationale for each exercise and contained illustrations showing how to use the correct technique. A training log was attached to the book.

During the specialised military training period (weeks 9 to 17) and the team training period (weeks 18 to 26), conscripts in the intervention companies were instructed to continue to exercise on their own at least once weekly. To support this command, instructed training sessions were provided in the evenings during the conscripts' leisure time. The conscripts were commanded to meet the exercise instructors once weekly to have their exercise logs checked and to receive individual guidance on how to correctly perform the exercises as needed. Conscripts in leading positions guided neuromuscular exercises as part of compulsory physical training two to four times per month during this training period. Selected exercises were also performed outdoors during field service.

Injury prevention counselling

Educational counselling was used to increase conscripts' knowledge and awareness of musculoskeletal injuries during various training situations. Each conscript received a

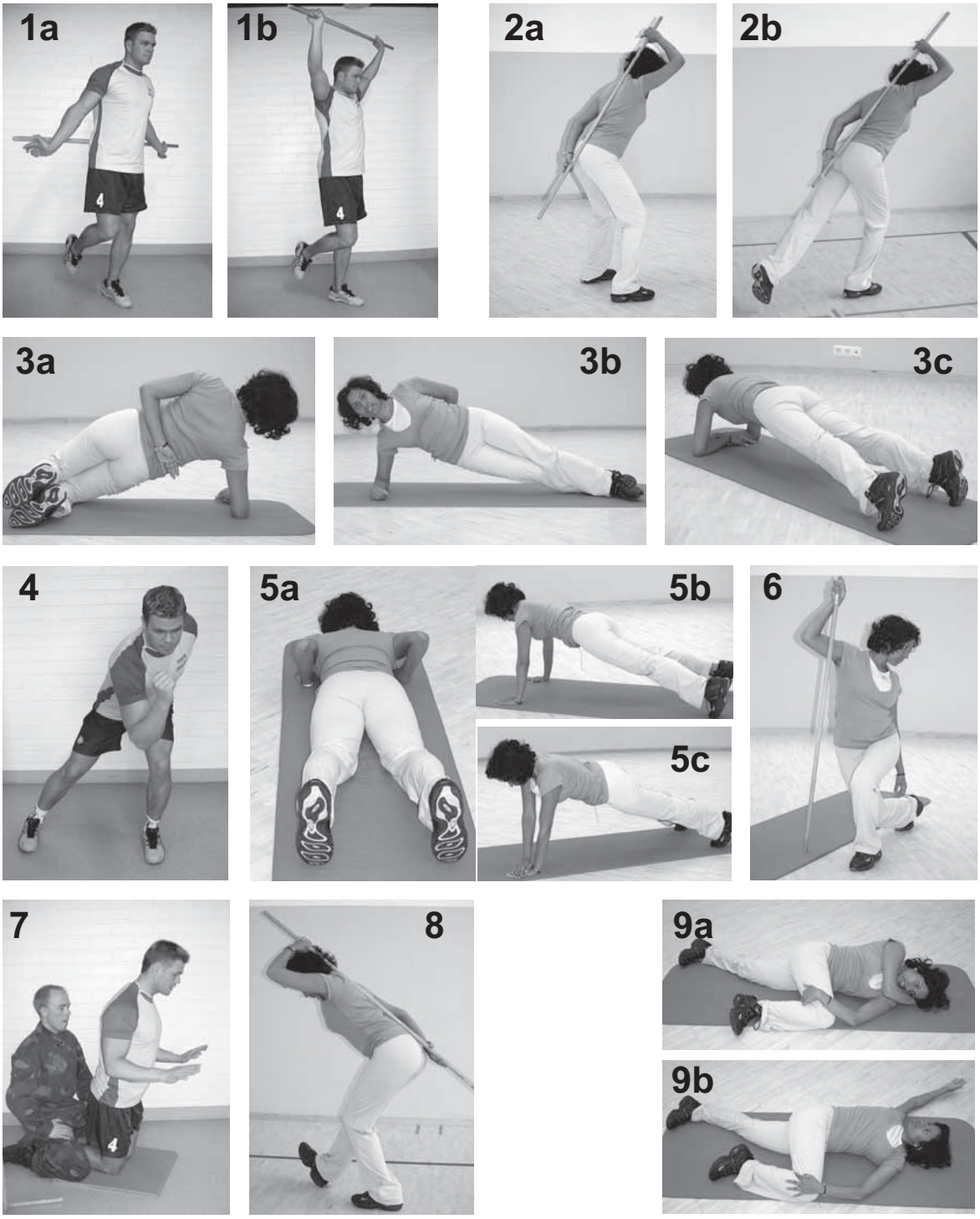

Figure 2 Neuromuscular training exercises performed by the intervention group. Exercises 1 through 9 and their specific aims are described in Table 2. The images were obtained in the Pori Brigade for the purposes of this study, and the individuals shown gave their consent to publish them.

Table 2 Neuromuscular training programme[a]

Exercises and repetitions	Aim
Exercise 1 One-leg standing with a stick 20 repetitions, 10 with each leg	Improvement in shoulder and neck posture and mobility Enhancement of balance and coordination
Exercise 2 Squat exercises with a stick using, respectively, two legs or one leg 16 repetitions on two legs 16 repetitions, eight each with one leg	Enhancement of control of lumbar NZ Increase in lower-extremity muscular strength Enhancement of balance
Exercise 3 Horizontal side support Stage 1 with flexed knees: five repetitions with 5 seconds of static holding on alternating sides (5 + 5) Stage 2 with straight knees: five circles from side to side with 5-second hold for each position (side, belly and side)	Enhancement of co-contraction of trunk muscles Improvement in lower-back and trunk stability Increase in trunk muscular endurance
Exercise 4 Jumping from side to side Rhythm: four slow jumps + eight fast jumps Exercise time: 60 seconds	Enhancement of coordination and agility Enhancement of control of lumbar NZ Increase in lower-extremity muscular endurance
Exercise 5 Modified pushups As many repetitions as possible Exercise time: 60 seconds	Improvement of upper-extremity extensor strength Enhancement of co-contraction of trunk muscles Improvement in lower-back and trunk stability
Exercise 6 Stretching exercise for hip flexor muscles 10-second stretch done five times on alternating sides	Increase in extensibility of hip flexor and side muscles Increase in lower-extremity muscular strength
Exercise 7 Hamstring exercise on the knees Eight to 12 repetitions	Increase in eccentric capacity of hamstring muscles Enhancement of trunk motor control
Exercise 8 Stretching exercise with a stick for hamstring muscles Three repetitions of 20-second stretches each with alternating legs	Increase in extensibility of hamstring and calf muscles Enhancement of control of lumbar NZ
Exercise 9 Upper-body rotation while lying on one's side; a "yoga stretch" Duration of 60 seconds for each side	Improvement in rotational mobility of thoracic spine Increase in extensibility of pectoral muscles

[a]NZ, neutral zone.

guidance booklet with information on situations and duties that were supposed to pose a high risk for injury. These included the training on uneven surfaces, landing from vehicles and lifting heavy materials. Furthermore, information on how to manage acute injuries was provided. A 1-hour lecture on these potentially hazardous training and combat actions was provided by one of the instructors in the middle of the basic training period. The counselling lecture was repeated once during the special military training period. Furthermore, the leaders of the companies and the exercise instructors addressed the potential hazards of field service when appropriate.

