Ilona Mikkola

PREVALENCE OF METABOLIC SYNDROME AND CHANGES IN BODY COMPOSITION, PHYSICAL FITNESS AND CARDIOVASCULAR RISK FACTORS DURING MILITARY SERVICE
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PREVALENCE OF METABOLIC SYNDROME AND CHANGES IN BODY COMPOSITION, PHYSICAL FITNESS AND CARDIOVASCULAR RISK FACTORS DURING MILITARY SERVICE

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UNIVERSITY OF OULU, OULU 2011
Abstract

Metabolic syndrome (MetS) is a cluster of obesity-related cardiometabolic risk factors. It predicts the development of cardiovascular disease and type 2 diabetes, which are major public health concerns. Visceral obesity and insulin resistance are the predominant underlying factors of MetS, other diagnostic components being elevated blood pressure, high triglycerides, and low HDL-cholesterol. The most important treatment of MetS is through lifestyle changes.

There are limited data concerning the prevalence of MetS among young populations. Furthermore, even though the effects of physical activity on MetS components are well established at an individual basis and in some subpopulations, large population-based data about associations of young men’s fitness and MetS-related cardiometabolic risk factor changes are warranted.

In Finland, military service is compulsory for males. In 2005, 1,160 young men (mean age 19.2 years, range 18–28 years) were followed throughout their military service (6–12 months) in the Sodankylä Jaeger Brigade. The military service period includes high amounts of physical exercise, but no dietary restrictions. Physical fitness, anthropometrics, body composition, and cardiometabolic risk factors were assessed at the beginning and at the end of military service.

Among the entire study population, the prevalence of MetS was 3.5–6.8%, depending on the definition used, and increased in parallel with an increasing body mass index. On the average, the military training period resulted in a decrease in body weight and amount of fat tissue, especially visceral fat, and improved physical fitness. Body composition and fitness improvements were more pronounced in overweight and obese service men. Beneficial changes in body composition and related cardiovascular risk factor improvements were associated with increased physical fitness, especially aerobic fitness.

This study indicates that an improvement in physical fitness is related to improvements in body fat distribution and cardiovascular health at population level in young men. This is an age when co-morbidities are usually as yet non-existing, but might be most efficiently prevented by lifestyle changes, such as becoming physically active.

Keywords: body composition, body mass index, cardiovascular risk factors, exercise, metabolic syndrome, military conscripts, young men
Mikkola, Ilona, Metabolisen oireyhtymän vallitsevuus sekä kohonkoostumuksen, fyysisen kunnon ja kardiovaskulaaristen riskitekijöiden muutokset varusmiespalvelusaikana.

Oulun yliopisto, Lääketieteellinen tiedekunta, Terveystieteiden laitos, Yleislääketiede, PL 5000, 90014 Oulun yliopisto; Puolustusvoimat, Sotilaslääketieteen Keskus, PL 2, 15701 Lahti; Rovaniemen terveyskeskus, PL 8216, 90101 Rovaniemi; Oulun yliopistollinen sairaala, Yleislääketieteen yksikkö, PL 10, 90029 OYS

Oulu

Tiivistelmä


Liikunnan tiedetään johtavan edullisiin kehonkoostumusmuutoksiin sekä kardiovaskulaaririskitekijöiden parantumiseen. Laajat väestöton tuntumukset nuorten aikuisen kunnon ja varhais-ten valtimosairausriskitekijöiden muutosten välisistä yhteyksistä kuitenkin puuttuvat.


Asiasanat: kehonkoostumus, liikunta, metabolinen oireyhtymä, nuoret miehet, painoindeksi, sydän- ja verisuonitautien riskitekijät, varusmiehet
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Rovaniemi, September 2011

Ilona Mikkola
## Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
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<tbody>
<tr>
<td>ATPIII</td>
<td>the National Cholesterol Education Program Adult Treatment Panel III</td>
</tr>
<tr>
<td>β</td>
<td>beta coefficient</td>
</tr>
<tr>
<td>BF</td>
<td>body fat</td>
</tr>
<tr>
<td>BIA</td>
<td>bioimpedance analysis</td>
</tr>
<tr>
<td>BP</td>
<td>blood pressure</td>
</tr>
<tr>
<td>BMI</td>
<td>body mass index</td>
</tr>
<tr>
<td>CT</td>
<td>computed tomography</td>
</tr>
<tr>
<td>dBP</td>
<td>diastolic blood pressure</td>
</tr>
<tr>
<td>fat%</td>
<td>body fat percentage</td>
</tr>
<tr>
<td>FFM</td>
<td>fat-free mass</td>
</tr>
<tr>
<td>FM</td>
<td>fat mass</td>
</tr>
<tr>
<td>HDL</td>
<td>high-density lipoprotein</td>
</tr>
<tr>
<td>IDF</td>
<td>International Diabetes Federation</td>
</tr>
<tr>
<td>LBM</td>
<td>lean body mass</td>
</tr>
<tr>
<td>LDL</td>
<td>low-density lipoprotein</td>
</tr>
<tr>
<td>MFI</td>
<td>muscle fitness index</td>
</tr>
<tr>
<td>MetS</td>
<td>metabolic syndrome</td>
</tr>
<tr>
<td>MRI</td>
<td>magnetic resonance imaging</td>
</tr>
<tr>
<td>sBP</td>
<td>systolic blood pressure</td>
</tr>
<tr>
<td>SD</td>
<td>standard deviation</td>
</tr>
<tr>
<td>SE</td>
<td>standard error</td>
</tr>
<tr>
<td>TBW</td>
<td>total body water</td>
</tr>
<tr>
<td>TG</td>
<td>triglyceride</td>
</tr>
<tr>
<td>VFA</td>
<td>visceral fat area</td>
</tr>
<tr>
<td>VO\textsubscript{2}\text{max}</td>
<td>maximal oxygen uptake</td>
</tr>
<tr>
<td>WC</td>
<td>waist circumference</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
<tr>
<td>WHR</td>
<td>waist-to-hip-ratio</td>
</tr>
</tbody>
</table>
List of original articles

This thesis is based on the following articles, which are referred to the text by their Roman numerals.


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1 Introduction

Obesity, physical inactivity, and low cardiorespiratory fitness often occur simultaneously, and are dependent on each other. During the past few decades, the prevalence of obesity has increased alarmingly worldwide in all age groups (World Health Organization 2011), including adolescents and young adults also in Finland (Kautiainen et al. 2002). Moreover, an increase in young men’s body mass index (BMI) and a decrease in physical fitness have been reported (Santtila et al. 2006). Changes in social environments and the modern sedentary lifestyle in urbanized societies combined with a hyperenergetic diet are often cited as explanatory factors for these trends (Kyröläinen et al. 2010, Tammelin et al. 2007).

Obesity, especially visceral obesity, is related to the presence of a cluster of cardiovascular risk factors – metabolic syndrome (MetS). MetS is a major risk factor for cardiovascular disease (Isomaa et al. 2001) and type 2 diabetes (Lorenzo et al. 2003). Lifestyle intervention with dietary modifications and physical activity is a key tool in the treatment of obesity and related metabolic abnormalities. Increased physical activity reduces fat mass, especially visceral fat (Kay & Fiatarone Singh 2006, Ross et al. 2000). Training results in beneficial changes in body composition, which can be seen especially in overweight and obese subjects (Kay & Fiatarone Singh 2006) and they also occur without weight loss (Pratley et al. 2000).

Unfortunately, it is known that physical activity decreases dramatically from youth to young adulthood (Telama & Yang 2000). Therefore, young adulthood is an interesting age to investigate the effects of physical activity on health factors, such as body fat distribution and cardiometabolic risk factors. It is relevant to concentrate on male population, because over 40% of the Finnish male population aged 45–72 years have been reported to suffer from metabolic abnormalities, which associate with central obesity, even in normal-weight subjects (Saaristo et al. 2008). Acting already at a younger age, preventing these visceral obesity related disturbances in metabolism might be efficient, as co-morbidities are yet non-existent. Hence, there is a need for effective lifestyle modifications in management of obesity in this age group.

Given that obesity and related co-morbidities are nowadays an excessive burden to health care, increasing interest for population level investigations of its managements has come to prominence. It is obvious that personnel in a clinical practice cannot concentrate only on individual counselling – the main interest of
health behaviour education should be focused on population level. Therefore, physicians and nurses in primary health care should be aware of different modifications of tools to combat obesity in different age groups. Very promising results in such trials have been achieved. For example, in a large Finnish Diabetes Prevention Study, it has been shown that primary prevention of type 2 diabetes is possible by lifestyle intervention in high-risk patients (Tuomilehto et al. 2001). However, unselected population-based studies concerning early cardiovascular risk factor management in young adulthood are warranted.

The perspective of the present study is optimal in terms of answering to that need. A large, population-based sample of Finnish young men in compulsory military service offered us a unique opportunity to study the prevalence of cardiovascular risk factors at baseline and changes in them during military service that includes a considerable amount of physical exercise.
2 Review of the literature

2.1 Metabolic syndrome and related independent cardiovascular risk factors

A cluster of cardiovascular risk factors, known today as metabolic syndrome, was first described by the Swedish physician Kylin in the 1920s (Kylin 1923). He noticed that hypertension, hyperglycaemia and gout tend to occur together more often than would be possible just by a chance. Later on, this cluster of cardiovascular risk factors was commonly related to central obesity (Vague 1947).

In 1988, Gerald Reaven used the term “Syndrome X” (Reaven 1988) to describe the close interrelationships between obesity, hyperinsulinaemia, glucose intolerance and dyslipidaemia. Also the terms “deadly quartet syndrome” (Kaplan 1989), “dysmetabolic syndrome” (Groop & Orho-Melander 2001) and “insulin resistance syndrome” (Ferrannini et al. 1991) have been used for this constellation of risk factors of metabolic origin. The term “metabolic syndrome” (MetS) was first coined by the World Health Organization (WHO) in 1998 (Alberti & Zimmet 1998). MetS was defined as impaired glucose regulation and/or insulin resistance occurring together with at least two of the following conditions: dyslipidaemia, high blood pressure, obesity or microalbuminuria. Following this, several definitions of MetS have been provided by different professional organizations (see chapter 2.1.2).

In prospective studies it has been shown that MetS strongly predicts development of atherosclerotic cardiovascular disease (Ford 2005, Isomaa et al. 2001), and type 2 diabetes (Lorenzo et al. 2003). Furthermore, MetS is also associated with all-cause mortality (Ford 2005). However, it has still been under active debate whether a diagnosis of this syndrome improves treatment of patients over traditional approaches (Hu 2008). The main controversy is that MetS has too many definitions and it has not yet a settled status in clinical practice (Eckel et al. 2010). Some studies even indicate the MetS does not predict cardiovascular events any better than the sum of its components (Eckel et al. 2010, Koskinen et al. 2009, Wannamethee et al. 2005). However, MetS provides a practical tool for physicians to assess the risk for development of cardiovascular disease or diabetes. Moreover, the term has also become relatively familiar among the general population.
2.1.1 The mechanisms underlying metabolic syndrome

The predominant underlying components of MetS appear to be visceral obesity and insulin resistance (Grundy et al. 2005). Other important risk factors of MetS are physical inactivity (Ilanne-Parikka et al. 2010) and poor aerobic fitness (Ferreira et al. 2005). Further, many other associated factors exist, as described below. However, the complete mechanism of MetS is not yet fully understood.

Visceral obesity, chronic low grade inflammation, and insulin resistance

Visceral obesity is a prevailing underlying factor of MetS (Park et al. 2003) and it is one of the MetS components in several definitions of MetS (chapter 2.1.2). About 10% of total body fat tissue consists of visceral fat (fat located inside the peritoneal cavity), and about 25–50% of total abdominal fat mass is visceral fat, the rest being subcutaneous adipose tissue (Miles & Jensen 2005).

Fat tissue synthesizes and secretes specific hormones, inflammatory cytokines (leptin, tumor necrosis alpha, interleukin-6, resistin, and adiponectin), and free fatty acids (Hu 2008). Circulating concentrations of leptin, interleukin-6, and tumor necrosis-alpha increase in parallel with increasing amount of adipose tissue (Saltiel 2001). Correspondingly, an association between adiposity and diminished output of adiponectin has been detected (Shaibi et al. 2007). Hence, MetS represents a state of chronic, low-grade inflammation (Hu et al. 2004).

Due to its anatomical location, visceral fat tissue delivers cytokines and free fatty acids straight to the portal circulation, and therefore it has a major influence on liver metabolism (i.e. glucose and insulin metabolism). Subcutaneous fat, on the other hand, secretes free fatty acids and hormones to systemic circulation, which would make it less disadvantageous to liver metabolism (Hu 2008).

Insulin resistance is considered a common link between obesity and metabolic risk factors (Reaven 1988). It is defined as a defect in insulin action resulting in fasting hyperinsulinaemia to maintain euglycemia. However, even before fasting hyperinsulinaemia develops, postprandial hyperinsulinaemia exists (Eckel 2005). Insulin resistance explains most of the development of MetS (Eckel et al. 2010) and it is clearly associated with an excess amount of visceral fat (Cameron et al. 2008).
Physical inactivity and poor physical fitness

A low amount of physical activity is associated with an increased risk for developing MetS (Ferreira et al. 2005, Ilanne-Parikka et al. 2010, Laaksonen et al. 2002). Accordingly, low aerobic fitness is an independent risk factor for developing MetS (Ferreira et al. 2005, Lakka et al. 2003). Also muscular strength has an association with the prevalence of MetS (Jurca et al. 2004).

For example, in a Dutch study, the determinants for developing MetS from adolescence to young adulthood (despite of an increase in body fatness) were a considerable decrease in aerobic fitness, as well as a marked decrease in vigorous physical activity. It is of note that an increase in the amount of physical activities of light-to-moderate intensity did not prevent development of MetS in young adulthood (Ferreira et al. 2005). In a recent Finnish study, increased moderate-to-vigorous leisure time physical activity was associated with decreased likelihood for developing MetS (Ilanne-Parikka et al. 2010).