Conscripts in the control companies conducted their service as usual, except for their awareness of their role as a control group in the study. In addition, they filled in all the study questionnaires and participated in the baseline fitness test battery.

Outcome measures

The primary outcome measure was an acute lower- or upper-limb injury that occurred during the 6-month military service. The severity of injuries was a secondary outcome measure of the study. In addition to injuries sustained during active service hours, injuries and disorders that occurred during conscripts' leisure time or on the way to or from the garrison for leave were also included in the study.

Injury definition and registration

The data for the first cohort to arrive were collected from 10 July 2006 to 5 January 2007; for the second cohort that arrived, they were collected from 8 January 2007 to 6 July 2007; for the third cohort arrival, they were collected from 9 July 2007 to 4 January 2008; and for the fourth cohort to arrive, they were collected from 7 January 2008 to 4 July 2008. Injury was defined as an acute event that resulted in physical damage to the body for which the conscript sought medical care from the garrison clinic. Overuse, heat or cold injuries were not included in the analysis. During military service, all conscripts had to use the services of military healthcare units. The date, anatomical location, type, aetiological

circumstances, severity and diagnosis of each injury were registered in computerised patient records. Because conscripts may have sought medical care several times for the same injury, the total number of health clinic visits exceeded the number of injuries. The health clinic visits were considered to be for the same injury when the conscript had sustained an injury of the same type and location during the preceding 2 weeks or if a physician had marked in the conscript's files that the reason for the visit was related to the previous injury.

The type of injury was categorised as acute if it had a sudden onset involving known trauma [19,20,29]. For example, sprains, strains, ligament ruptures and joint dislocations were categorised as acute injuries.

After careful clinical examination, necessary diagnostic tests and radiographs, the most accurate diagnosis was selected by a physician according to the *International Statistical Classification of Diseases and Related Health Problems, 10th Revision* [30]. The anatomical location of the injury was reported according to the diagnosis. The severity of the injury was categorised according to the number of days of limited duty, with 1 to 3 days being minimal, 4 to 7 days being mild, 8 to 28 days being moderate and more than 28 days being severe [19,20,31]. Limited duty involved a physical restriction that prevented the conscript from fully participating in military training events. Release from military service was indicated when a physician determined that a conscript was unable to continue military training. Releases from military service due to musculoskeletal injury were registered as severe injuries.

Statistical analysis

SPSS 17.0 for Windows software (SPSS Inc., Chicago, IL, USA) was used for statistical analysis. All analyses were performed according to the intention-to-treat principle. The primary analysis was intervention group vs. control group for assessment of the difference of change in injury incidence between the prestudy period and the study period. Secondary analysis was performed to assess differences between participants at two fitness levels (low vs. moderate to high).

Injury incidence was calculated by dividing the number of new injuries by the exposure time. The incidences with 95% confidence intervals (95% CIs) were expressed per 1,000 person-days. To examine differences in injury rates between the intervention and control groups, the unadjusted and adjusted hazard ratios (HRs) between groups were obtained by using the Cox proportional hazard model for categorical outcomes and the negative binomial model for count data (number of off-duty days). The negative binomial model was chosen instead of the Poisson regression model because of the distribution of the count data. The overdispersion parameter was taken into account by estimating the value in the negative binomial model. $P < 0.05$ was considered statistically significant.

Results were expressed as HRs and calculated with 95% CIs with age at baseline forced into the model. The interaction term of company (intervention vs. control) and study period (prestudy period vs. study period) was entered into the model to analyse the differences in changes in incidence of injuries between intervention and control companies. In the data analysis, based on the published literature, conceptually compatible and logical risk factors were chosen for multivariate models. Only possibly significant explanatory variables ($P < 0.20$) in the initial univariate models were included for the multivariate conceptual models. Urbanisation level of the conscript's home residence was included in the multivariate model as a possible confounder. Higher age, smoking status (previous or current regular smoker), high alcohol intake, poor baseline medical condition (chronic impairment or disability due to prior musculoskeletal injury, as well as earlier musculoskeletal symptoms or orthopaedic surgery), poor school performance (educational level and grades combined) and high waist circumference were entered into the model as known or possible risk factors. Physical activity level during the 3 months before entering the military and the CPFI were considered effect modifiers and were entered into the multivariate model.

Results

The details of the flow of participants through the study are shown in Figure 1. The rate of consent to participate was 98%. Most dropouts were due to a change of company after the 8-week basic military training period. Twenty dropouts in the intervention group and twenty-nine in the control group were due to musculoskeletal injuries. Data for these men who dropped out were included in the analyses for the time during which they participated. The intervention group's compliance was good. The intervention group followed the training programme according to the plan three times weekly as part of compulsory service during the first 8-week period. After this point, an average of 83% of the conscripts attended the training sessions and reached the preset minimum number of exercise sessions.

The number and incidence of acute injuries and corresponding HRs for men in the intervention and control companies during the prestudy and study periods are shown in Table 3. The intervention companies had a somewhat higher risk of injury before the intervention. In the intervention companies, the risk for acute ankle injuries decreased significantly compared to that of the control companies during the study period (adjusted HR = 0.34, 95% CI = 0.15 to 0.78, $P = 0.011$). The risk decline was observed in conscripts with a low baseline fitness level, as

Table 3 Incidence per 1,000 person-days of different types of musculoskeletal injuries and hazard ratios for changes in incidence between the intervention and control companies during prestudy and study periods[a]

Variable	Company	Prestudy period (n = 508/436)[b]		Study period (n = 501/467)[b]		Age-adjusted HR (95% CI)	HR adjusted model[c] (95% CI)
		Number	Incidence	Number	Incidence		
Acute injuries, all	Int	246	3.16	150	2.14	0.74 (0.52 to 1.06)	0.75 (0.51 to 1.09)
	Ctrl	149	2.73	155	2.44		
Lower extremity	Int	136	1.75	90	1.28	0.84 (0.55 to 1.30)	0.82 (0.52 to 1.31)
	Ctrl	91	1.67	96	1.51		
Knee	Int	50	0.64	48	0.68	1.05 (0.55 to 2.00)	1.32 (0.65 to 2.67)
	Ctrl	35	0.64	38	0.60		
Ankle	Int	37	0.48	17	0.24	0.38 (0.17 to 0.86)	0.34 (0.15 to 0.78)
	Ctrl	21	0.38	37	0.58		
Upper extremity	Int	53	0.68	31	0.44	0.57 (0.28 to 1.16)	0.52 (0.24 to 1.12)
	Ctrl	26	0.48	31	0.49		
Total number of off-duty days[d]	Int	917	11.8	546	7.8	0.46 (0.26 to 0.83)	0.55 (0.29 to 1.04)
	Ctrl	419	7.7	677	10.7		
Discharged from military service[e]	Int	34	0.44	42	0.60	0.78 (0.41 to 1.51)	0.81 (0.42 to 1.57)[f]
	Ctrl	26	0.48	52	0.82		
Follow-up days							
	Int	77,871		70,222			
	Ctrl	54,620		63,494			

[a]HR, hazard ratio; 95% CI, 95% confidence interval; Int, intervention company; Ctrl, control company. HRs were calculated by using the Cox proportional hazard model if not otherwise mentioned. Statistical significance level was set at $P < 0.05$. HRs are based on the interaction term of each study group (intervention or control), and study period was entered into the model to analyse the difference in the change in incidence between the groups. [b]Number of conscripts in the intervention and control companies per study period; [c]adjusted for age, urbanisation level of the home residence, smoking, alcohol intake, earlier musculoskeletal symptoms, orthopaedic surgeries, chronic disabilities due to earlier musculoskeletal injuries, school success, previous physical activity, waist circumference and conscript's physical fitness index (n = 11 adjusting variables); [d]because of acute injuries, rate ratio was obtained using a negative binomial model; [e]after the 2-week run-in period; [f]not adjusted for waist circumference or physical fitness level, since 36 discharged individuals had missing information.

well as in those with a moderate to high baseline fitness level (Tables 4 and 5). In addition, among men with moderate to high baseline fitness, the risk for acute upper-extremity injury decreased significantly in the intervention companies compared to the control companies (adjusted HR = 0.37, 95% CI = 0.14 to 0.99, P = 0.047) (Table 4). Furthermore, the intervention companies tended to have less training time loss due to injuries (adjusted HR = 0.55, 95% CI = 0.29 to 1.04).