Other risk factors for metabolic syndrome and related conditions

Many other behavioural factors such as smoking (Park et al. 2003), sleep deprivation (Hall et al. 2008), alcohol abstinence or decreased alcohol intake (Ferreira et al. 2005, Sidorenkov et al. 2010) and mental stress (Pykkonen et al. 2010) have been observed to be associated with occurrence of MetS.

Considerable individual and ethnic variations exist in the clinical manifestations of MetS in obese subjects, and it is likely that the expression of each metabolic risk factor falls partly under its own genetic control (Grundy et al. 2005). For example, in a recent large prevalence study of MetS in the United States (U.S.) Ford et al. (2010) found that MetS prevalence was lower among African American men than among white or Mexican American men, and lower among white women than among African American or Mexican American women (Ford et al. 2010). The prevalence of MetS increases with age (Ford et al. 2010, Mattsson et al. 2007) and it appears to be more frequent in males than in females (Ferreira et al. 2005, Ford et al. 2010, Mattsson et al. 2007).

MetS associates with several other conditions, such as psoriasis (Love et al. 2010), gallstone disease (Mendez-Sanchez et al. 2005), sleep apnoea (Bhushan et al. 2010) and other sleep symptoms, such as difficulties falling asleep, loud snoring, and unrefreshing sleep (Troxel et al. 2010). MetS is also common in patients with polycystic ovary syndrome (Ehrmann et al. 2006, Mendez-Sanchez...
et al. 2005). Higher concentration of vitamin D is inversely associated with the occurrence of MetS among adolescents, independent of adiposity (Reis et al. 2009). Furthermore, self-reported intake frequency of cola drink (irrespective of presence of sugar) is independently positively associated with MetS (Hostmark 2010).

2.1.2 Classification criteria of metabolic syndrome

Several different definitions of MetS exist. The first definition criteria were provided by the WHO in 1998 (Alberti & Zimmet 1998), followed by the European Group for the Study of Insulin Resistance (EGIR) (Balkau & Charles 1999), the National Cholesterol Education Program Adult Treatment Panel III (ATP III) (Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults 2001), the American Association of Clinical Endocrinologist (AACE/ACE) (Einhorn et al. 2003), the International Diabetes Federation (IDF) (Alberti et al. 2005), and the American Heart Association (AHA) (Grundy et al. 2005). The newest consensus criteria have been provided by the World Heart Federation, the International Atherosclerosis Society, and the International Association for the Study of Obesity (Alberti et al. 2009).

Even though the classification criteria differ from each other, nearly all of them include the same kind of combination of (abdominal) obesity, blood pressure and biochemical indicators. The different definition criteria and their components are presented in Table 1.
Table 1. Definitions of metabolic syndrome.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Obesity</th>
<th>BP (mmHg)</th>
<th>Lipoproteins (mmol/l)</th>
<th>Glucose</th>
<th>Insulin resistance</th>
<th>Other</th>
<th>Fulfilled criteria</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHO (Alberti &amp; Zimmet 1998)</td>
<td>WHR &gt; 0.90/M, &gt; 0.80/F and/or BMI&gt;30kgm²</td>
<td>≥ 140/90</td>
<td>TG ≥ 1.7 and/or HDL &lt; 0.9/M; &lt; 1.0/F</td>
<td>*</td>
<td>IGT, IFG or T2DM</td>
<td>Microalbuminuria</td>
<td>IGT, IFG, T2DM, or lowered insulin sensitivity required+2 other components</td>
</tr>
<tr>
<td>EGIR (Balkau &amp; Charles 1999)</td>
<td>WC ≥ 94cm/M, ≥ 80cm/F</td>
<td>≥ 140/90</td>
<td>TG ≥ 2.0 and/or HDL &lt; 1.0 or medication</td>
<td>Non-diabetic but fG/2h plasma glucose ≥ 6.1/7.8 mmol/l</td>
<td>Highest quartile of fasting insulin values (not diabetic)</td>
<td>No</td>
<td>Insulin component required+2 other components</td>
</tr>
<tr>
<td>ATP III (Expert Panel on Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults 2001)</td>
<td>WC ≥ 102cm/M, ≥ 88cm/F</td>
<td>≥ 130/85</td>
<td>TG ≥ 1.7 and/or HDL &lt; 1.04/M; &lt; 1.29/F</td>
<td>fG ≥ 6.1 mmol/l</td>
<td>No</td>
<td>No</td>
<td>Any 3 of the 5 components</td>
</tr>
<tr>
<td>AACE (Einhorn et al. 2003)</td>
<td>Not necessarily (see **)</td>
<td>≥ 130/85</td>
<td>TG ≥ 1.7 or HDL &lt; 1.0/M; &lt; 1.03/F</td>
<td>fG ≥ 6.1 mmol/l or IGT</td>
<td>*high risk</td>
<td>Requirement of high-risk presence and 2 other components</td>
<td></td>
</tr>
<tr>
<td>IDF (Alberti et al. 2005)</td>
<td>WC ≥ 94cm/M, ≥ 80cm/F</td>
<td>≥ 130/85 OR HDL &lt; 1.04/M; &lt; 1.29/F</td>
<td>TG &gt; 1.7 and/or T2DM</td>
<td>fG ≥ 5.6 mmol/l or T2DM</td>
<td>No</td>
<td>No</td>
<td>Increased WC required+2 other components</td>
</tr>
<tr>
<td>Reference</td>
<td>Obesity</td>
<td>BP (mmHg)</td>
<td>Lipoproteins (mmol/l)</td>
<td>Glucose</td>
<td>Insulin resistance</td>
<td>Other</td>
<td>Fulfilled criteria</td>
</tr>
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</tr>
<tr>
<td>AHA (Grundy et al. 2005)</td>
<td>WC ≥ 102 cm/M; ≥ 88 cm/F</td>
<td>sBP ≥ 130 and/or dBP ≥ 85</td>
<td>TG &gt; 1.7</td>
<td>fG ≥ 5.6 mmol/l</td>
<td>No</td>
<td>No</td>
<td>Any 3 of the 5 components</td>
</tr>
<tr>
<td>Consensus criteria (Alberti et al. 2009)</td>
<td>Elevated WC (population- and country-specific definitions; in Europe the IDF cut-off points)</td>
<td>sBP ≥ 130 and/or dBP ≥ 85</td>
<td>TG ≥ 1.7 and/or HDL &lt; 1.0/M; &lt; 1.3/F or medication</td>
<td>fG ≥ 5.6 mmol/l</td>
<td>No</td>
<td>No</td>
<td>Same as IDF</td>
</tr>
</tbody>
</table>

dBP = diastolic blood pressure, F = female, fG = fasting glucose, HDL = high-density lipoprotein cholesterol, IFG = impaired fasting glucose, IGT = impaired glucose tolerance, LDL = low-density lipoprotein cholesterol, M = male, sBP = systolic blood pressure, T2DM = type 2 diabetes mellitus, TG = triglycerides, WC = waist circumference, WHR = waist-to-hip-ratio *IGT, IFG, or T2DM **high risk: BMI > 25 kgm^-2; waist limits as IDF criteria; diagnosis of for example hypertension, cardiovascular disease; patient having a family history of corresponding disease; history of gestational diabetes; glucose intolerance; certain ethnicity; sedentary lifestyle; age > 40. (Einhorn et al. 2003)
The most commonly used definitions in recent research appear to be those provided by the WHO, ATPIII, and IDF. The main difference is that the IDF definition presupposes the presence of abdominal obesity, whereas the WHO and ATPIII definitions do not. In contrast, the WHO definition requires failure in insulin action, and includes microalbuminuria as one of its components.

The ATPIII MetS definition had a slightly higher hazard ratio for developing cardiovascular disease in a 10-year follow-up among a study population of more than 1,500 middle-aged adults, compared with the definitions provided by the WHO, EGIR, and AACE (Dekker et al. 2005). In this study of Dekker et al. (2005), MetS defined by ATPIII criteria was associated with a 2-fold increase in age-adjusted risk of fatal cardiovascular disease event in males, and nonfatal in females (Dekker et al. 2005). It is worth noticing that the IDF definition of MetS was not included in that study.

The IDF criteria appeared to have a lower predictive power for coronary events than ATPIII criteria in both genders in a study of 7,152 German middle-aged adults (Assmann et al. 2007). On the other hand, in a Finnish study of more than 10,000 adults, the MetS defined by IDF predicted cardiovascular mortality more than MetS defined by WHO (Qiao & DECODE Study Group 2006).

Agreement between those definitions that require the measurement of insulin levels (WHO and EGIR) appears to be substantial or very good (the kappa coefficient varying between 0.64 and 0.83) (Can & Bersot 2007, Dekker et al. 2005, Lin et al. 2009). Correspondingly, agreement between ATPIII and IDF definitions that do not require the measurements of insulin levels has in different studies varied from substantial to very good (kappa being 0.67–0.87) (Can & Bersot 2007, Dekker et al. 2005, Lin et al. 2009).

2.1.3 Prevalence of metabolic syndrome

Prevalence of metabolic syndrome in general adult populations

The prevalence of obesity has increased dramatically worldwide during the past few decades (World Health Organization 2011). In addition, the prevalence and incidence of MetS has increased in parallel with increasing obesity. For example, in the U.S. the age-adjusted MetS prevalence in males aged 20–70 years in 2002 was 24% (Ford et al. 2002). Eight years later, in 2010 MetS prevalence was 34.3% among US adults (Ford et al. 2010). In Russia, the overall MetS
prevalence among adult males aged 18–90 years was 9.5% (data collected in 2000) (Sidorenkov et al. 2010). In Iranian adult population (data collected 1999–2001) MetS occurred in 31% of adults (Azizi et al. 2003).

In Europe, adult MetS prevalence has been reported to be 10.4% (18.3% in men and 3.2% in women) in Dutch adults (Ferreira et al. 2005). In Finnish men aged 42–60 years, MetS prevalence was 7.4% (Everson et al. 1998), and in French males aged 35–64 years 23% (Marques-Vidal et al. 2002).

**Prevalence of metabolic syndrome in adolescents and young adults**

There are limited published data on the prevalence of MetS in younger populations (adolescents and young adults), especially in European populations. Moreover, comparisons between different studies are difficult, because a settled definition of MetS is nonexistent, especially in adolescents (Cook et al. 2003).

Regardless of the definition criteria, the surveys in different ethnic populations, age groups and pubertal stages suggest a MetS prevalence range of 1 to 15.5% among adolescents and young adults. Table 2 presents the studies examining MetS prevalence in adolescents and young adult populations aged 12- to 36- years.
Table 2. Metabolic syndrome prevalence in adolescent and young adult (12–36 years old) populations. Age stated as range, unless stated otherwise.

<table>
<thead>
<tr>
<th>Reference</th>
<th>Age (years)</th>
<th>N/Gender</th>
<th>Study period</th>
<th>Location</th>
<th>MetS prevalence (used definition)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Afkhami-Ardkani et al. (2010)</td>
<td>14 (mean)</td>
<td>932/M+F</td>
<td>1999–2000</td>
<td>Iran</td>
<td>7.4% (ATPIII), 3.5% (IDF), 4.1% (AHA)</td>
</tr>
<tr>
<td>Alvarez et al. (2006)</td>
<td>12–19</td>
<td>388/F</td>
<td>2003</td>
<td>Brazil</td>
<td>3.2% (modified ATPIII)</td>
</tr>
<tr>
<td>Cook et al. (2003)</td>
<td>12–19</td>
<td>2430/M+F</td>
<td>1988–1992 (NHANES III study)</td>
<td>U.S. Overall: 4.2% (ATPIII, modified by age); 6.1%/M 2.1%/F</td>
<td></td>
</tr>
<tr>
<td>Duncan et al. (2004)</td>
<td>12–19</td>
<td>991/M+F</td>
<td>1999–2000</td>
<td>U.S. Overall: 6.4% (ATPIII, modified by age); 9.1%/M, 3.7%/F</td>
<td></td>
</tr>
<tr>
<td>Ferguson et al. (2010)</td>
<td>18–20</td>
<td>839/M+F</td>
<td>2005–2007</td>
<td>Jamaica Overall: 1.2% (consensus); 0.5%/M, 1.7%/F</td>
<td></td>
</tr>
<tr>
<td>Ferreira et al. (2005)</td>
<td>36 (mean)</td>
<td>364/M+F</td>
<td>2003</td>
<td>the Netherlands Overall: 10.4% (ATPIII); 18.3%/M, 3.2%/F</td>
<td></td>
</tr>
<tr>
<td>Goodman et al. (2007)</td>
<td>12–19</td>
<td>1098/F</td>
<td>2001–2002</td>
<td>U.S. Overall: 3.4% (AHA), 4.5% (IDF)</td>
<td></td>
</tr>
<tr>
<td>Heriva et al. (2006)</td>
<td>31 (mean)</td>
<td>5999/M+F</td>
<td>1997–1998 (Cohort Northern Finland 1966)</td>
<td>Finland Overall: 5.8% (ATPIII); 6.8%/M, 4.8%/F</td>
<td></td>
</tr>
<tr>
<td>Mattsson et al. (2007)</td>
<td>32 (mean)</td>
<td>2182/M+F</td>
<td>2001</td>
<td>Finland Overall: 9.8% (EGIR), 13% (ATPIII), 14.3% (IDF)</td>
<td></td>
</tr>
<tr>
<td>Rodriguez-Moran et al. (2004)</td>
<td>10–18</td>
<td>965/M+F</td>
<td>appr. 2004</td>
<td>Mexico Overall: 6.5% (ATPIII), 7.7% (AACE), 4.5% (WHO), 3.8% (EGIR)</td>
<td></td>
</tr>
<tr>
<td>Saito et al. (2007)</td>
<td>15 (mean)</td>
<td>1446/M</td>
<td>appr. 2006</td>
<td>Japan Overall: 1.4% (ATP, modified by age)</td>
<td></td>
</tr>
<tr>
<td>Yoo et al. (2004)</td>
<td>30 (mean)</td>
<td>1181/M+F</td>
<td>(the Bogalusa heart study) 1995–1996</td>
<td>U.S. Overall: 12.0% (ATPIII); 15.5%/white M, 11.2%/African American M, 10.7%/white F, 10.0%/African American F</td>
<td></td>
</tr>
</tbody>
</table>

F = females, M = males
2.1.4 Mean values of independent cardiometabolic risk factors in young adults

Even though MetS provides a framework for studying the accumulation of cardiovascular risk factors, independent metabolic cardiovascular risk factors exist as well. Some of them are MetS components while others are not. However, they are all somehow related to MetS. Major independent risk factors for cardiovascular disease, according to the AHA are: high total cholesterol, high low-density-lipoprotein (LDL) cholesterol, low high-density lipoprotein (HDL) cholesterol, high triglyceride (TG), high blood pressure (BP), diabetes mellitus, advancing age, (abdominal) obesity and physical inactivity (Grundy et al. 1999).