Discussion

The present study was a randomised, controlled trial designed to evaluate the effects of a neuromuscular training and injury prevention counselling programme on injury risk in a representative sample of young Finnish men. The training programme focused on improving the men's motor skills and body control. Compared to the control group, the intervention group had significantly fewer ankle injuries and a trend toward a decreased risk of upper-extremity injuries.

The present study has several strengths. First, the definition of injury was clear and predetermined. In addition, the data set of injuries was collected using computerised patient files. This guaranteed a high coverage of injuries because all patients who entered the garrison clinic were recorded in the computerised system. Second, the study design with unit randomisation included preplanned injury prevention counselling in the intervention group (attention effect) and resulted in minimal intervention influence on the control group (avoidance of contamination bias). Third, the participation rate was high (98%), and compliance with training was very good because of the army training setting. Fourth, the military environment provided highly standardised conditions for investigating the effect of the intervention: Conscripts in all cohorts in the trial trained in the same area, ate the same food and lived in the same barracks, and, moreover, the daily military programmes were nearly equal, providing equal opportunity for rest and sleep [32,33].

The study also has limitations. First, the lack of individual randomisation and the impossibility of full double blinding in this type of study limit the strength of the conclusions. The randomisation phase, data collection and data analysis were fully blinded, but for obvious reasons the young conscripts and exercise instructors could not be masked. Second, the group or cluster size was large because of the military setting, thus leading to a low number of allocated groups. Although this factor was taken into account in the study design and we were able to assess the baseline risk of injury in the companies during

Table 4 Incidence per 1,000 person-days of different types of musculoskeletal injuries and hazard ratios for changes in incidence between the intervention and control companies during prestudy and study periods in moderately to highly fit conscripts[a,b]

Variable	Company	Prestudy period (n = 333/291)[c]		Study period (n = 315/298)[c]		Age-adjusted HR (95% CI)	HR adjusted model[d] (95% CI)
		Number	Incidence	Number	Incidence		
Acute injuries, all	Int	160	3.05	85	1.88	0.77 (0.49 to 1.22)	0.74 (0.46 to 1.18)
	Ctrl	88	2.31	86	2.00		
Lower extremity	Int	82	1.56	56	1.24	0.88 (0.51 to 1.51)	0.82 (0.46 to 1.45)
	Ctrl	52	1.37	55	1.28		
Knee	Int	27	0.51	26	0.57	1.18 (0.51 to 2.75)	1.22 (0.49 to 3.01)
	Ctrl	22	0.58	21	0.49		
Ankle	Int	17	0.32	12	0.26	0.53 (0.18 to 1.51)	0.50 (0.17 to 1.46)
	Ctrl	12	0.32	20	0.46		
Upper extremity	Int	37	0.70	16	0.35	0.43 (0.17 to 1.09)	0.37 (0.14 to 0.99)
	Ctrl	15	0.39	20	0.46		
Total number of off-duty days[e]	Int	600	11.4	339	7.5	0.46 (0.22 to 0.97)	0.43 (0.19 to 0.97)[f]
	Ctrl	218	5.7	424	9.8		
Discharged from military service[g]	Int	10	0.19	19	0.42	1.06 (0.34 to 3.27)	1.13 (0.36 to 3.58)[f]
	Ctrl	8	0.21	20	0.46		
		Follow-up days					
	Int	52,542		45,316			
	Ctrl	38,052		43,054			

[a]HR, hazard ratio; 95% CI, 95% confidence interval; Int, intervention company; Ctrl, control company. HRs were calculated by using the Cox proportional hazard model if not otherwise mentioned. Statistical significance level was set at $P < 0.05$. HRs are based on the interaction term of each study group (intervention or control), and study period was entered into the model to analyse the difference in the change in incidence between the groups. [b]Two highest tertiles of conscripts according to physical fitness (Conscript's physical fitness index > 14.04 points); [c]number of conscripts in the intervention and control companies per study period; [d]adjusted for age, urbanisation level of the home residence, smoking, alcohol intake, earlier musculoskeletal symptoms, orthopaedic surgeries, chronic disabilities due to earlier musculoskeletal injuries, school success, previous physical activity and waist circumference (n = 10 adjusting variables); [e]because of acute injuries, rate ratio was obtained from negative binomial model; [f]not adjusted for waist circumference, since 15 discharged individuals had missing information; [g]after the 2-week run-in period.

the prestudy period, the findings can be generalised only to similar settings in which young individuals are trained and counselled in groups or teams. Third, the findings can be generalised to young men only because no more than 3% of the conscripts were females, and they were excluded from the study. A fourth limitation is the fact that after the initial 8 weeks of basic training, the training programmes became more divergent as a result of the more specialised military service in each company. This also caused some participants to drop out because of a company change. On the other hand, all conscripts were followed up for the first 8 weeks of service. Finally, some conscripts might have been more inclined to seek professional medical care than others. This factor should have affected all of the companies similarly, however.

In the present study, a strong emphasis was placed on proper technical performance of every single exercise manoeuvre. Before the intervention the instructors were educated with regard to the correct training technique and how to best instruct each exercise and observe typical mistakes in each exercise manoeuvre, as well as how to appropriately correct mistakes. Some previous studies have indicated that neuromuscular training can play a crucial role in preventing acute lower-extremity injuries [12-17,19,20], and the present intervention study supports those findings. In the study of Hewett and coworkers [12], multiple 6-week training programmes for high school sports teams decreased the rate of serious knee ligament injuries as well as the rate of noncontact knee ligament injuries. The study of Olsen and colleagues [16] showed that a structured warmup programme among young handball players reduced the risk of traumatic knee and ankle injuries, as well as the overall risk for severe and noncontact injuries. In a recent randomised study of top-level pivoting sport athletes [19], we found significant reductions in the risk of ankle injuries. Soligard and colleagues [20] found that a comprehensive neuromuscular training programme was effective in decreasing overuse injuries among young soccer players.