In 2007, the mean total cholesterol, LDL-cholesterol, TG, and HDL-cholesterol in young Finnish male adults were 5.19 mmol/l, 3.28 mmol/l, 1.65 mmol/l, and 1.21 mmol/l, respectively (Raiko et al. 2010). The changes in total cholesterol, HDL-cholesterol and LDL-cholesterol have been favourable among young Finnish population during the past few decades, also among young adults (Raiko et al. 2010, Viikari et al. 2006). This has been suggested to be due to changes in population’s diet: between 2002 and 2007 the consumption of saturated fats declined and the proportion of polyunsaturated fatty acids increased in the Finnish diet (Raiko et al. 2010).

The mean systolic and diastolic blood pressure of young adults and adolescents has been reported to have decreased during the years 1980–2001 (Viikari et al. 2006), but after that, between 2001–2007, an increase in BP levels has been observed (Raiko et al. 2010). In 2007, the mean BP among young Finnish males was 126/79 mmHg. At the same time the mean waist circumference (WC) of young males was 94.4 cm showing an increasing trend between 2001 and 2007 (Raiko et al. 2010).

The use of diabetes medication among young Finnish males increased from 0.4% to 1.1% between the years 2001–2007 (Raiko et al. 2010).

2.1.5 Assessments of behavioural underlying factors of metabolic syndrome

Non-laborious underlying factors of MetS are excess body fat (especially visceral fat), physical inactivity and low fitness, especially aerobic fitness. All of these features are also independent risk factors for cardiovascular disease. However, assessing these risk factors is not necessarily simple and unambiguous,
particularly in epidemiological studies. Therefore, it is important to review the literature concerning the different assessment techniques of these non-laborious variables.

**Body composition and visceral fat**

An increased amount of adipose tissue in the visceral area is a strong predictor of morbidity and mortality, independent of BMI (Hayashi et al. 2004, Jacobs et al. 2010). Moreover, excess weight and weight gain during adolescence and adult life, even within the normal BMI range, significantly modify the individual’s risk for cardiovascular disease already at a young age (Berenson et al. 1998, Olshansky et al. 2005). Therefore, it is essential to assess the amount of body fat in addition to measuring weight and BMI.

Imaging methods such as magnetic resolution imaging (MRI) and computed tomography (CT) are considered the most accurate methods and gold standard in measuring body composition (Ross & Janssen 2005). However, both of these methods are expensive, not portable and time-consuming, and therefore often unsuitable for use in population level studies. In epidemiological studies, traditionally used methods for assessing body composition have been measurements of BMI, self-reported BMI, waist circumference, waist-to-hip-ratio and skinfold thicknesses. During recent years, bioimpedance analysis has also become a widely used method for body composition assessments in epidemiological studies.

Table 3 presents the commonly used methods for assessing body composition and fat distribution.
<table>
<thead>
<tr>
<th>Method</th>
<th>Description</th>
<th>Strengths</th>
<th>Limitations</th>
<th>Suitability for epidemiological studies</th>
</tr>
</thead>
<tbody>
<tr>
<td>Magnetic resonance imaging (MRI)</td>
<td>Cross-sectional scans of selected organs/tissues</td>
<td>Very high accuracy, no radiation.</td>
<td>High costs, high operator skills required, time consuming. Not suitable for morbidly obese.</td>
<td>-</td>
</tr>
<tr>
<td>Computed tomography (CT)</td>
<td>As MRI</td>
<td>Even higher accuracy than MRI.</td>
<td>Same limitations as in MRI.</td>
<td>-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Additionally radiation exposure.</td>
<td></td>
</tr>
<tr>
<td>Dual-energy x-ray absorptiometry (DEXA)</td>
<td>Provides estimates of fat-free mass (FFM), fat mass (FM), bone mineral density.</td>
<td>High accuracy, high reproducibility, increasing acceptance as a reference method.</td>
<td>High costs, some radiation (safe for children, but not for pregnant women), not portable.</td>
<td>+/-</td>
</tr>
<tr>
<td></td>
<td>Technique is based on the principle that two x-ray beams of different energies pass through the body and attenuate differentially by bone and soft tissue.</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Underwater weighing (densitometry)</td>
<td>Based on the fact that fat is less dense than water. Subject’s weight is measured in air as well as underwater. Fat percentage (Fat%) is calculated according to two-compartment model.</td>
<td>Has been considered as a gold standard.</td>
<td>Time-consuming, not suitable e.g. for children/older subjects, high requirement for co-operation of study subjects.</td>
<td>+/-</td>
</tr>
<tr>
<td>Skinfold thicknesses</td>
<td>Includes the measures of a double skin layer and the fat beneath it, commonly measured over for example biceps, triceps, and abdomen. Fat% is estimated by using measurements in prediction equations.</td>
<td>Suitable for large epidemiological studies, quick, and low in costs.</td>
<td>Does not provide opportunity to measure visceral fat. Difficult to measure severely obese subjects. Accuracy is not very high.</td>
<td>+</td>
</tr>
<tr>
<td>Method</td>
<td>Description</td>
<td>Strengths</td>
<td>Limitations</td>
<td>Suitability for epidemiological studies</td>
</tr>
<tr>
<td>---------------------------------------------</td>
<td>------------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>----------------------------------------------------------------------------</td>
<td>-----------------------------------------</td>
</tr>
<tr>
<td>Bioimpedance analysis (BIA)</td>
<td>Based on a resistance difference for fat and FFM. Lean body mass and water have low resistance. BIA estimates total body water and FM.</td>
<td>Relatively low in costs, portable, safe, and simple to use. No radiation.</td>
<td>Accuracy can be affected by body structure, BMI, hydration and disease status.</td>
<td>+</td>
</tr>
<tr>
<td>Dilution method (hydrometry)</td>
<td>Measures total body water using isotopes. Based on the principle that water exists in a relatively stable proportion FFM.</td>
<td>Simple, safe, relatively inexpensive. High accuracy.</td>
<td>Accuracy can be affected by hydration status, and illness.</td>
<td>+</td>
</tr>
<tr>
<td>Air-displacement plethysmography (ADP)</td>
<td>Uses air instead of water (i.e. in densitometry) displacement for measuring body volume and density.</td>
<td>Quick and more comfortable alternative to densitometry. Suitable also for children and older adults.</td>
<td>High cost, not portable</td>
<td>+</td>
</tr>
<tr>
<td>Waist circumference (WC) and waist-to-hip-ratio (WHR)</td>
<td>Indirect assessments of visceral adipose tissue. Validated against measures of abdominal fat by DXA and CT. Predict disease incidence and mortality.</td>
<td>Safe, quick, low in costs</td>
<td>Do not distinguish visceral fat and subcutaneous abdominal fat.</td>
<td>+</td>
</tr>
<tr>
<td>Body mass index (BMI)</td>
<td>Weight (kg) divided by square of height (m²). Validity against measures of abdominal fat by DEXA and CT. Predict disease incidence and mortality.</td>
<td>Safe, quick, low at costs</td>
<td>Does not distinguish FM and FFM, or visceral fat and subcutaneous abdominal fat.</td>
<td>+</td>
</tr>
<tr>
<td>Total body potassium (TBK)</td>
<td>Based on differences in potassium content between muscle and fat mass.</td>
<td>Reference measure of body cell mass.</td>
<td>High in cost. Not in use in clinical practice. (Völgyi 2010)</td>
<td>-</td>
</tr>
<tr>
<td>Neutron activation analysis (NAA)</td>
<td>Body elements such as calcium, sodium, chloride can be determined.</td>
<td>One of the most sophisticated methods available.</td>
<td>Requirements of high technology and skills, expensive, radiation. (Völgyi 2010)</td>
<td>-</td>
</tr>
</tbody>
</table>

BMI = body mass index  
Fat% = fat percentage  
FFM = fat-free mass  
FM = fat mass
Physical activity

Physical activity is defined as an increase of energy expenditure by performing any bodily movement (Caspersen et al. 1985). Daily energy expenditure consists of basal metabolic rate (50–70% of total energy expenditure), thermic effect of food (appr. 7–10%) and physical activity, which is the most variable component of total energy expenditure. Physical activity includes structured (such as sports, transportation and leisure) and non-structured activities (such as housework and movements of daily living). (Pettee et al. 2008)

Exercise is defined as planned, structured and repetitive bodily movements done in order to improve and/or maintain physical fitness (Caspersen et al. 1985). When differentiating between the terms physical activity and exercise, the latter is a type of physical activity, but not all physical activity is considered exercise (Pettee et al. 2008). For example, daily physical activities, such as child care and housework are not considered exercise.

There is a lack of a reasonable golden standard method for assess physical activity. Furthermore, an inconsistent use of the terms physical activity, exercise, and sports has contributed to confusion (Pettee et al. 2008).

Energy expenditure assessed by measurement of body heat production can be done directly or indirectly (Jequier et al. 1987). Direct measurement of energy expenditure is the most reliable measure of energy expenditure and physical activity. Direct calorimetry assesses energy expenditure by the amount of heat produced by an organism. Indirect measurements include assessment of oxygen consumption from which energy expenditure can be calculated. In addition, the doubly labelled water technique (Black et al. 1986) and labelled bicarbonate method (Elia et al. 1992) can be used for estimating energy expenditure. Physical activity can be assessed by a direct observation technique which is reliable and provides a possibility to code all movement types in a time unit. However, these assessments are not suitable for epidemiological studies.

Physical activity in epidemiological studies can be assessed by subjective measures. Physical activity logs collect information on the type, duration, and intensity of movement. Physical activity can also be assessed by pedometers, body-borne devices for measuring steps and/or distance. Single-site accelerometers, usually worn at the hip, which measure accelerations occurring during body movement are also used in assessing physical activity. Furthermore, heart rate monitoring can be used to predict energy expenditure during free-living physical activity. (Lee et al. 2009)
Fitness

Fitness is a set of attributes that people have or achieve (Caspersen et al. 1985). Being physically fit has been defined as “an ability to carry out daily tasks with vigour and alertness, without undue fatigue and with ample energy to enjoy leisure-time pursuits and to meet unforeseen emergencies” (Caspersen et al. 1985).

Physical fitness can be divided into two components: health- and skill-related fitness. Health-related fitness includes cardiorespiratory and muscular endurance, muscle strength, body composition and flexibility. Skill-related fitness includes agility, balance, coordination, speed, power and reaction time (Caspersen et al. 1985). All areas of physical fitness can be trained by exercising or being physically active.

Aerobic (=cardiorespiratory) fitness relates to how well the cardiorespiratory system works to transport and utilize oxygen in the body. Maximal oxygen uptake (VO\(_{2\text{max}}\)) can be defined as the highest level of oxygen consumption that is utilized by the body during peak physical exertion (American College of Sports Medicine 2000).

A direct measurement of maximal VO\(_2\text{max}\) and oxygen uptake corresponding to anaerobic threshold are accepted golden standard methods for measuring aerobic fitness (Farrell et al. 1979, Taylor et al. 1955). VO\(_2\text{max}\) (mlkg\(^{-1}\)min\(^{-1}\)) is a determination of the body’s maximal capacity to utilize oxygen during demanding work. These tests require highly trained staff and sophisticated equipment and are time-consuming and expensive, however. Thus, direct assessment of VO\(_2\text{max}\) or anaerobic threshold may not be possible in large population-based studies.

Several different indirect submaximal exercise tests have been developed for estimating VO\(_2\text{max}\) and they appear to provide very good estimations for VO\(_2\text{max}\). For example, the Canadian Aerobic Fitness (CAF) test correlates highly to treadmill VO\(_2\text{max}\) (r = 0.90) (Cox et al. 1992). During the CAF test, the respondents have to complete three-minute stepping stages (up and down steps with increasing intensity) one or more times. The test is completed when the subjects’ heart rate reaches 85% of their age-predicted maximal heart rate. Submaximal cycle ergometer test and McArdle submaximal step test (McArdle et al. 1981) are also examples of reliable estimates of VO\(_2\text{max}\) (Hartung et al. 1993). Furthermore, heart rate monitoring, based on the assumption of a linear relationship between VO\(_2\text{max}\) and heart rate, provides an assessment of aerobic fitness (Wilmore & Haskell 1971).
Field tests measure either the distance that is covered in a certain time or the time to reach a particular distance (Pettee et al. 2008). For example, a widely used test in the U.S. is the 1.5-miles (2.4 km) run test which provides a correlation of 0.95 with measured VO$_{2\text{max}}$ (Hartung et al. 1993). Other examples of field tests are the 12-minute Cooper running test (see the methods-section) and the 2-km walking test (UKK walk test) (Oja et al. 1991).

Furthermore, non-exercise models have been developed to be used in epidemiological studies to estimate VO$_{2\text{max}}$ without exercise testing (Jackson et al. 1990). Non-exercise models are based on self-filled questionnaires and they appear to predict VO$_{2\text{max}}$ accurately in most adults (constant error $<$ 1mlkg$^{-1}$min$^{-1}$) whose VO$_{2\text{max}}$ varies between 30 and 50 mlkg$^{-1}$min$^{-1}$ but with reduced accuracy at the extremes of fitness (VO$_{2\text{max}}$ $<$ 30 and $>$ 50 mlkg$^{-1}$min$^{-1}$) (Wier et al. 2006).

Muscular fitness tests are very specific to the muscle group tested, the type of contraction, the velocity of muscle movement, the type of equipment and the joint range of motion. No single test exists for evaluating total body muscular strength or endurance. The one repetition maximum, the greatest resistance that can be moved through the full range of motion has been standardized for dynamic strength assessment. Muscular endurance is the ability of a muscle group to execute repeated contractions over a period of time. (American College of Sports Medicine 2000)

### 2.2 Effects of physical activity on body composition and cardiometabolic risk factors

It is well established that regular exercise and increased physical activity have several beneficial effects on health. It improves cardiometabolic risk factors (Shaw et al. 2006), reduces the amount of adipose tissue (Shaw et al. 2006) and improves insulin sensitivity (Sigal et al. 2004).