One of the reasons for the current study was that at the turn of the millennium, there was a substantial (62%) rise in the number of premature discharges in the Finnish army due to musculoskeletal injuries [34]. This was most likely due to the 100% increase in physical exercise in the Finnish military service programme in July 1998. At that time, 8% to 10% of the conscripts

Table 5 Incidence per 1,000 person-days of different types of musculoskeletal injuries and hazard ratios for change in incidence between the intervention and control companies during prestudy and study periods in low fitness conscripts[a,b]

Variable	Company	Prestudy period (n = 166/133)[c]		Study period (n = 174/144)[c]		Age-adjusted HR (95% CI)	HR adjusted model[d] (95% CI)
		Number	Incidence	Number	Incidence		
Acute injuries, all	Int	83	3.37	60	2.47	0.77 (0.42 to 1.39)	0.79 (0.41 to 1.51)
	Ctrl	58	3.63	63	3.21		
Lower extremity	Int	53	2.15	32	1.32	0.84 (0.40 to 1.78)	0.86 (0.38 to 1.92)
	Ctrl	39	2.44	38	1.94		
Knee	Int	22	0.89	20	0.82	1.05 (0.37 to 2.99)	1.48 (0.46 to 4.81)
	Ctrl	13	0.81	14	0.71		
Ankle	Int	20	0.81	5	0.21	0.23 (0.06 to 0.85)	0.17 (0.04 to 0.68)
	Ctrl	9	0.56	17	0.87		
Upper extremity	Int	14	0.57	14	0.58	1.04 (0.30 to 3.62)	0.93 (0.24 to 3.56)
	Ctrl	10	0.63	8	0.41		
Total number of off-duty days[e]	Int	303	12.3	203	8.4	0.69 (0.26 to 1.82)	0.64 (0.23 to 1.79)[f]
	Ctrl	198	12.4	217	11.1		
Discharged from military service[g]	Int	17	0.69	13	0.54	0.68 (0.24 to 1.97)	0.72 (0.24 to 2.12)[f]
	Ctrl	11	0.69	15	0.76		
		Follow-up days					
	Int	24,599		24,292			
	Ctrl	15,963		19,628			

[a]HR, hazard ratio; 95% CI, 95% confidence interval; Int, intervention company; Ctrl, control company. HRs were calculated by using the Cox proportional hazard model if not otherwise mentioned. Statistical significance level was set at $P < 0.05$. HRs are based on the interaction term of each study group (intervention or control), and study period was entered into the model to analyse the difference in the change in incidence between the groups. [b]The lowest tertile of conscripts according to physical fitness (conscript's physical fitness index ≤14.04 points); [c]number of conscripts in the intervention and control companies per study period; [d]adjusted for age, urbanisation level of the home residence, smoking, alcohol intake, earlier musculoskeletal symptoms, orthopaedic surgeries, chronic disabilities due to earlier musculoskeletal injuries, school success, previous physical activity and waist circumference (n = 10 adjusting variables); [e]because of acute injuries, rate ratio obtained from negative binomial model; [f]not adjusted by waist circumference, since 16 discharged individuals had missing information; [g]after the 2-week run-in period.

were prematurely discharged from the Finnish Defence Forces. In a very recent study, we found that co-impairments in cardiorespiratory and muscular fitness (that is, poor results in Cooper's test combined with a poor result in the standing long jump, pushup or back-lift test) were highly associated with musculoskeletal injuries and disorders, showing a dose-response relationship. Similarly, abdominal obesity and high BMI were clearly associated with poor outcomes [35].

The present study underlines the importance of musculoskeletal injuries as a cause of morbidity and premature discharge from military service in the Finnish Defence Forces. Given that 90% of young men in Finland enter military service, the high occurrence of injuries in this population has a direct impact on public health. The current findings provide a challenge to researchers and military personnel to better recognise and identify the risk factors and mechanisms of injury to initiate preventive actions among conscripts.

Conclusions

A neuromuscular training and injury prevention counselling programme was effective in preventing acute ankle and upper-extremity injuries in young male army conscripts. A similar programme could be useful for all young individuals who are initiating regular exercise.

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Authors' contributions

JP, HT, JS, VM, OO, PV, PK and HP contributed to study conception and design. JP and JS carried out the literature search and coordinated and managed all parts of the study, including testing and refining the intervention and data collection. OO and PV contributed to the testing of the intervention programme and the education of instructors, which were

planned with JP and JS. HT conducted data collection and performed preliminary data preparation. HT conducted data analyses, and all of the authors contributed to the interpretation of data. JP wrote the first draft of the paper, and all authors provided substantive feedback on the paper and contributed to the final manuscript. All authors have approved the submitted version of the manuscript. HP is the guarantor.

Competing interests

We declare that all authors had (1) no financial support for the submitted work from anyone other than their employer; (2) no financial relationships with commercial entities that might have an interest in the submitted work; (3) no spouses, partners or children with relationships with commercial entities that might have an interest in the submitted work; and (4) no nonfinancial interests that may be relevant to the submitted work.

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Neuromuscular exercise and counseling decrease absenteeism due to low back pain in young conscripts-a randomized, population-based primary prevention study

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Study Design. Controlled intervention with group randomization.

Objective. To investigate the effectiveness of a 6-month neuromuscular exercise (NME) and counseling program for reducing the incidence of low back pain (LBP) and disability in young conscripts with a healthy back at the beginning of their compulsory military service.

Summary of Background Data. Basic military training is physically demanding on the back and requires adequate physical fitness. LBP causes significant morbidity and absence from military service.

Methods. Participants were conscripts of four successive age cohorts (n=1409). In the pre-study year, before adoption of the intervention, two successive cohorts of conscripts of four companies (n=719) were followed prospectively for 6 months to study the baseline incidence of different categories of LBP. In the intervention year, conscripts (n=690) of two new cohorts of the same companies (intervention group: anti-tank, engineer; control group: signal, mortar) were followed for 6 months. The intervention program aimed to improve conscripts' control of their lumbar neutral zone (NZ), and specifically to avoid full lumbar flexion in all daily tasks.

Results. Total number and incidence of off-duty days due to LBP were significantly decreased in the intervention companies compared to controls (adjusted hazard ratio = 0.42, 95% confidence interval = 0.18 to 0.94, p = 0.035). The number of LBP cases, number of health clinic visits due to LBP, and number of the most severe cases showed a similar decreasing trend, but without statistical significance.

Conclusions. These findings provide evidence that exercise and education to improve control of the lumbar NZ have a prophylactic effect on LPB-related off-duty service days in the military environment when implemented as part of military service among young healthy men.

word count:275

Key words: primary prevention, low back pain, exercise, counseling, young population

Mini abstract

Effectiveness of a 6-month neuromuscular exercise and counseling program for reducing the incidence of low back pain and disability was studied in a randomized controlled intervention study of healthy conscripts. The number of off-duty days was reduced by 58% in intervention companies compared to controls.

Key points

- Effectiveness of a 6-month neuromuscular exercise and educational counseling program for reducing the incidence of low back pain and disability was investigated in young conscripts with a healthy back, assessed by a questionnaire and routine medical screening by a physician at the beginning of compulsory military service.
- The findings indicate less severe injuries to spinal structures in the intervention group compared to controls, which led to physicians prescribing fewer off-duty days.
- Exercise and counseling to improve control of the lumbar neutral zone had a prophylactic effect on low back pain-related off-duty service days in the military environment, and may provide a target for the primary prevention of low back pain.