#### 2.2.1 Effects of exercise on body composition and cardiovascular risk factors in general in adults

Most authors agree that regularity is more important than the type of exercise in promoting weight loss (Mannucci 2007). However, it is well established that especially aerobic type of exercise has beneficial effects on weight and body fat distribution in obese individuals (Boudou et al. 2003, Dumortier et al. 2003, Irwin et al. 2003, Mourier et al. 1997, Pritchard et al. 1997, Ross et al. 2000,
Strength training has been shown to have positive effects on body composition by increasing fat-free mass and reducing the amount of adipose tissue, but it does not typically decrease body weight (Donnelly et al. 2004).

Given that especially visceral fat is harmful for health, it is of note that strenuous physical training has been shown to result in greater reduction of visceral adipose tissue compared with subcutaneous adipose tissue (Mourier et al. 1997) even though weight loss in not necessarily observed (Pratley et al. 2000).

A report provided by U.S. National Institutes of Health suggests that physical activity or exercise has only a modest impact on the magnitude of weight loss (Jakicic et al. 2008). This report concluded that exercise alone interventions resulted in approximately only 2–3% weight loss. Together with diet, combined exercise provided only a limited amount of additional weight loss compared to diet only interventions (Jakicic et al. 2008).

A recent recommendation by the American College of Sports Medicine suggests 150–250 minutes of moderate physical activity per week to prevent weight gain (Donnelly et al. 2009). A generally recommended amount of physical exercise for healthy adults is moderate intensity physical exercise (such as walking) at least 2.5 hours per week or vigorous physical exercise (such as jogging) 1.5 hours per week. Additionally for all adults, strength training two times a week is recommended (U.S. Department of Health and Human Services 2008).

A large systematic review of the influence of exercise on abdominal fat was conducted in 2006 (Kay & Fiatarone Singh 2006). The weight change during the reviewed exercise trials varied from +0.2 kg to −7.5 kg, and the decrease in visceral fat between 4.4–48% (Boudou et al. 2003, Castaneda et al. 2002, Irwin et al. 2003, Mourier et al. 1997, Pritchard et al. 1997, Ross et al. 2000, Ross et al. 2004). The duration of the exercise interventions varied from 8 weeks to 12 months, all the trials including aerobic type of exercise, with one exception. In the study including resistance training only, the amount of weight gained was 0.2 kg and the amount of visceral fat did not change (Castaneda et al. 2002). It is noteworthy that all those studies were conducted among middle-aged or older subjects (over 43 years) and all the study subjects in those trials were overweight or obese, some of them diabetic patients.

In a large meta-analysis, aerobic training 3.7 times per week (corresponding energy expenditure being 1,000 kcal per week) resulted in an increase of HDL–cholesterol of 5% (Kodama et al. 2007). Similarly, a review article by Leon and Sanchez (2001) suggested aerobic exercise interventions to increase HDL–
cholesterol by 5%, and to decrease LDL- and TG-levels by 5 and 3.5%, respectively (Leon & Sanchez 2001). In those trials, the amount of exercise varied between 3–5 times per week, at least 30 minutes per session, corresponding on average to energy expenditure of 1,200–1,500 kcal per week. However, some of those studies also included dietary intervention in addition to physical exercise. Additionally, aerobic exercise interventions have been shown to result in decrease of 5 mmHg in systolic blood pressure (sBP) and 2 mmHg in diastolic blood pressure (dBP) (Cornelissen & Fagard 2005, Dickinson et al. 2006).

The effects of strength training on lipoproteins are less clear. In a meta-analysis (Kelley & Kelley 2009) strength training resulted in reduction of TG by 6.4%, but no change in HDL-cholesterol. In a systematic review by Tambalis et al. (Tambalis et al. 2009), the effect of strength training on lipoproteins remained inconsistent. In a meta-analysis by Cornelissen and Fagard, a strength training period (lasting on the average 16 weeks) resulted in reduction of sBP and dBP by 3 and 4 mmHg, respectively (Cornelissen & Fagard 2005).

### 2.2.2 Effects of exercise on body composition and visceral fat in young adults

Large population-based epidemiological cohorts about the effects of exercise on body composition in young healthy adults are all but lacking. The trials conducted during military service are presented in chapter 2.4.1. Examples of intervening trials dealing with the effects of exercise on body composition in healthy young adults are presented as follows.

A randomized controlled aerobic training intervention study enrolled 131 overweight or obese university students (aged 17–35 years) and lasted for 16 months. The intervention included 5 training sessions per week, the duration of each varying between 20–45 minutes and intensity 55–70% of maximal oxygen consumption, corresponding approximately to energy expenditure of 2,000 kcal per week. The intervention resulted in weight, visceral fat area, and fat mass reduction of 5.2 kg, 22.5 cm², and 4.9 kg, respectively, among male subjects (Donnelly et al. 2003). No significant change in lean body mass occurred.

In a study of 19 young healthy women completing an exercise intervention of 8 weeks including 3 weekly sessions of aerobic exercise, with an intensity of first ventilation threshold, each session lasting 60 minutes resulted in a mean weight loss of 1.5% and fat mass loss of 6.0% (Stasiulis et al. 2010). Furthermore, in a study of 33 professional, highly fit male rugby players (no control group) who
performed 4-week pre-season training (including both aerobic and strength training) a fat reduction of 1.4% and an increase in fat-free mass of 2.0 kg was detected (Argus et al. 2010).

In a group of 8 healthy, normal-weight Japanese women who participated in an exercise intervention lasting 7 months (including endurance exercise appr. 30 minutes 5 days a week, 60–70% of heart rate reserve), a reduction in fat mass and increase in lean body mass of 4 kg and 1 kg was detected, respectively (Kondo et al. 2006). Correspondingly, body fat percentage (fat%) decreased from 22.5 to 18.5%.

Even though it is commonly accepted that endurance training induces substantial alterations in total adiposity, resistance training has other advantages on body composition. In a study conducted in obese youth, a resistance training period of 12 weeks did not affect on amount of body fat or visceral fat, but increased lean body mass by 2.2 kg (Van Der Heijden et al. 2010).

In a study of 36 untrained 31-year-old men, the subjects were divided into 4 groups (Nybo et al. 2010), i.e., the control group, and the following three exercise groups: 1) a group that performed intense interval running, 2) a group that performed strength training and 3) a group that performed prolonged moderate intense continuous running. The first group trained 40 minutes per week and the other groups 150 minutes per week. The duration of the intervention was 12 weeks. The only group that achieved a decrease in fat% was the continuous running group. In that group, the body fat percentage decreased from 24.3±1.6 to 22.6±1.6, which was significantly lower than the pretraining value. In the other groups no significant change in the amount of body fat occurred. Correspondingly, the only group in which an increase in lean body mass occurred was the strength training group, in which the mean increase in total lean body mass was 1.8 kg (Nybo et al. 2010).

To summarize, among rather small subgroups of healthy young adults, the beneficial effect of aerobic exercise on the amount of body fat has been observed. Strength training does not affect the amount of body fat, but it increases the amount of muscle mass.

**2.2.3 Effects of exercise on cardiovascular risk factors in young adults**

A few training studies on cardiometabolic risk factors in healthy young adults exist and examples of their results are presented as follows.
An intervention of 19 young healthy women completing an exercise intervention of 8 weeks including 3 weekly sessions of aerobic exercise resulted in a increase of 17% in HDL level, and a decrease of 0.8% and 26% in LDL-cholesterol and TG levels, respectively (Stasiulis et al. 2010). In another study, a group of 21- to 36-year-old young men (n = 36, 20 assigned to an intervention group, and 16 to a control group) completed a high intensity training period (running) of 8 weeks which resulted in an increase in HDL-cholesterol (+0.2 mmol/l), but no changes in triglyceride levels were detected. The exercise intervention included interval training sessions 3 times a week (intensity 90% of maximal heart rate, approximately 423 kcal per session). (Musa et al. 2009)

Among a group of eight Japanese healthy, young, normal-weight women, an exercise intervention of seven months resulted in beneficial changes in cardiometabolic risk factors: HDL-cholesterol increased and LDL-cholesterol decreased by 4.7% and 2.4%, respectively (Kondo et al. 2006). Corresponding changes among 8 obese women were 24.7% and 14.3%, respectively (Kondo et al. 2006).

In a study conducted among obese men (n = 10, mean age 32.1 years), the study subjects completed an exercise intervention of 2 weeks, including 6 sessions of 4–6 repeats of 30-second anaerobic sprints, with 4–5-minute recovery between each repetition (i.e. interval type of aerobic exercise) (Whyte et al. 2010). The intervention resulted in a significant decrease of sBP (121±3mmHg vs 127±3mmHg).

To summarize, among small subgroups of healthy young adults, exercise interventions have been detected to result in increase in HDL-cholesterol and decrease in LDL-cholesterol, TG, and sBP levels.

2.3 Trends of prevalence of obesity and physical fitness in young adults

The prevalence of obesity and fatness has increased during the last few decades in Western countries in all age groups, including adolescents and young adults (Kautiainen et al. 2002, Ogden et al. 2006). Additionally, an increase in average body weight of 6–12% among young men entering military service has been observed for example in Norway (Dyrstad et al. 2005), Sweden (Rasmussen et al. 1999), Finland (Santtila et al. 2006) and the US (Sharp et al. 2002).

The combination of obesity together with decreasing physical activity and fitness is a major health concern. A decline in young adults’ fitness has been
observed. For example, in Norway and Finland the aerobic fitness of young men in military service has decreased by 8–12% over the past few decades (Dyrstad *et al.* 2005, Santtila *et al.* 2006). It has been assumed that sedentary lifestyle and physical inactivity provide an explanation for this trend. It has also been observed that daily television viewing (≥ 2 hours per day) is associated with poor muscular fitness in 19-year-old Finnish young adults (Paalanne *et al.* 2009).

### 2.4 Military service

In Finland, the national defence is based on the civic duty of military service. This duty is mandatory for all Finnish men and begins when a man turns 18, and continues until he reaches the age of 60. For women, military service is voluntary.

Every year approximately 25,000 men (80% of the age group) complete the Finnish military service, after which they remain in the reserve. The duration of the military service period is 12, 9, or 6 months, depending on training and tasks. Those trained to be officers and non-commissioned officers serve for 12 months, specialist troops serve for 9 or 12 months, and privates serve for a minimum period of 6 months. The obligation to enter into service begins at the age of 19, and may be postponed to the age of 29. Usually men enter military service at the age of 19 to 20.

Civilian service is an alternative for military service. Every year approximately 2,500 men complete the civilian service (362 days). Moreover, approximately 10% of the age group is exempted due to mental or psychological reasons that come up in medical examinations in preceding call-ups or during military service.

In addition to Finland, compulsory military service also occurs for example in Norway. In some other countries (e.g. the U.S.) military defence is based on recruited military service, when military trainees represent a more selected sample of a certain age group.

Military service is a unique environment which includes strict discipline, mandatory physical training, institutional feeding, group living as well as changes in sleeping habits. Military service can be considered an exercise training period, and studying military conscripts during compulsory military service provides a large, nearly population-based sample of young men for scientific purposes.
2.4.1 Dietary habits during military service

The recommended content of energy in the food served to every conscript daily by the military forces is 13.4–15.1 MJ (= 3,200–3,600 kcal), 30% of which consists of fat, 55% of carbohydrates, and 15% of proteins (Rehunen 1996). Service men take breakfast, lunch and dinner in the garrison. Additionally, they are allowed to buy food items in the garrison cafeteria or elsewhere. The service men are on leave from the garrison during evenings and on many weekends. It has been estimated that these optional food items make up ca. 25% of the daily energy intake of the service men (Bingham 2004). Diet during military service is not hypo- but rather hyperenergetic: the energy intake is about 25% higher than the energy need among civilian men of the same age (Rehunen 1996).

2.4.2 Physical training during military service

The amount of physical training during the 8-week basic training period at the beginning of military service corresponds on average to 4 hours of sports-related training (such as running, cross-country skiing, Nordic walking, strength training, swimming, recovery training) and a minimum of 8 hours of combat and march training per week (Santtila et al. 2008). After the basic training period, the amount of physical exercise depends on the tasks and type of training.

2.4.3 Effects of military service on weight, body composition, fitness, and cardiometabolic risk factors

When reviewing previous military studies, it is important to take into account whether they were conducted in setting of compulsory or recruited military service. Recruited service men may be more motivated and often selected than those in compulsory military service.

The military training period has been shown to result in beneficial changes in body composition and fat distribution (Croteau & Young 2000, Friedl et al. 2001, Lee et al. 1994, Mattila et al. 2009, Patton et al. 1980, Santtila et al. 2008). Especially those military service men who are initially most obese benefit from the lifestyle changes associated with military training (Friedl et al. 2001, Lee et al. 1994).

In the previous military studies, the military training period resulted in a mean weight loss of 3.1% (Croteau & Young 2000), or 1.1–16.1 kg (Lee et al. 1994).

In a study describing changes in body composition during the Finnish compulsory military service, a weight decrease of 2 kg, a decrease in fat mass (FM) of 3.2 kg and an increase in lean body mass of 1.2 kg during the first 3 months of the service (Mattila et al. 2009) was detected. These beneficial changes were partly lost during the next 3 months of training: the mean weight increased by 0.9 kg and FM by 0.8 kg compared to after the first 3 months of training (Mattila et al. 2009). The reductions in weight and FM are highlighted in conscripts in the highest BMI fourth (BMI > 26.4 kg\(\text{m}^{-2}\)): total weight and FM reduction of 6.2 kg and 6.2 kg, respectively, was detected. The lean body mass (LBM) level remained at the baseline level (Mattila et al. 2009). During the second 3-month period, they gained weight 0.6 kg in parallel with a slight decrease of FM (−0.09 kg) and increase of LBM (+0.97 kg) compared to the results after the first 3 months of training (Mattila et al. 2009).