INTRODUCTION

The prevalence of low back pain (LBP) among adolescents and young adults in civil[1,2] and military populations[3,4] is high, affecting approximately 50% of people by the age of 20.[5] Furthermore, hospitalization for LBP during military service causes significant morbidity in previously healthy Finnish conscripts.[6] Extensive evidence indicates that LBP during young adulthood predicts LBP later in life, which is distressing[2,7] and emphasizes the need to focus on the prevention of LBP in young populations.[5]

An increased risk for LBP was recently reported in Finnish conscripts with a poor fitness level in trunk muscular endurance and aerobic performance, and a low educational level.[8] The strongest risk factor at entry was poor fitness in both back-lift and push-up tests, i.e., co-impairment (hazard ratio [HR] 2.8; 95% confidence interval [CI]: 1.4–5.9). The findings indicate that basic military training is physically demanding on the back and requires adequate physical fitness. In contrast to education level, poor entry-level fitness of conscripts is a modifiable risk factor of LBP and amenable to prevention programs.

Current evidence for the effects of interventions to prevent recurrent and chronic LBP emphasizes a biopsychosocial approach.[9] Psychological and social factors are associated with back pain and disability, and serve as prognostic indicators.[10] Accordingly, studies of programs combining physical exercise with some type of advice or counseling have reported small positive effects in patients with LBP.[11-13] To our knowledge, however, there are no randomized controlled studies in which these preventive interventions were targeted to healthy individuals. The aim of the present study was to investigate the effectiveness of a 6-month neuromuscular exercise (NME) and an educational counseling program for reducing the incidence of LBP and disability in young Finnish conscripts with a healthy back at baseline.

MATERIALS AND METHODS

Study design and sample size

Military service in Finland is compulsory and annually about 90% of 19-year-old men enter into the service. The study was carried out in The Pori Brigade, a typical Finnish garrison. The anti-tank, signal, mortar, and engineer companies were enrolled in the study, while the conscripts of each age cohort are randomly assigned to them. Four successive age cohorts of conscripts (total n= 2057) began service in these companies in July 2006 (n=359), January 2007 (n=619), July 2007 (n=522) and January 2008 (n=557). The first two successive cohorts were followed prospectively for one term (6 months) to assess the baseline incidence of LBP and disability (pre-study year), and to find out possible differences in these between the four companies. After the pre-study year, the companies were randomized into two groups[14] (two intervention companies and two control companies), and the two new successive cohorts were followed prospectively for one term, providing the data for the intervention (intervention year).

The above described original study sample was the same in the previous intervention study reporting effectiveness on risk of acute musculoskeletal injury.[14] A pre-study power analysis for estimating the required sample size for was based on that primary outcome (acute musculoskeletal

injuries), for which a detailed description, including participants randomization, is available online.[14] In short, based on previous studies of physical activity related injuries, the incidence of acute lower-limb injuries was estimated to be 0.6 injuries per person-year. A minimum 33% reduction in the incidence of lower-limb injuries, from 0.6 injuries per person-year in the control group to 0.4 injuries per person-year in the intervention group, would be detected with the sample size of 500 persons per group. Using the company as the unit of randomization with a computer-generated randomization program, an independent statistician who had no information about the study subjects performed the randomization of companies into the intervention and control groups for the July 2007 and January 2008 cohorts. Approval for the study protocol was obtained from the Ethics Committee of Pirkanmaa Hospital District (reference R07076). The clinical trial identification number is NCT00595816.

Participants

The rate of consent to participate in original study sample was high (98%). Eligible participants for the present study were those conscripts with healthy back at the beginning of their service, while previous LBP is a strong predictor of future back pain.[2,7,8] Conscripts entering military service were young healthy men, all of whom had a medical check-up by a clinician during the 12 months before entering the military. At entrance they answered questions on prevalence of LBP with and without radiation and related disability, and during the first 2 weeks of the study (run-in period) had a routine medical screenings performed by a physician. Conscripts who reported at least 1 day of LBP or disability in everyday activities due to LBP during the month before military entry were excluded as well as those who did not respond to the pre-information questionnaire or had excluding ICD-10 diagnosis by physician. Details of the flow of study participants, including exclusion, drop-outs, and number of conscripts who completed the present study in each company during pre-study year and intervention year is presented in Figure 1.

In the pre-study year, altogether 259 of 978 conscripts refused to participate, were excluded or lost to follow-up during first two weeks. Previous LBP was the main reason for exclusion (n=214), 10 had missing data (n=10) and 1 excluding ICD-10 diagnosis: M41 (scoliosis)**.** Following the medical screening, an additional 8 men were lost. The total number of conscripts that were followed-up of 180 days or until drop-out was 719 (for details see Figure 1).

In the intervention year, altogether 389 of 1079 conscripts were lost, 258 due to LBP and 13 for missing data, seven had excluding diagnosis: M41 (scoliosis, n=5), M40.3 (flatback syndrome, n=1), and M51.9 **(**intervertebral disc disorder, n=1)**.** Following the medical screening, an additional 69 men lost (for details see Figure 1). The total number of conscripts that were followed-up of 180 days or until drop-out was 690: 356 in the intervention group and 334 in the control group (for details see Figure 1).

Baseline characteristics of the participants

All conscripts filled in a standard pre-information questionnaire during the first week of military service. Assessment of physical fitness was conducted in 97% of the conscripts during the first 2 weeks of their service. The assessment methods were applied according to standard procedures in the Finnish Defense Forces, and are reported elsewhere.[14,15] Baseline characteristics of the study participants are presented in Table 1.

Intervention program

The intervention program was performed in addition to the standard military training program (2 months basic training followed by 4 months specific training). A common NME program for the reduction of acute extremity injuries and LBP was used; epidemiologic data indicate that trunk muscular function plays an important role in both.[16] The dosage and aim of each exercise of progressive NME program is presented in Table 2, the figures are available online.[14] Specific counseling material was targeted to prevent LBP and injury as described below.

Both NME and counseling were aimed at reducing the incidence of LBP by improving the control of the lumbar neutral zone (NZ) and specifically avoiding full lumbar flexion.[12] All exercises (see Table 2) required control of the NZ.[17,18] Exercises 2a, 2b, and 8 emphasize the avoidance of full lumbar flexion. The theoretical basis of this was the hypothesis of microdamage occurring in spinal ligaments, discs, facets, and capsules.[19-23] When the microdamage exceeds a certain threshold due to high loads, many repetitions, long duration, and/or insufficient rest, acute inflammation is triggered.[23] This in turn elicits muscle spasms and significant changes in muscular activity and synchronization,[24,25] leading to chronic LBP.[19]

Counseling was based on the cognitive-behavior modeling.[26] The aims were to increase conscript awareness of tasks during daily military life potentially harmful for the lower back, and to increase personal knowledge, understanding, and skills regarding performance of these tasks in a less harmful manner, and thus reduce the fear of pain.[27] For this purpose, the conscripts in the intervention companies received a guidebook (see Table 3). Selected illustrations of the guidebook are shown in Figures 2 and 3, and are referred to in Table 3. One 1-hour lecture was provided during both the basic and special training periods. In addition, company leaders with two educated exercise instructors addressed the potential hazards of field service when appropriate.[14]

Conscripts in the control companies conducted their service as usual, except for their awareness of their role as a control group in the study. In addition, they filled in all of the study questionnaires.

Low back pain registration and outcome measures

The date and diagnosis of each LBP case were registered in the electronic patient records at the garrison healthcare unit. Because the conscripts may have sought medical care several times for the same episode of LBP, the total number of healthcare visits exceeded the number of LBP cases. In addition to active service hours, LBP occurring during the conscripts' leisure time or on the way to or from the garrison was included in the study.