Previous studies mostly suggest that military type of training results in improvements in aerobic fitness, even though some reports suggest unaltered (Daniels et al. 1979) or even decreased fitness (Dyrstad et al. 2006). The effects of recruited military service on aerobic fitness of the military trainees have mostly been reported to be beneficial. For instance, improvement in aerobic fitness has been reported to vary between 3.7 and 23% (Bell et al. 2000, Croteau & Young 2000, Kraemer et al. 2004, Patton et al. 1980, Popovich et al. 2000) during the U.S. military training period. Improved aerobic fitness has also reported to occur during military service in Singapore (Lim & Lee 1994) and Great Britain (Vogel et al. 1978, Williams 2005). Women have shown a more considerable improvement in fitness compared with men during military service (Bell et al. 2000, Patton et al. 1980).

Nonetheless, among highly fit U.S. male cadets aerobic fitness did not change during the 6-week basic training period (Daniels et al. 1979), and in some subgroups, aerobic fitness has even decreased: among Junior infantry soldier recruits, aerobic fitness decreased, while Junior Infantry leaders’ fitness improved in the British army (Legg & Duggan 1996).

Mixed responses for muscular strength have been also reported: In some studies, no change was seen in muscular endurance measures (Bell et al. 2000), whereas some reports suggest improved muscular fitness during the military service period (Kraemer et al. 2004).
Among conscripted Norwegian service men, physical fitness improved during the basic training period, but only in the poorest initial VO$_{2\text{max}}$ group (Dyrstad et al. 2006). It is noteworthy, that improvement decreased to baseline level already at the end of the military service period. The amount of physical exercise in Norwegian military service is at least 2 hours per week in at least 2 sessions, but actual physical training is suggested to be less than that required by regulations (Dyrstad et al. 2006).

In 140 conscripted Finnish military service men, a significant improvement in physical fitness level was detected: after 6 months of training, the result in the Cooper 12-minute running test increased by 150 meters (14%) and mean muscular fitness by 2.9 points (40%) (Mattila et al. 2009). The corresponding improvements were pronounced in the highest BMI group (BMI > 26.4 kg/m$^2$) being 250 meters and 3.31 points, respectively (Mattila et al. 2009).

Changes in metabolic variables during military service have rarely been investigated. However, in parallel with improvement in body composition, the basic training period of 13 weeks resulted in decreased total cholesterol and LDL-cholesterol of 2.9% and 22.4%, respectively, among 66 female U.S. marine trainees (Lieberman et al. 2008). Correspondingly, the increase in HDL-cholesterol was 3.7% (Lieberman et al. 2008). Also opposite data exist: in a Finnish military study, the military service period resulted in unfavourable increases in mean total cholesterol and LDL-cholesterol, even though a favourable increase in mean HDL-cholesterol was detected (Tähtinen et al. 2000).

### 2.5 Research gaps

Obesity has increased alarmingly during the past few decades. This phenomenon can already be seen in young adulthood. Consequently, obesity co-morbidities are a major public health concern all over the world. Therefore, an urgent need for population-based data about management of obesity and related metabolic disorders has come to prominence.

Even though some data exist about the prevalence of MetS in adolescents, only a few studies have focused on the prevalence of this cluster of cardiovascular risk factors in post-pubertal young adults. Especially population-based data about MetS prevalence in European young men according to the IDF criteria are needed.

The beneficial effects of physical activity and improvement of fitness on health are well established. Especially aerobic training is known to be crucial. However, most of the previous studies determining the effects of physical activity
and exercise on body composition, fat distribution and cardiometabolic risk factors have been conducted among older and obese adults. Hence, there is a lack of population-based data about the influence of physical fitness changes on body composition and cardiovascular risk factors in young healthy adults.
3 Purpose of the study

The purpose was to obtain data about early cardiometabolic risk factors in young men. Additionally, the aim of the present study was to increase knowledge about the effects of military training period on young men’s body composition, physical fitness and cardiometabolic health.

More specifically this study was to address the following questions:

1. What is the prevalence of metabolic syndrome in young Finnish military conscripts in different BMI categories?
2. How do the body composition and anthropometric characteristics of young men in different BMI categories change during the military training period?
3. What is the relation of body composition changes to aerobic fitness changes according to BMI during military service?
4. What is the association of the changes in cardiometabolic risk factors and physical fitness and fat distribution during military service?
4 Subjects and methods

4.1 Study population

In 2005, a total of 1,467 men attended military service in the Sodankylä Jaeger Brigade (67°N, 27°E), Finland. This garrison draws service men from a large area, mainly from northern Finland. Their mean age at the beginning of the service was 19.2 (SD 1.0 years, range 18 to 28 years). All service men were invited to participate in the present study, and 79% of them (n = 1,160) attended. They were all Caucasian in their ethnic background. Dropout was mainly caused by 140 conscripts who discontinued their service due to medical reasons. The dropout in Finnish military service was mainly caused by musculoskeletal problems (Taanila et al. 2011). The complete number of study subjects of whom paired data of fitness, body composition, anthropometry, and laboratory measurements were available varied between 945 and 1,137 depending on the measured parameter.

The length of military service depends on the tasks and type of military training. Of all study subjects 58% served for 6 months (privates), 9% for 9 months (privates in need of special knowledge and skills) and 33% for 12 months (officers, non-commissioned officers, and privates in need of special professional skills). More than half of the service men (51.6%) entered military service in January, and the rest in July 2005.

4.2 Study protocol

The data collection was conducted at the beginning and at the end of military service in the military hospital of Sodankylä Jaeger Brigade. Depending on the platoon’s schedule, the service men arrived for data collection between 5 a.m. and 2.15 p.m. During the assessments, the conscripts wore light clothing (t-shirt and shorts). The data were collected in an environmental temperature of 20–25°C (except for Cooper test). To avoid measurement errors in body composition analysis, the subjects spent at least 30 minutes indoors before the body composition analysis. Thus, their skin temperature had reached the plateau of thermoneutral level. The subjects were instructed to empty the urinary bladder before the measurements and not to participate in clinical examinations until two hours had passed after a meal. All the measurements were performed by trained assessors, nurses or physicians. Blood samples were taken by physicians or
trained (by professionals) medical assistants after an overnight fast prior to the other measurements (the blood samples were taken approximately between 5–7 a.m.).

4.3 Measurements

4.3.1 Anthropometrical measurements

Weight was measured in connection with the bioelectrical impedance assessment (BIA) analyses (see body composition analysis) at an accuracy of 0.1 kg. In the study of Article I, weight was recorded by scales with accuracy of 0.5 kg. Height was measured by a ruler attached to the wall with 0.5 cm accuracy. WC was defined as the smallest girth midway between the lowest rib and the iliac crest. Hip circumference was measured at the trochanter level. Waist-to-hip-ratio (WHR) was calculated by dividing waist circumference by hip circumference. Weight, height, WC and WHR were all measured once.

4.3.2 Blood pressure measurement

Blood pressure was measured using a validated digital automatic blood pressure monitor (Omron Healthcare, model HEM-757, Japan) after 10 minutes of resting in a sitting position. Blood pressure was measured by the trained observers. The blood pressure protocol (one measurement) of the defence forces was followed in those subjects who entered service in January. After that, two measurements (10 minutes’ rest between the two measurements) were conducted, and the mean value of those was used (O’Brien et al. 2001).

4.3.3 Body composition analysis

Body composition was analysed by segmental multifrequency-BIA (InBody720, Biospace, Korea), which is based on the resistance of conductance of currents at five specific frequencies (from 1 kHz to 1 MHz). The device operates by using a tetrapolar eight-point tactile electrode method. Resistance is measured from each of the four limbs and the trunk, considering the body parts as five cylinders. The instrument makes use of eight tactile electrodes: two are in contact with the palm and thumb of each hand, and two are in contact with anterior and posterior sole of
each foot. The body composition estimation by BIA is based on assessing total body water (TBW), protein, minerals and body fat.

The subjects’ personal data (measured height, gender and age) were entered into the BIA device. During the measurements the subjects were instructed to grab the hand electrodes of the machine with wet hands so that the thumb was placed on top of the handgrip, while the other fingers were holding the bottom of it. The subjects were asked to straighten their elbows, leaving some space between the armpits and the body (ca. 15 degree lateral abduction). During the measurements the subjects stood still on the foot electrodes in wet bare feet and were not allowed to talk. The duration of the measurement was approximately 1.5 minutes. The BIA device analysed the following parameters: fat percentage (fat %), fat mass (FM, kg), fat-free mass (FFM, kg), skeletal muscle mass (SMM, kg), lean body mass (LBM, kg) and visceral fat area (VFA, cm²).

The BIA method is especially suitable for large epidemiological studies since it is non-invasive, portable and low in cost. The accuracy of the method is high for assessing TBW (Bedogni et al. 2002). The BIA slightly underestimates the amount of fat mass (−1.56%) among normal-weight subjects and correspondingly overestimates it among overweight and obese subjects (0.58% and 3.4%, respectively) compared to the dual-energy x-ray absorptiometry (DEXA) method (Shafer et al. 2009). However, these errors cannot be considered biologically significant.

4.3.4 Biochemical measurements

Fasting blood samples from the antebrachial vein were taken by physicians or trained medical assistants after an overnight fast. Serum was separated from blood by centrifuging samples at 1500 x g for 15 minutes until cells and plasma or serum was separated. Serum was then immediately frozen at −20ºC.

Biochemical assessments were performed in the laboratory of Oulu Deaconess Institute by using commercially available hexokinase assay (glucose), homogeneous enzymatic test (HDL-cholesterol), enzymatic tests (total cholesterol), and enzymatic colorimetric test (triglyceride and LDL-cholesterol) (all the tests by Konelab™ analysers, Thermo Electron Oy, Vantaa, Finland) according to national quality standards.
4.3.5 Lifestyle assessments

**Physical activity**

Physical activity level was assessed at beginning of the military service by a questionnaire developed by NASA’s Johnson Space Centre (Jackson et al. 1990). The subjects were instructed to rate their physical activity on a 0–7 scale and asked to select one value that best represented their physical activity level during the previous month. The responses 0 and 1 represented no regular physical activity, 2 or 3 represented participation in regular moderate intensity activities, and 4 to 7 represented participation in regular vigorous physical activity (Matthews et al. 1999). Furthermore, a non-exercise model provides estimation for VO$_{2\text{max}}$ without exercise testing in large epidemiologic studies (Matthews et al. 1999).

**Smoking**

Smoking habits were assessed by a questionnaire. Study subjects answered the question “Are you currently smoking?” with six alternatives. Those who answered that they did not smoked at all or that they smoke on one day a week or more seldom were categorized as non-smokers. Those who reported smoking on 2–7 days a week were categorized as smokers.

4.3.6 Aerobic fitness

Aerobic fitness was assessed by using the 12-minute Cooper running test (Cooper 1968). The test provides a good estimation of VO$_{2\text{max}}$, the correlation coefficients being 0.84–0.92 relative to the maximal exercise and direct gas analyses (Cooper 1968, Grant et al. 1995).

The running test was performed outdoors and controlled by trained supervisors. The test timing and circumstances (except for weather) were standardized. Participants were instructed to run 12 minutes with a maximal effort, and the test result was reported by the distance run with 10 metres’ accuracy. Cooper test result $\geq$ 3,000 m equals very good, 2,600–2,999 m good, 2,200–2,599 m satisfactory, and < 2,200 m poor aerobic fitness.
Muscular fitness was measured by five tests in order to detect strength of abdominal and back muscles, the upper body, as well as explosive muscle strength. Participants were asked to perform as many repetitions of concentric muscle actions as possible during 60 seconds, with a 5-minute break for recovery between each component.

Abdominal (and hip flexor) muscle fitness was assessed by sit-ups: the subjects lay on the floor on their backs, hands behind the neck, knees bent at 90° angle while an assistant supported the ankles. The elbows were directed forward. During the movement, the upper body was elevated from the ground so that the elbows touched the knees. The result of the test was the number of sit-up-movements done in 60 seconds, and results were recorded to the accuracy of the nearest repetition. The test-retest reliability of the test is good (Alaranta et al. 1994)

Back muscle (and hip extensor) fitness was assessed by the back-up- test: the subjects lay on the floor face down with straightened legs, both hands behind the neck while the assistant supported the legs. The upper body was then elevated about 30 cm from the floor and then lowered down to the starting position. The result of the test was the number of movement repetitions conducted in 60 seconds recorded to the accuracy of the nearest repetition.

The upper body strength was measured by push-ups (pectoral muscles, arm- and shoulder-extensor muscles) and pull-ups (arm- and shoulder-flexor muscles). In the starting position the back and the legs are off the floor, while subject was leaning on his toes and the flat of the hands face down. Hands were kept shoulder-wide and at shoulder level. The legs were close to each other. The elbows were straight and fingers pointing forward. During the movement, the subject bent the elbows at a 90° angle while the body remained fixed and then straightened the elbows back to the starting position. The result was the number of push-ups completed in 60 seconds. The starting position of the pull-ups was with the subject gripping on the horizontal bar, hands shoulder-wide, while the body was suspended by extended arms. Then the body was pulled up by bending the elbows so that the chin crossed the bar. The movement was finished by lowering the body until the elbows and shoulders were fully extended. The result was the number of pull-ups completed in 60 seconds. The bar was situated at the height where the feet of the conscript did not reach the floor surface.
The explosive muscle strength of the lower limbs was tested by a standing long jump. The subjects stood still on the line marked on the floor, the legs near to each other. Then they took off and landed using both feet. Prior to the jump, the subjects swing their arms and bent their knees to provide power for the jump. The jump was performed twice. The result of the standing long jump test was recorded to the accuracy of the nearest 1 cm.

Muscular fitness was graded for each component (0 = poor, 1 = satisfactory, 2 = good, 3 = very good), and a sum of scores of individual components was calculated to determine the total muscle fitness index (MFI, 0–4 = poor, 5–8 = satisfactory, 9–12 = good and 13–15 = very good) (Santtila et al. 2006).

### 4.4 Metabolic syndrome

Identification of MetS was based on definitions given by the IDF and ATPIII. The criteria of the components of MetS are described in chapter 2.1.2. in the literature review of this thesis.