The outcome measures of the present study were the number and incidence of LBP, total number of healthcare visits due to LBP, total number of off-duty days, and at least 5 off-duty days due to LBP (see Table 4 for description). Off-duty included any physical restriction that prevented full participation in military training.

Statistical analysis

SPSS 17.0 for Windows software (SPSS Inc., Chicago, IL) was used for statistical analysis. All analyses were performed according to the intention-to-treat principle. The primary analysis was intervention group vs. control group for assessment of a difference in change of LBP and disability between the pre-study year and intervention year. The incidence of outcome measures (see Table 4) was calculated by dividing the number of cases in each outcome measure by the exposure time and expressed per 1000 person-days. To examine differences in rates of the LBP outcomes between the intervention and control groups, the unadjusted and adjusted HRs between groups were obtained using the Cox proportional hazard model for categorical outcomes. The negative binomial model instead of the Poisson regression was chosen for count data due to a skewed distribution. Results are expressed as HRs and calculated with 95% CIs with age at baseline forced into the model. The interaction of the company (intervention vs. control) and study period (pre-study year vs. intervention year) was entered into the model to analyze differences in the change in the incidence rate of different outcome measures between intervention and control companies. Risk factors of LBP and possible confounders were added in the adjusted models based on a former epidemiologic study.[8] The list of adjusted variables is presented in Table 4.

RESULTS

In the intervention year, the conscripts in the intervention group followed the training program according to the plan three times weekly as part of compulsory service during the first 8-week period. After this point, a mean of 83% of the conscripts attended the training sessions.[14] In both study years, most dropouts after the 8-week basic military training period (Figure 1) were due to a

change in company (n=325). In pre-study year there were 54 dropouts for anti-tank and engineer company, and 120 for signal and mortar. Corresponding figures for intervention year were 76 and 75, respectively. Data for all conscripts that dropped out were included in the analyses for the time during which they participated.

The number of events and the incidence of the outcome measures of LBP for men in the intervention and control companies, and corresponding HRs (intervention vs. control) during the pre-study and intervention year are shown in Table 4. The intervention companies had a somewhat higher number of events and incidence of LBP than the controls during the pre-study year. The total number of events and incidence of off-duty days due to LBP was significantly decreased in the intervention companies compared to controls during the intervention year (adjusted HR = 0.42, 95% CI = 0.18 to 0.94, p = 0.035). The decrease in the number of conscripts with five or more off-duty days was larger in the intervention group (21 vs. 5) than in the control group (10 vs. 7), but the adjusted difference (HR 0.44, 95% CI = 0.11 to 1.77) was not statistically significant. The incidence of LBP and related healthcare visits was not significantly different between the groups (Table 4).

DISCUSSION

Our study comprised a pre-planned NME and counseling intervention program to prevent LBP and disability in young men with a previously healthy back that were engaged in high level of physical activity including heavy military tasks. The target for the NME was to improve the conscripts' movement control of the lower back, and enhance trunk muscular endurance and spine stability. Special emphasis was placed on developing patterns of squatting with control of the lumbar NZ, i.e., learning to differentiate between lumbar spine flexion and hip flexion.[12,28-30] Counseling comprised a guidebook and two lectures aimed at improving the conscripts' awareness of potentially harmful actions/situations for low back injury and pain. These rather simple preventive actions in the intervention companies were successful in reducing the total number of off-duty days

by 58% compared to control companies. The incidence of health clinic visits due to LBP, however, was not different between groups.

The results indicated that conscripts in the intervention group experienced less severe injuries to spinal structures than conscripts in the control group, which led to physicians prescribing fewer off-duty days. Plausible biologic explanations for the less severe injury include the following: First, the conscripts in the intervention companies may have been more aware than controls of activities harmful to the lower back and thus more able to avoid full lumbar flexion,[21,22,24] especially in heavy tasks, such as lifting, as suggested in the guidebook (Figure 2). Second, NME might have improved conscripts' ability to resist compressive loading due to enhanced muscular endurance[28] and/or co-contraction of the trunk muscles during daily tasks.[17,18] Third, the conscripts' movement control might have improved due to the NME and/or they were able to imitate (i.e., learn by observing)[31] the correct postures of common tasks introduced in the guidebook.

A psychosocial explanation for reduced off-duty days could be altered experience of LBP and related behavior. Theoretically, the latter is be best explained by altered pain-related fear avoidance beliefs.[27,33,34] Pain has clear emotional and behavioral consequences that influence the development of persistent problems and treatment outcome.[34] It is possible that the conscripts in the intervention companies were less afraid than controls or felt more competent to return to duty regardless of their experience of LBP. Avoiding loading that is harmful for the back was systematically emphasized in the guidebook in different types of activities, and examples of how to conduct these duties in a less harmful manner were presented. Furthermore, the key elements of the skills needed to correct behaviors potentially harmful to the lower back were rehearsed in the NME program.

Only two former randomized controlled trials have emphasized control of the lumbar NZ as a main goal of exercise and counseling interventions. Our previous study among middle aged men with recurrent LBP, but well able to work, indicated that these types of interventions contribute to decreasing the intensity of LBP and positively improving personal expectations of the maintenance

of future work ability.[12] The findings of an earlier study[11] of exercise and ergonomic counseling for 13 weeks indicated reduced incidence and recurrence of LBP in non-chronic working patients. The main difference between the studies is that the present study focused on primary prevention of LBP, the others on secondary prevention. In addition, the disability measures in the studies were not comparable.

The limitations of the present study relate to study design. First, the method of group randomization (intervention vs. control companies) was used to avoid a contamination bias. Due to this, the results of the present study can only be generalized to the group level. Randomization by clusters is not possible because there were only four different companies (anti-tank, signal, mortar and engineer) per cohort of young men. The potential bias, therefore, is that the effect of company on the outcome measures is not fully included in the present results. Knowledge of the incidence rates of LBP in the pre-study year for the different companies, however, helped to control this effect.

Second, the specific effects of NME vs. counseling on the outcome measures cannot be identified. Subjective assessment methods such as a fear avoidance beliefs questionnaire[35] and patient specific function scale[36] were not included in the study protocol. Use of these assessment methods among conscripts visiting the garrison healthcare unit due to LBP might have provided more information regarding the psychological effects of exercise and counseling.

The strengths of the study include the use of computerized patient files, which guaranteed a high coverage of LBP. Second, data collection during the year before the intervention provided valuable baseline knowledge on the incidence of LBP and disability, and thus improved the reliability of the study results. Third, the military environment provides standard conditions for studying the effects of intervention, especially in terms of physical and social environment. Fourth, because the intervention was integrated into military service, a high level of compliance was achieved. Fifth, during the exercise sessions a strong emphasis was placed on proper technical performance of every single exercise maneuver. Before the intervention, instructors were educated with regard to the

correct training technique and how to best instruct each exercise and observe typical mistakes in each exercise maneuver, as well as how to appropriately correct the mistakes. Finally, the content of the guidebook was planned together with the personnel of the Pori Brigade. This ensured that the harmful tasks of military and everyday life for the back introduced in the guidebook were relevant to the conscripts.