### 4.5 Statistical analysis

The prevalence of MetS and its components was calculated according to four BMI categories. The BMI (kgm$^{-2}$), according to the criteria and classification provided by the WHO, was categorized as underweight (BMI < 18.5 kgm$^{-2}$), normal weight (BMI 18.5–24.9 kgm$^{-2}$), overweight (BMI > 25–29.9 kgm$^{-2}$), and obese (BMI ≥ 30 kgm$^{-2}$). The degree of agreement between those two definitions of MetS was determined with use of the “kappa coefficient”. (Article I)

Body composition, physical fitness and cardiometabolic risk factors were presented as mean and standard deviation (SD) or range. Paired t-test was used to evaluate the difference between mean values at baseline and in the end of the military service for body composition, fitness and cardiometabolic risk factors. (Articles II, III, IV).

Differences in anthropometry and body composition variables between different BMI groups as well as between the reported physical activity groups (no, moderate, high intensity) were tested by ANCOVA, adjusting for age, branch of service and duration of the military service period. After performing the ANCOVA, pairwise comparisons in anthropometry and body composition were performed where the normal-weight subjects and those reporting high intensity previous physical activity were considered as control groups. Adjusting for
multiple comparisons was performed using Dunnett post hoc test. (Articles II and III)

Associations between changes in body composition parameters and the Cooper test result were examined by bivariate (Pearson’s) correlation test. Linear regression analyses were used to examine the effects of body composition change and Cooper test result. The possible association between body composition and BMI categories was added to the regression model to investigate whether the change in body composition and Cooper test results have a different association according to the BMI categories. The following variables were controlled in the regression model: service period (entire study population), branch of service (entire study population) and age. The results are presented separately for the 6-month training and for the entire population, with the training group period ranging from 6 to 12 months. (Article III)

Associations between changes in dependent and independent variables (change in weight, VFA, Cooper test or MFI) were assessed by Pearson correlation coefficients. Linearity assumptions of the model were checked by means of standard scatter plots, with linear and nonlinear fit. Associations between the changes in weight, aerobic fitness, blood pressure and serum lipoproteins were linear (data not shown), and therefore linear regression analysis was applied in the subsequent statistical analysis. (Article IV)

Multivariate linear regression analysis, adjusting for length of service, smoking and baseline value of the independent variable, was used to estimate the association of independent variables with the dependent variables. A change in aerobic and muscular fitness as independent variables was adjusted by change in weight and vice versa. (Article IV)

The statistical analyses were performed by using SAS version 9.1 (Article I), and version 9.1.3 (Articles II, III and IV) for Windows (SAS Institute Inc., Gary, NC).

4.6 Ethical consideration

Prior the study, all servicemen have been briefed and informed about the aims and the course of the study both orally and in writing. All participants gave their written consent for using data for scientific purposes. All collected data were stored confidentially at the Institute of Health Sciences, University of Oulu. The study protocol was approved by the Ethics Committee of Lapland Central Hospital, Rovaniemi, Finland.
5 Results

5.1 Baseline characteristics of the study subjects (Articles I-IV)

Table 4 presents the anthropometrical measurements, cardiometabolic risk factors, and physical fitness of the study population at the beginning of the military service. At the baseline, the subjects’ mean height was 177 cm.

Table 4. Characteristics of the cohort at the beginning of the military service. All values are mean (standard deviation), unless stated otherwise.

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Baseline</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>1070</td>
<td>19.3 (1.0)</td>
</tr>
<tr>
<td>Weight (kg) (mean, range)</td>
<td>1070</td>
<td>75.1 (47.2–140.0)</td>
</tr>
<tr>
<td>Body mass index (kg/m^2) (mean, range)</td>
<td>1070</td>
<td>23.9 (16.3–46.0)</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>1056</td>
<td>81.6 (10.2)</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>1060</td>
<td>128.8 (13.5)</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>1061</td>
<td>69.8 (9.8)</td>
</tr>
<tr>
<td>Total cholesterol (mmol/l)</td>
<td>998</td>
<td>3.89 (0.83)</td>
</tr>
<tr>
<td>LDL-cholesterol (mmol/l) (mean, SD)</td>
<td>986</td>
<td>2.23 (0.74)</td>
</tr>
<tr>
<td>HDL-cholesterol (mmol/l)</td>
<td>998</td>
<td>1.29 (0.30)</td>
</tr>
<tr>
<td>Triglycerides (mmol/l)</td>
<td>1000</td>
<td>0.79 (0.36)</td>
</tr>
<tr>
<td>Cooper test (m) (mean, range)</td>
<td>1146</td>
<td>2482 (1000–3910)</td>
</tr>
<tr>
<td>Muscle fitness index (points)</td>
<td>1137</td>
<td>8.0 (1–15)</td>
</tr>
</tbody>
</table>

5.2 The prevalence of the metabolic syndrome among young Finnish males (Article I)

According to the IDF criteria, the overall prevalence of MetS was 6.8% (75/1099) at the beginning of the military service. Correspondingly, the prevalence of MetS was 8.8% (24/274) and 55.4% (51/92) in overweight and obese subjects, respectively. The prevalence and concentrations of the different components of the MetS, according to the IDF definition by BMI categories, are presented in table 5.

According to the MetS definition provided by ATPIII, the overall prevalence of MetS was 3.5% (39/1099). Correspondingly, among overweight and obese service men the prevalence amounted to 3.3% (9/274) and 27.2%, respectively (Table 6).
Table 5. The prevalence of the metabolic syndrome (IDF criteria) and its components in Finnish military conscripts by four body mass index (BMI) categories. Mean (95% confidence interval, CI). (Article I, published by permission of Elsevier).

<table>
<thead>
<tr>
<th>BMI (kg/m(^2)) categories</th>
<th>Waist circumference ≥ 94 cm</th>
<th>Fasting plasma glucose ≥ 5.6 mmol/l</th>
<th>Triglyceride &gt; 1.7 mmol/l</th>
<th>HDL-cholesterol &lt; 1.04 mmol/l</th>
<th>Blood pressure ≥ 130/85 mmHg</th>
<th>Metabolic syndrome n % n</th>
</tr>
</thead>
<tbody>
<tr>
<td>&lt; 18.5 (n = 31)</td>
<td>-</td>
<td>4</td>
<td>12.9</td>
<td>0</td>
<td>6</td>
<td>19.4</td>
</tr>
<tr>
<td>18.5–24.9 (n = 702)</td>
<td>2</td>
<td>0.3</td>
<td>17.9</td>
<td>7</td>
<td>1.0</td>
<td>12.8</td>
</tr>
<tr>
<td>25–29.9 (n = 274)</td>
<td>48</td>
<td>17.5</td>
<td>59</td>
<td>13</td>
<td>4.7</td>
<td>26.6</td>
</tr>
<tr>
<td>≥ 30 (n = 92)</td>
<td>84</td>
<td>91.3</td>
<td>33</td>
<td>11</td>
<td>12.0</td>
<td>46.7</td>
</tr>
<tr>
<td>All (1099)</td>
<td>134</td>
<td>12.2</td>
<td>221</td>
<td>31</td>
<td>2.8</td>
<td>19.3</td>
</tr>
</tbody>
</table>

(1.1–24.7) (5.4–33.3) (41.2–48.5) (10.3–15.2) (58.6–69.9) (5.4–12.1) (58.6–69.9) (36.5–56.9) (64.9–82.9) (45.3–65.6)
Table 6. The prevalence of the metabolic syndrome (ATPIII criteria) and its components in Finnish military conscripts by four body mass index (BMI) categories. (Article I, published by permission of Elsevier).

<table>
<thead>
<tr>
<th>BMI (kg/m²) categories</th>
<th>Waist circumference ≥ 102 cm</th>
<th>Fasting plasma glucose ≥ 6.1 mmol/l</th>
<th>Triglyceride &gt; 1.7 mmol/l</th>
<th>HDL-cholesterol &lt; 1.04 mmol/l</th>
<th>Blood pressure ≥ 130/85 mmHg</th>
<th>Metabolic syndrome</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>n</td>
<td>% (95% CI)</td>
<td>n</td>
<td>% (95% CI)</td>
<td>n</td>
<td>% (95% CI)</td>
</tr>
<tr>
<td>&lt; 18.5 (n = 31)</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6</td>
<td>19.4</td>
</tr>
<tr>
<td>18.5–24.9 (n = 702)</td>
<td>-</td>
<td>0</td>
<td>14</td>
<td>2.0</td>
<td>7</td>
<td>1.0</td>
</tr>
<tr>
<td>25–29.9 (n = 274)</td>
<td>2</td>
<td>0.7</td>
<td>8</td>
<td>2.9</td>
<td>13</td>
<td>4.7</td>
</tr>
<tr>
<td>≥30 (n = 92)</td>
<td>49</td>
<td>53.3</td>
<td>3</td>
<td>3.3</td>
<td>11</td>
<td>12.0</td>
</tr>
<tr>
<td>All (1099)</td>
<td>51</td>
<td>4.6</td>
<td>25</td>
<td>2.3</td>
<td>31</td>
<td>2.8</td>
</tr>
</tbody>
</table>

CI = confidence interval.
The prevalence of MetS according to both definitions increased in parallel with increasing BMI (Tables 5 and 6). Also the levels of MetS components increased in parallel with increasing BMI, with the exception of HDL-cholesterol, which decreased, i.e. got worse (Tables 5 and 6).

For the whole study population, the proportion of the agreement regarding the number of MetS cases identified either with IDF or ATPIII criteria alone was moderate, the kappa-value being 0.48 (95% CI, 0.37–0.60). The IDF identified 74.4% of those who had MetS according to the ATPIII definition.

Various combinations of components by which the subjects fulfilled the criteria of MetS (according to IDF and ATP III criteria) are presented in detail in Table 7. Assuming abdominal obesity and using IDF criteria, the most common combinations, comprising 80% (60/75) of all cases of MetS, were HDL-cholesterol + blood pressure, glucose + blood pressure, and glucose + HDL-cholesterol + blood pressure. The corresponding combinations according to ATP III criteria were waist circumference + HDL-cholesterol + blood pressure, triglycerides + HDL-cholesterol + blood pressure, waist circumference + triglycerides + HDL-cholesterol + blood pressure, covering 79% (31/39) of the MetS cases.
Table 7. The number of subjects who fulfilled the criteria of metabolic syndrome (IDF and ATPIII criteria) based on different combinations of the components. (Article I, published by permission of Elsevier).

<table>
<thead>
<tr>
<th>Number of subjects</th>
<th>Waist circumference</th>
<th>Components of metabolic syndrome</th>
<th>IDF</th>
<th>ATPIII</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Fasting plasma glucose</td>
<td>Serum triglycerides</td>
<td>Serum HDL-cholesterol</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>20</td>
<td>1</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>13</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>5</td>
<td>6</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>-</td>
<td>1</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
<tr>
<td>27</td>
<td>17</td>
<td>Yes</td>
<td>Yes</td>
<td>Yes</td>
</tr>
</tbody>
</table>

| 1                  | -                   | Yes                      | Yes | Yes   | Yes |
| -                  | 1                   | Yes                      | Yes | Yes   | Yes |
| -                  | 3                   | Yes                      | Yes | Yes   | Yes |
| -                  | 8                   | Yes                      | Yes | Yes   | Yes |

1 ≥ 94 cm and ≥ 102 cm according to IDF and ATPIII criteria, respectively
2 ≥ 5.6 mmol/l and ≥ 6.1 mmol/l cm according to IDF and ATPIII criteria, respectively
3 serum triglycerides > 1.7 mmol/l, serum HDL-cholesterol < 1.04 mmol/l and blood pressure ≥ 130/85 mmHg.

5.3 Body composition, physical activity, and physical fitness of the young men entering military service (Articles I, II and III)

Prevalence of overweight and obesity was 25% (274/1099) and 8% (92/1099), respectively. Furthermore, 3% (31/1099) of the subjects were underweight and 64% (702/1099) were of normal weight.

At the beginning of the military service, no previous physical activity was reported by 32% (n = 24) of obese, 18% (n = 43) of overweight, 15% (n = 97) of normal-weight, and by 11% (n = 4) of underweight men. Practicing moderately regular physical activity was most often reported by underweight men (35%, n = 13), followed by obese (28%, n = 21), overweight (26%, n = 60) and normal-weight (25%, n = 161) subjects. Normal-weight men reported most often being engaged in regular vigorous physical activity (60%, n = 394), followed by
overweight (56%, n = 1319), underweight (n = 51%, n = 19) and obese (41%, n = 31) men.

The mean Cooper test result at the beginning of the military service was 2,482 metres (range 1,000–3,910), equalling satisfactory result. The mean muscular fitness index was 8 points, equalling satisfactory result.

5.4 Changes in anthropometrical measures and body composition during military service (Articles II, III, IV)

The changes in anthropometrical measures during military service are presented in Table 8. In general, the mean body weight decreased during the military service. Among overweight and obese conscripts, a clinically relevant reduction in weight and BMI was observed (Table 8). In contrast, the mean body weight and BMI increased in the groups of underweight and normal-weight men.
Table 8. Anthropometric characteristics of the study subjects (n = 1,003) by BMI categories. The values at baseline and their changes during military service. (Article II, published by permission of Wolters Kluwer Health).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline</th>
<th>Change</th>
<th>% Change</th>
<th>Paired t-test p-value for change</th>
</tr>
</thead>
<tbody>
<tr>
<td>All, n = 1003</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>75.1 (13.7)</td>
<td>0.5 (5.2)</td>
<td>−0.7</td>
<td>0.0029</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>81.6 (10.2)</td>
<td>0.1 (5.8)</td>
<td>0.1</td>
<td>0.7293</td>
</tr>
<tr>
<td>WHR</td>
<td>0.85 (0.05)</td>
<td>−0.04 (0.05)</td>
<td>0</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>BMI</td>
<td>23.9 (4.0)</td>
<td>−0.3 (1.7)</td>
<td>−1.7</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>BMI &lt; 18.5 kgm−2, N = 37</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>55.1 (4.3)</td>
<td>3.7 (2.6)b</td>
<td>6.9</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>68.1 (4.0)</td>
<td>−3.8 (3.9)</td>
<td>5.6</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>WHR</td>
<td>0.78 (0.02)</td>
<td>−0.02 (0.05)</td>
<td>0</td>
<td>0.4142</td>
</tr>
<tr>
<td>BMI</td>
<td>17.8 (0.6)</td>
<td>1.1 (0.9)b</td>
<td>6.2</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>BMI 18.5–24.9 kgm−2 n = 655</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>69.3 (7.2)</td>
<td>1.3 (3.4)</td>
<td>1.9</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>77.2 (5.4)</td>
<td>−1.5 (4.5)</td>
<td>1.9</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>WHR</td>
<td>0.83 (0.03)</td>
<td>−0.03 (0.05)</td>
<td>0</td>
<td>0.0091</td>
</tr>
<tr>
<td>BMI</td>
<td>21.9 (1.6)</td>
<td>0.3 (1.1)</td>
<td>1.4</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>BMI 25–29.9 kgm−2 n = 235</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>84.5 (7.8)</td>
<td>−3.7 (5.1)b</td>
<td>−4.4</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>88.5 (6.0)</td>
<td>−2.3 (6.3)b</td>
<td>−2.6</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>WHR</td>
<td>0.89 (0.03)</td>
<td>−0.05 (0.05)b</td>
<td>0</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>BMI</td>
<td>27.1 (1.4)</td>
<td>−1.4 (1.6)b</td>
<td>−4.8</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>BMI ≥30 kgm−2 n = 76</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>106.1 (11.8)</td>
<td>−8.2 (6.9)b</td>
<td>−7.7</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>WC (cm)</td>
<td>105.1 (7.5)</td>
<td>−7.0 (6.9)b</td>
<td>−6.6</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>WHR</td>
<td>0.96 (0.05)</td>
<td>−0.06 (0.04)b</td>
<td>−10.0</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>BMI</td>
<td>33.5 (3.1)</td>
<td>−2.9 (2.1)b</td>
<td>−8.7</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

a = Global test for anthropometry by BMI categories; weight F(3,969) = 163, p < 0.0001, WHR F = 2.4, p < 0.0001, Waist F = 89, p < 0.0001, BMI F = 183.3, p < 0.0001
b = Pairwise comparisons for anthropometrical parameters by BMI categories (p < 0.05) compared to the reference group (normal BMI 18.5–24.9 kg/m²)
BMI = body mass index, SD = standard deviation, WC = waist circumference, WHR = waist-to-hip-ratio,

During the military service, the mean value of FM and VFA of all men decreased. (Table 9). At the same time, FFM increased. In the group of underweight men, FM increased by 44.2%. Although the overall amount of fat tissue increased, VFA decreased by 38.1% among the underweight men, who also gained the largest
amount of lean tissue during the military service compared with other groups. FM and VFA decreased markedly in the groups of overweight and obese men. The increase in FFM did not differ markedly from the other BMI groups (except for underweight men). Overall, the reduction in VFA did not differ markedly between BMI groups (Table 9).

Table 9. Body composition of the young men (n = 1,003) by body mass index (BMI) categories (kgm\(^{-2}\)) at the beginning of military service and the changes in the body composition variables during military service. Values are presented as mean (SD).

<table>
<thead>
<tr>
<th>Variable</th>
<th>Beginning Mean (SD)</th>
<th>Change Mean (SD)</th>
<th>% Change</th>
<th>Paired t-test p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>All, n = 1003</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FM (kg)</td>
<td>13.4 (9.1)</td>
<td>-1.3 (4.7)</td>
<td>-9.7</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>FFM (kg)</td>
<td>61.7 (7.3)</td>
<td>0.8 (2.5)</td>
<td>1.3</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>VFA (cm(^2))</td>
<td>65.5 (50.3)</td>
<td>-28.3 (33.2)</td>
<td>-43.4</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>BMI &lt; 18.5, n = 37(^a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FM (kg)</td>
<td>4.3 (2.0)</td>
<td>1.9 (1.8)</td>
<td>44.2</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>FFM (kg)</td>
<td>50.8 (4.3)</td>
<td>1.9 (2.0)</td>
<td>3.5</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>VFA (cm(^2))</td>
<td>18.9 (15.7)</td>
<td>-7.2 (15.1)</td>
<td>-38.1</td>
<td>0.0064</td>
</tr>
<tr>
<td>BMI 18.5–24.9, n = 655(^a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FM (kg)</td>
<td>9.1 (3.7)</td>
<td>0.3 (2.9)</td>
<td>4.4</td>
<td>0.0028</td>
</tr>
<tr>
<td>FFM (kg)</td>
<td>60.2 (6.2)</td>
<td>0.9 (2.4)</td>
<td>1.5</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>VFA (cm(^2))</td>
<td>44.1 (28.4)</td>
<td>-19.3 (26.1)</td>
<td>-44.0</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>BMI 25–29.9, n = 235(^a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FM (kg)</td>
<td>19.5 (5.1)</td>
<td>-4.0 (4.6)(^b)</td>
<td>-20.5</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>FFM (kg)</td>
<td>65.1 (6.4)</td>
<td>0.3 (2.3)</td>
<td>0.5</td>
<td>0.0306</td>
</tr>
<tr>
<td>VFA (cm(^2))</td>
<td>98.6 (34.6)</td>
<td>-43.8 (32.6)(^b)</td>
<td>-44.4</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>BMI ≥ 30, n = 76(^a)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FM (kg)</td>
<td>35.8 (8.1)</td>
<td>-8.9 (6.1)(^b)</td>
<td>-24.9</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>FFM (kg)</td>
<td>70.0 (7.4)</td>
<td>0.8 (2.9)</td>
<td>1.1</td>
<td>0.0137</td>
</tr>
<tr>
<td>VFA (cm(^2))</td>
<td>170.7 (56.5)</td>
<td>-68.5 (45.3)(^b)</td>
<td>-40.1</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

\(^a\)Global test for the difference in body composition parameters by BMI categories: FFM F = 3.2, P < 0.024; FM F = 198, P < 0.0001; VFA F = 89.2, P < 0.0001

\(^b\)Pairwise comparisons for body composition parameters by BMI categories (P < 0.05) compared with control group (normal BMI 18.5–24.9 kgm\(^{-2}\)). BMI = Body mass index, FM = Fat mass, FFF = Fat-free mass, VFA = Visceral fat area.

The effects of previous physical activity on changes in body composition were the most considerable in the group of overweight men (Figure 1 and Table 10). Among those overweight men who reported no previous physical activity, weight,
FM and VFA were reduced more compared with those who reported exercising vigorously (Table 10). In under- and normal-weight young men reporting regular vigorous physical activity, the VFA was reduced less during military training compared to those who reported no physical activity prior to military service in the corresponding BMI groups (Figure 1). There were no marked changes in body composition between the smokers and non-smokers.
Table 10. Body composition at the beginning of military service and body composition changes during military service in different body mass index (BMI) and previous physical activity (no, moderate, high) groups. (Article II, Published by permission of Wolters Kluwer Health).

<table>
<thead>
<tr>
<th>Variable by BMI categories</th>
<th>BMI &lt; 18.5 kg/m²</th>
<th>BMI 18.5–24.9 kg/m²</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>No</td>
<td>Moderate</td>
</tr>
<tr>
<td></td>
<td>n</td>
<td>Beginning Mean (SD)</td>
</tr>
<tr>
<td>Weight²₃ (kg)</td>
<td>4</td>
<td>55.5 (7.5)</td>
</tr>
<tr>
<td>FM²₃ (kg)</td>
<td>4</td>
<td>3.6 (1.7)</td>
</tr>
<tr>
<td>FFM²³ (kg)</td>
<td>4</td>
<td>51.9 (6.0)</td>
</tr>
<tr>
<td>VFA²₃ (cm²)</td>
<td>4</td>
<td>15.8 (8.6)</td>
</tr>
</tbody>
</table>

For BMI < 18.5 kg/m²:
- Weight (kg): 4, Mean: 55.5, SD: 7.5, Change: 3.0, SD: 1.8, Paired t-test p-value: 0.0049.
- FM (kg): 4, Mean: 3.6, SD: 1.7, Change: 1.4, SD: 2.5, Paired t-test p-value: 0.0592.
- FFM (kg): 4, Mean: 51.9, SD: 6.0, Change: 1.7, SD: 1.8, Paired t-test p-value: 0.1641.
- VFA (cm²): 4, Mean: 15.8, SD: 8.6, Change: −10.6, SD: 8.3, Paired t-test p-value: 0.0831.

For BMI 18.5–24.9 kg/m²:
- Weight (kg): 97, Mean: 68.6, SD: 3.3, Change: 1.1, SD: 1.6, Paired t-test p-value: 0.0014.
- FM (kg): 97, Mean: 9.3, SD: 2.8, Change: 0.3, SD: 2.2, Paired t-test p-value: 0.364.
- FFM (kg): 97, Mean: 59.3, SD: 6.1, Change: 0.9, SD: 1.5, Paired t-test p-value: 0.0002.
- VFA (cm²): 97, Mean: 48.4, SD: 27.2, Change: −22.9, SD: 23.4, Paired t-test p-value: <0.001.
<table>
<thead>
<tr>
<th>Variable by BMI categories</th>
<th>No</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>n Beginning</td>
<td>Mean (SD)</td>
<td>Change</td>
<td>%</td>
</tr>
<tr>
<td>Weight</td>
<td>43</td>
<td>84.2 (8.2)</td>
<td>-4.3</td>
</tr>
<tr>
<td>(kg)</td>
<td></td>
<td>43</td>
<td>20.5 (4.6)</td>
</tr>
<tr>
<td>FM</td>
<td>43</td>
<td>63.7 (6.6)</td>
<td>0.4</td>
</tr>
<tr>
<td>(kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VFA</td>
<td>43</td>
<td>106.7 (30.5)</td>
<td>-49.4</td>
</tr>
<tr>
<td>(cm²)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

BMI > 30 kg/m²

<table>
<thead>
<tr>
<th>Variable by BMI categories</th>
<th>No</th>
<th>Moderate</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>n Beginning</td>
<td>Mean (SD)</td>
<td>Change</td>
<td>%</td>
</tr>
<tr>
<td>Weight</td>
<td>24</td>
<td>107.7 (14.0)</td>
<td>-8.8</td>
</tr>
<tr>
<td>(kg)</td>
<td></td>
<td>24</td>
<td>38.4 (9.8)</td>
</tr>
<tr>
<td>FM</td>
<td>24</td>
<td>69.3 (6.9)</td>
<td>0.8</td>
</tr>
<tr>
<td>(kg)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>VFA</td>
<td>24</td>
<td>190.1 (77.8)</td>
<td>-78.5</td>
</tr>
<tr>
<td>(cm²)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

a = within reported previous physical activity and BMI (global test)
b = pairwise comparisons in body composition between reported previous physical activity (control group high physical activity)
c1 = within differences in group of no physical activity by BMI
c2 = within difference in group of moderate physical activity by BMI
c3 = within difference in group of high physical activity by BMI
d = pairwise comparisons between BMI categories, p < 0.05 (control group normal BMI 18.5–24.9 kg/m²)
Fig. 1. Changes in body composition by BMI categories during military service. Values represented as means (standard deviation). (Article II, published by permission of Wolters Kluwer Health).
5.4.1 Changes in aerobic and muscular fitness during military service (Articles III, IV)

When examining the entire study population (n = 945), the result in the Cooper test improved by 6.8% (169 m) during the 6–12-month military service period (Table 11). During the 6-month training period, the underweight men improved the Cooper test result on average by 108 m, the normal weight men by 199 m, overweight men by 268 m, and obese men by 281 metres. A similar improvement in the Cooper test according to BMI categories was observed for the entire study population (all the service men; 6–12 months’ of service). The mean muscle fitness index at baseline was 8.0 points (range 1–15) and improved by 1.5 points (SD 2.3) in all service men.

Table 11. Cooper test results (distance in metres) of the study subjects by BMI categories measured at the beginning and the end of military service for those who served 6 months and in all subjects (6–12-months’ service).

<table>
<thead>
<tr>
<th>Duration of the military service</th>
<th>n</th>
<th>Baseline mean (SD)</th>
<th>Change mean (SD)</th>
<th>% Change</th>
<th>Paired t-test p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>6 months</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All 543</td>
<td></td>
<td>2410.0 (346.4)</td>
<td>218.7 (271.0)</td>
<td>9.1</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Underweight 23</td>
<td></td>
<td>2592.2 (317.9)</td>
<td>108.3 (268.0)</td>
<td>4.2</td>
<td>0.0656</td>
</tr>
<tr>
<td>Normal weight 343</td>
<td></td>
<td>2508.6 (316.8)</td>
<td>198.7 (279.6)</td>
<td>7.9</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Overweight 131</td>
<td></td>
<td>2272.4 (283.6)</td>
<td>268.4 (260.7)</td>
<td>11.8</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Obese 46</td>
<td></td>
<td>1975.9 (249.4)</td>
<td>280.7 (195.7)</td>
<td>14.2</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>6 –12 months (months)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All men 945</td>
<td></td>
<td>2501.9 (364.6)</td>
<td>169.0 (259.3)</td>
<td>6.8</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Underweight 35</td>
<td></td>
<td>2635.7 (281.8)</td>
<td>93.1 (231.5)</td>
<td>3.5</td>
<td>0.0230</td>
</tr>
<tr>
<td>Normal 624</td>
<td></td>
<td>2602.4 (335.1)</td>
<td>142.7 (263.3)</td>
<td>5.5</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Overweight 218</td>
<td></td>
<td>2346.5 (300.6)</td>
<td>223.9 (252.7)</td>
<td>9.5</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Obese 68</td>
<td></td>
<td>2009.0 (260.5)</td>
<td>273.3 (197.1)</td>
<td>13.6</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

The Cooper test change during the military service was associated with changes in body weight (r = 0.241, p < 0.0001), waist circumference (r = 0.189, p < 0.0001), FM (r = 0.213, p < 0.0001), FFM (r = 0.101, p = 0.0018), and VFA (r = -0.416, p < 0.0001) during the first 6 months of service. Similar associations were observed for the entire study population, 6–12-month service: weight (r = -0.305, p < 0.0001), waist circumference (r = -0.187, p < 0.0001), FM (r = -0.288, p < 0.0001), FFM (r = -0.101, p = 0.0019) and VFA (r = -0.465, p < 0.0001).
The association between changes in body composition and in the Cooper test during the military service by BMI categories is presented in Figure 2 (6 months of service). Similar associations were seen in the entire study population, 6–12-months’ of service. A significant association between the change in Cooper test result and changes in body weight (p < 0.001), WC (p < 0.001), FM (p < 0.001), and VFA (p < 0.001) by BMI categories was observed for those who served 6 months, as well as for the entire study population (6–12-month service).