The results of the present study suggest that exercise and counseling to improve control of the lumbar NZ has a prophylactic effect on LPB-related off-duty service days in the military environment when implemented as a part of the military service. Because the majority of the young male population in Finland participates in military service, these results also have important public health implications. Further studies are needed to clarify the effectiveness of each part of the intervention.

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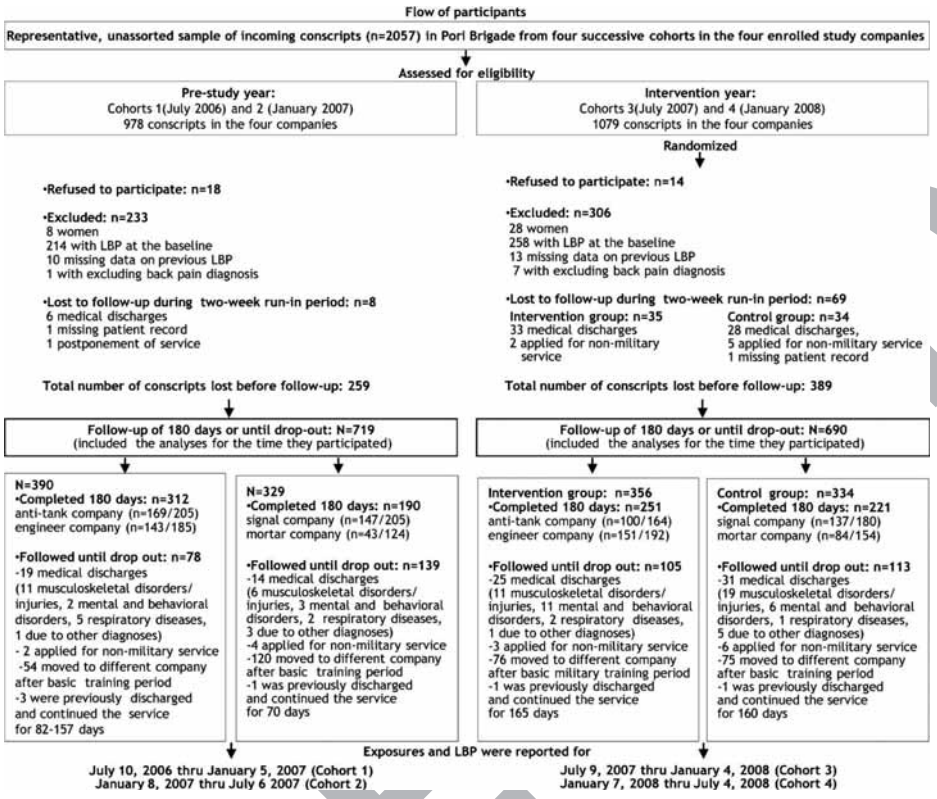

Figure 1. Flowchart of companies and participants through the pre-study and intervention.

Figure 2. Illustrations of the Guidebook on how to control the lumbar neutral zone: lifting, squatting, shoveling, and digging.

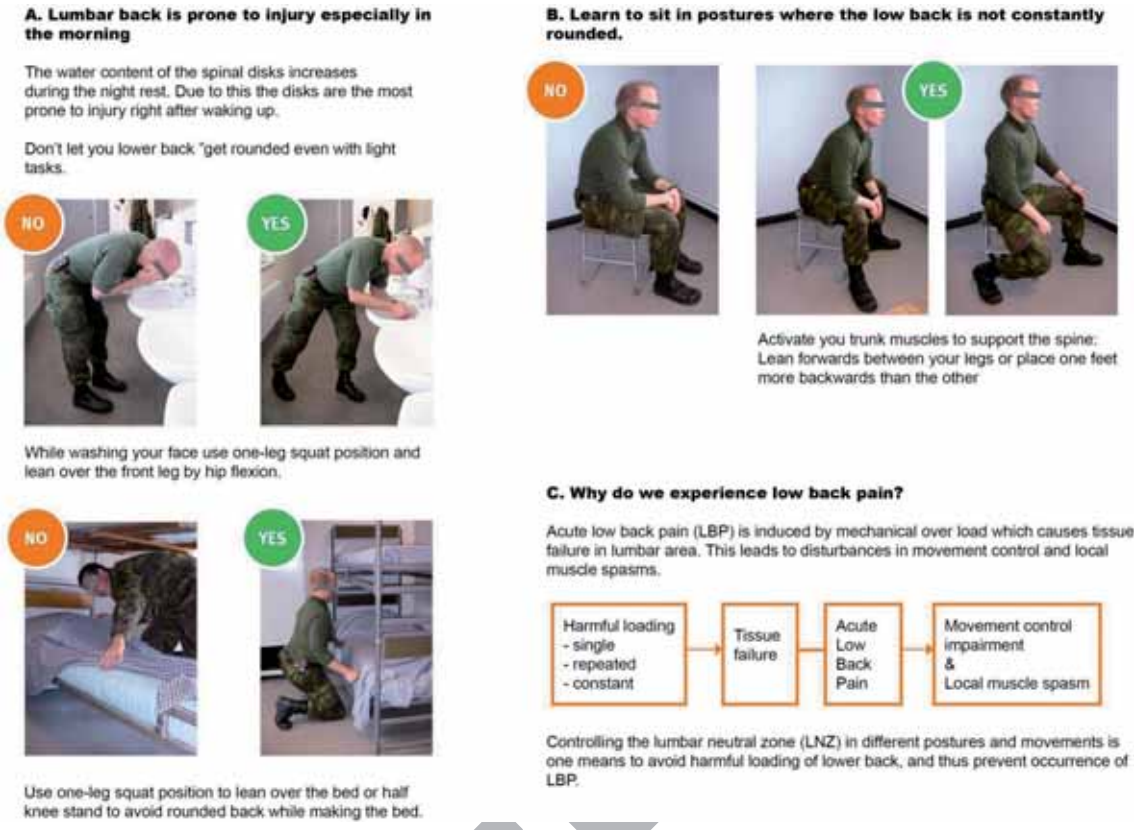

Figure 3. Illustrations of the Guidebook on how to control the lumbar neutral zone: washing face, making bed, sitting.

Table 1. Baseline characteristics of 1409 male conscripts by company and study period.

Variable	Pre-study year (N=719)				Intervention year (N=690)				Missing	P-value[1]
	Intervention group		Control group		Intervention group		Control group			
	Anti-tank company 06-07	Engineer company 06-07	Signal company 06-07	Mortar company 06-07	Anti-tank company 07-08	Engineer company 07-08	Signal company 07-08	Mortar company 07-08		
Number of conscripts	205	185	205	124	164	192	180	154	0 (0%)	
Age, median, years	19	19	19	19	19	19	19	19	0 (0%)	0.025 [2]
Body mass index, median, kg/m^2	23.8	23.5	22.5	22.7	23.2	23.5	22.9	23.3	118 (7%)	0.038[2]
Waist circumference, median, cm	87.0	86.0	85.0	84.5	84.0	86.4	83.8	86.2	99 (7%)	0.033[2]
12-minute run test result, median, m	2310	2410	2360	2515	2395	2420	2305	2500	31 (2%)	0.703[2]
	Yes	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*	*Yes*		
Good physical fitness[4],%	55	54	54	64	56	49	45	71	35 (2%)	0.490[3]
Hometown population ≥10000 persons,%	0.326[3]	61	56	63	51	65	59	66	62	2 (0%)
High level of previous physical activity[6],%	33	37	28	35	29	28	23	54	0 (0%)	0.065[3]
Good self-assessed health[7],%	63	52	60	52	59	58	47	75	0 (0%)	0.907[3]
Chronic impairment or disability,%	13	13	9	16	4	15	17	10	6 (0%)	0.426[3]
Orthopedic surgery, %	9	9	6	9	9	11	9	6	1 (0%)	0.555[3]
Clear musculoskeletal symptoms[8],%	21	23	21	20	22	25	24	14	1 (0%)	0.637[3]
Previous or current regular smoker, %	0.032[3]	40	55	44	35	48	53	44	40	2 (0%)
Use of alcohol ≥ 3 times per week, %	0.069[3]	14	20	13	15	22	21	24	10	1 (0%)

[1]P-value for difference between the study group and year
[2]P-value was examined by using a Kruskal-Wallis test for median difference
[3]P-value was examined by using $\chi 2$ statistics for difference
[4]Combination of Cooper's and push up test excellent or good
[5]Graduated or studies in higher education institution
[6]Sweating exercise at least three times per week during the last month before military entry
[7]Compared to age-mates
[8]Symptoms lasting more than 7 days in at least one anatomic region during the last month before entering the military

Table 2. Dosage and aims of the neuromuscular training program

Exercise and dosage	Aimed to enhance/improve
1. One-leg standing with a stick 20 repetitions (10+10) with alternating legs	•balance and coordination •shoulder-neck posture and mobility
2. Squat exercise with a stick on two and one leg 16 repetitions (rep.) on two legs, 16 rep. (8+8) with alternating legs	•balance and control of lumbar neutral zone (NZ) •lower extremity muscular strength
3. Horizontal side-support Stage one (flexed knees): 5 rep. with 5 s static holding (5+5) with alternating side Stage two (straight knees): 5 circles of "side-belly-side" with 5 s hold for each	•co-contraction of trunk muscles and back stability •trunk muscular endurance
4. Jumping from side to side Rhythm: 4 slow jumps + 8 fast jumps; exercise time 60 s	•coordination and agility; control of lumbar NZ •lower extremity muscular endurance
5. Modified push-up Repetitions as many as possible; exercise time 60 s	•upper extremity extensor strength •co-contraction of trunk muscles and back stability
6. Stretching exercise for hip flexor muscles 5 x 10 s stretch with alternating side	•extensibility of hip flexor and side muscles •lower extremity muscular strength
7. Hamstring exercise on knees; repetitions 8-12	•eccentric capacity of hamstring muscles •trunk motor control
8. Stretching exercise with a stick for hamstring muscles 3 x 20 s stretch with alternating legs	•extensibility of hamstring and calf muscles •control of lumbar NZ
9. Upper body rotation while side-lying, "yoga stretch" 1 x 60 s for both sides	•rotational mobility of thoracic spine •extensibility of pectoral muscles

Table 3. Summary of the contents of the guidebook for conscripts for the prevention of low back injury, pain, and disability*

Conscript's checklist of potentially harmful daily tasks and activities for low back

- ✓ Lifting heavy loads, for example while loading a truck, increases the risk of low back injury.
- ✓ Physically strenuous tasks, such as digging and shoveling, with a fully flexed (rounded) lower back increase the risk of low back injury. (Figure 2D)
- ✓ Light tasks, such as making the bed or washing your face, while leaning over or bending forward increase the risk of low back injury, especially in the morning. (Figure 3A)
- ✓ Sitting, driving a bike or a car with fully flexed (rounded) lower back, increases the risk of low back injury. (Figure 3B)

Good muscular fitness and movement control of the lower back help to prevent low back injury and pain

- Trunk muscles have an important role in stabilizing the spinal column. Co-contraction of the muscles around the spine (in front, sideways, from back) ensures good spinal stability. Squatting while leaning forward flexing hips and knees ensures co-contraction. (Figures 2 B, C, and D)
- Trunk muscles need to have good endurance capacity, while muscle fatigue decreases movement control, which may lead to impaired spinal stability.
- Keeping the lumbar spine in neutral zone improves safety. Such posture is similar to normal standing posture, i.e., the lumbar spine is not fully flexed or extended, the typical posture being a slight sway-back. (Figure 2A)
- In fully flexed lumbar postures the deep extensor muscles of the lower back cannot support the spine. Avoiding fully flexed postures decreases the risk of soft tissue injuries and backwards bulging of the disks. (Figure 2 B, C, and D; Figure 3 A and B)

Learn to conduct your daily military tasks in ways that are safe for your back

- Some of the military tasks are strenuous or otherwise demanding on the back. Follow the instructions given in this guidebook in all your daily tasks.
- It is important to use the correct lifting and squatting techniques. (Figure 2 B and C; Figure 3A)
- Fend for your back, it's worth it.

Take care of your back in leisure-time too

- Physical activity and muscular resistance training promote back health.
- Be aware of situations in which the safety of your back may be compromised:
  -resistance and other exercises while sitting, squatting and lifting
  -avoid full range of motion stretching exercises of the back
  -avoid full lumbar flexion in all exercises

*Selected topics and principles presented in this table are also illustrated in Figures 2 and 3 as referred in the table.

Table 4. Incidence (per 1000 person-days) of different categories of low back pain (LBP), including hazard ratios (HR), of changes in incidences between the intervention (Int.) and control (Ctrl.) companies during follow-up and intervention year.

Variable	Company	Pre-study year (n=390/329)‡ Number	Pre-study year (n=390/329)‡ Incidence	Intervention year (n=356/334)‡ Number	Intervention year (n=356/334)‡ Incidence	HR age-adjusted model (95% CI)	HR adjusted model* (95% CI)
Registered cases of LBP	Int.	82	1.34	58	1.13	0.95	0.93
	Ctrl.	49	1.17	47	1.02	(0.55-1.65)	(0.53-1.63)
Total number of health clinic visits due to LBP‡‡	Int.	145	2.38	82	1.60	0.81	0.82
	Ctrl.	81	1.93	77	1.66	(0.42-1.56)	(0.43-1.57)
Total number of off-duty days due to LBP‡‡	Int.	285	4.67	124	2.41	**0.40**	**0.42****
	Ctrl.	131	3.13	154	3.33	**(0.17-0.91)**	**(0.18-0.94)**
At least 5 off-duty days due to LBP	Int.	21	0.34	5	0.10	0.44	0.44
	Ctrl.	10	0.24	7	0.15	(0.11-1.73)	(0.11-1.77)
Follow-up days	Int.	61027		51383			
	Ctrl.	41900		46296			

Hazard ratio (HR) obtained from Cox proportional hazard model if not otherwise mentioned (level of significance <0.05). HR is based on interaction term of study group (intervention / control) and study period entered into the model for analyzing the difference of change in incidences between the groups.

‡ Number of conscripts in the intervention and control companies per study period (after the 2-week run-in period)

*Adjusted for age, smoking, baseline medical conditions (sports injury, sum factor of earlier musculoskeletal symptoms, chronic impairment or disability due to prior musculoskeletal injury, orthopedic surgery), school success (educational level and grades combined), urbanization level of the place of residence, physical activity during the previous 3 months before entering the military and baseline physical fitness level (12-minute running test and push-up test combined)

‡‡Rate ratio obtained from Negative binomial model

**Total number of off-duty days due to LBP, p=0.035