The association of the decrease in weight, WC and FM with an improved Cooper test result was more substantial between the overweight subjects compared with the normal-weight subjects (6 months of service). This association was also observed to be significantly different between the obese and normal-weight subjects when examining the entire study population. The association between the reduction in VFA and improved Cooper test was more pronounced in the overweight (p < 0.001) and obese (p < 0.001) subjects compared with normal-weight subjects, both for those whose training period was 6 months and for the entire study population (Figure 2). Because of the similarity of the associations, only the 6-month military service data is shown.
Fig. 2. Changes in the Cooper test result, anthropometry and body composition by BMI during military service (six months of service). Total numer (n) of study subjects 543. n (underweight) = 23, n (normal-weight) = 343, n (overweight) = 131, n (obese) = 46.

5.5 Changes in cardiovascular risk factors during military service (Article IV)

5.5.1 Changes in cardiovascular risk factors

The cardiometabolic risk factors of the whole study population at the baseline are presented in Table 4. Table 12 presents changes in them during military service.
Systolic blood pressure decreased and HDL-cholesterol increased significantly (p < 0.001 for both) during the military service (6–12 months). In contrast, diastolic blood pressure, total and LDL-cholesterol and triglycerides increased during the service.

Table 12. Absolute change of the cardiovascular risk factors of the study population from baseline to the end of military service. Values are mean (standard deviation), unless stated otherwise.

<table>
<thead>
<tr>
<th>Variable</th>
<th>n</th>
<th>Beginning</th>
<th>Change</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>1060</td>
<td>128.8</td>
<td>−2.1 (13.2)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>1061</td>
<td>69.8</td>
<td>2.0 (9.9)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Total serum cholesterol (mmol/l)</td>
<td>998</td>
<td>3.89</td>
<td>0.43 (0.79)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>LDL-cholesterol (mmol/l)</td>
<td>986</td>
<td>2.23</td>
<td>0.18 (0.64)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>HDL-cholesterol (mmol/l)</td>
<td>998</td>
<td>1.29</td>
<td>0.08 (0.26)</td>
<td>&lt; 0.0001</td>
</tr>
<tr>
<td>Triglycerides (mmol/l)</td>
<td>1000</td>
<td>0.79</td>
<td>0.42 (0.76)</td>
<td>&lt; 0.0001</td>
</tr>
</tbody>
</table>

5.5.2 Association between weight loss, body composition, cardiovascular risk factors and physical fitness (Article IV)

Table 13 presents that weight loss correlated strongly with the reduction in WC, FM and VFA. Weight loss correlated significantly with a decrease in both systolic and diastolic blood pressure (r = 0.203 and 0.155, respectively, p < 0.001), with a decrease in total and LDL-cholesterol and triglycerides, and an increase in HDL-cholesterol (p < 0.0001 for all). A decrease in VFA correlated with reductions in BP, TG and LDL-cholesterol similarly to those of weight loss (p < 0.001 for all), with the exception of triglycerides (not significant).

Improvement in aerobic and muscular fitness correlated significantly with weight loss and decrease in VFA (p < 0.0001 for all) (Table 13). The correlation was larger for the changes in Cooper test than for the changes in MFI.

The decrease in BP, particularly sBP, correlated more strongly with the improvement in aerobic fitness than with changes in muscular fitness. Compared to the improvement in muscular fitness, improvement in Cooper test correlated more strongly with improvement in lipoproteins.
Table 13. Pearson correlations between changes (Δ) in body composition and cardiovascular risk factors and changes in body weight, visceral fat area (VFA), Cooper test, and muscle fitness index (MFI) (P values in parentheses). (Article IV, published by permission by Elsevier).

<table>
<thead>
<tr>
<th>Change in variable</th>
<th>Δ Weight</th>
<th>Δ VFA</th>
<th>Δ Cooper test</th>
<th>Δ MFI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight (kg)</td>
<td>1.000</td>
<td>0.645 (&lt; 0.001)</td>
<td>−0.31 (&lt; 0.001)</td>
<td>−0.173 (&lt; 0.001)</td>
</tr>
<tr>
<td>Waist circumference (cm)</td>
<td>0.81 (&lt; 0.001)</td>
<td>0.394 (&lt; 0.001)</td>
<td>−0.183 (&lt; 0.001)</td>
<td>−0.116 (&lt; 0.001)</td>
</tr>
<tr>
<td>Fat mass (kg)</td>
<td>0.877 (&lt; 0.001)</td>
<td>0.695 (&lt; 0.001)</td>
<td>−0.296 (&lt; 0.001)</td>
<td>−0.178 (&lt; 0.001)</td>
</tr>
<tr>
<td>Lean body mass (kg)</td>
<td>0.435 (&lt; 0.001)</td>
<td>0.042 (0.176)</td>
<td>−0.093 (0.004)</td>
<td>−0.013 (0.6898)</td>
</tr>
<tr>
<td>Visceral fat area (cm²)</td>
<td>0.645 (&lt; 0.001)</td>
<td>1.000</td>
<td>−0.469 (&lt; 0.001)</td>
<td>−0.181 (&lt; 0.001)</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>0.203 (&lt; 0.001)</td>
<td>0.248 (&lt; 0.001)</td>
<td>−0.217 (&lt; 0.001)</td>
<td>−0.155 (&lt; 0.001)</td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>0.155 (&lt; 0.001)</td>
<td>0.106 (&lt; 0.001)</td>
<td>−0.065 (0.042)</td>
<td>−0.005 (0.8872)</td>
</tr>
<tr>
<td>Total serum cholesterol (mmol/L)</td>
<td>0.251 (&lt; 0.001)</td>
<td>0.128 (&lt; 0.001)</td>
<td>−0.074 (0.024)</td>
<td>−0.059 (0.0770)</td>
</tr>
<tr>
<td>LDL-cholesterol (mmol/L)</td>
<td>0.339 (&lt; 0.001)</td>
<td>0.236 (&lt; 0.001)</td>
<td>−0.115 (&lt; 0.001)</td>
<td>−0.063 (0.0588)</td>
</tr>
<tr>
<td>HDL-cholesterol (mmol/L)</td>
<td>−0.165 (&lt; 0.001)</td>
<td>−0.152 (&lt; 0.001)</td>
<td>0.04 (0.2186)</td>
<td>0.031 (0.3490)</td>
</tr>
<tr>
<td>Triglycerides (mmol/L)</td>
<td>0.043 (0.1738)</td>
<td>−0.058 (0.0725)</td>
<td>0.029 (0.3702)</td>
<td>−0.083 (0.012)</td>
</tr>
<tr>
<td>Cooper test (m)</td>
<td>−0.31 (&lt; 0.001)</td>
<td>−0.469 (&lt; 0.001)</td>
<td>1.000</td>
<td>0.216 (&lt; 0.001)</td>
</tr>
<tr>
<td>Muscle fitness index (points)</td>
<td>−0.173 (&lt; 0.001)</td>
<td>−0.181 (&lt; 0.001)</td>
<td>0.216 (&lt; 0.001)</td>
<td>1.000</td>
</tr>
</tbody>
</table>

5.5.3 Comparison of the effects of weight loss and physical fitness on cardiovascular risk factors (Article IV)

The association of weight loss with changes in BP and lipoprotein concentrations remained significant after the adjustment for baseline weight, changes in both parameters related to physical fitness (Cooper and MFI), length of the military service and smoking (Table 14).

The effects of the reduction in VFA on changes in BP and lipid levels were smaller than those of weight loss (Table 14), but remained significant for blood pressure, LDL and total cholesterol after adjustment for confounding factors. Effects of improvement in Cooper test as a modifier of cardiovascular risk factors were small, and were significant only for dBP after the adjustment for confounding factors. The increase in muscular fitness was associated with a decrease in dBP and triglyceride concentrations, even after the adjustment for confounding factors.

Additional adjustment for changes in either aerobic or muscular fitness did not alter the effect of weight loss on cardiovascular risk factors. Multiple linear regression analysis showed that the improvement in BP and lipoprotein concentrations with increased aerobic fitness was attributable to weight loss (Figure 3).
Table 14. Associations of the changes (Δ) in cardiovascular risk factors with changes in body weight, visceral fat area (VFA), aerobic fitness (Cooper) and muscle fitness index (MFI). Effect size is beta β coefficient (standard error, SE) and standardized beta (β), calculated by linear regression. * Analyses were adjusted for baseline value of the independent variable, length of military service and smoking. Changes in Cooper test and MFI were adjusted for changes in body weight. Changes in body weight and VFA were adjusted for changes in Cooper test and MFI. (Article IV, published by permission by Elsevier).

<table>
<thead>
<tr>
<th>Cardiovascular risk factor</th>
<th>Δ Weight (B (SE))</th>
<th>β</th>
<th>P value</th>
<th>Δ VFA (B (SE))</th>
<th>β</th>
<th>P value</th>
<th>Δ Cooper (B (SE))</th>
<th>β</th>
<th>P value</th>
<th>Δ MFI (B (SE))</th>
<th>β</th>
<th>P value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>0.3935 (0.0774)</td>
<td>0.1548</td>
<td>&lt; 0.001</td>
<td>0.0416 (0.0123)</td>
<td>0.1061</td>
<td>&lt; 0.001</td>
<td>-0.003 (0.0016)</td>
<td>-0.0645</td>
<td>0.042</td>
<td>-0.026 (0.1865)</td>
<td>-0.0046</td>
<td>0.887</td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>0.3882 (0.0578)</td>
<td>0.2027</td>
<td>&lt; 0.001</td>
<td>0.0740 (0.0091)</td>
<td>0.2479</td>
<td>&lt; 0.001</td>
<td>-0.008 (0.0012)</td>
<td>-0.2167</td>
<td>&lt; 0.001</td>
<td>-0.676 (0.1382)</td>
<td>-0.1553</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Total serum cholesterol (mmol/L)</td>
<td>0.0379 (0.0047)</td>
<td>0.2508</td>
<td>&lt; 0.001</td>
<td>0.0030 (0.0008)</td>
<td>0.1280</td>
<td>&lt; 0.001</td>
<td>-0.000 (0.0001)</td>
<td>-0.0736</td>
<td>0.024</td>
<td>-0.020 (0.0112)</td>
<td>-0.0586</td>
<td>0.077</td>
</tr>
<tr>
<td>LDL-cholesterol (mmol/L)</td>
<td>0.0417 (0.0037)</td>
<td>0.3391</td>
<td>&lt; 0.001</td>
<td>0.0046 (0.0006)</td>
<td>0.2362</td>
<td>&lt; 0.001</td>
<td>-0.000 (0.0001)</td>
<td>-0.1151</td>
<td>&lt; 0.001</td>
<td>-0.017 (0.0092)</td>
<td>-0.0628</td>
<td>0.059</td>
</tr>
<tr>
<td>HDL-cholesterol (mmol/L)</td>
<td>-0.008 (0.0015)</td>
<td>-0.1654</td>
<td>&lt; 0.001</td>
<td>-0.001 (0.0002)</td>
<td>-0.1522</td>
<td>&lt; 0.001</td>
<td>0.0000 (0.0000)</td>
<td>0.0401</td>
<td>0.219</td>
<td>0.0034 (0.0037)</td>
<td>0.0310</td>
<td>0.349</td>
</tr>
<tr>
<td>Triglycerides (mmol/L)</td>
<td>0.0062 (0.0046)</td>
<td>0.0434</td>
<td>0.174</td>
<td>-0.001 (0.0007)</td>
<td>-0.0583</td>
<td>0.073</td>
<td>0.0001 (0.0001)</td>
<td>0.0292</td>
<td>0.370</td>
<td>-0.026 (0.0105)</td>
<td>-0.0831</td>
<td>0.012</td>
</tr>
<tr>
<td>Cardiovascular risk factor</td>
<td>Δ Weight</td>
<td></td>
<td></td>
<td>Δ VFA</td>
<td></td>
<td></td>
<td>Δ Cooper</td>
<td></td>
<td></td>
<td>Δ MFI</td>
<td></td>
<td></td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>----------</td>
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<td></td>
</tr>
<tr>
<td>Adjusted</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic blood pressure (mmHg)</td>
<td>0.7223</td>
<td>0.2746</td>
<td>&lt; 0.001</td>
<td>0.0703</td>
<td>0.1707</td>
<td>0.003</td>
<td>-0.001</td>
<td>-0.0237</td>
<td>0.546</td>
<td>-0.019</td>
<td>-0.0032</td>
<td>0.929</td>
</tr>
<tr>
<td>(mmHg)</td>
<td>(0.1133)</td>
<td>(0.0238)</td>
<td></td>
<td>(0.0020)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.2121)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Diastolic blood pressure (mmHg)</td>
<td>0.2168</td>
<td>0.1000</td>
<td>0.009</td>
<td>0.0449</td>
<td>0.1440</td>
<td>0.010</td>
<td>-0.004</td>
<td>-0.1087</td>
<td>0.005</td>
<td>-0.449</td>
<td>-0.1024</td>
<td>0.004</td>
</tr>
<tr>
<td>(mmHg)</td>
<td>(0.0831)</td>
<td>(0.0173)</td>
<td></td>
<td>(0.0015)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.1556)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total serum cholesterol (mmol/L)</td>
<td>0.0475</td>
<td>0.3083</td>
<td>&lt; 0.001</td>
<td>0.0042</td>
<td>0.1731</td>
<td>0.004</td>
<td>-0.000</td>
<td>-0.0412</td>
<td>0.294</td>
<td>-0.017</td>
<td>-0.0508</td>
<td>0.169</td>
</tr>
<tr>
<td>(mmol/L)</td>
<td>(0.0067)</td>
<td>(0.0015)</td>
<td></td>
<td>(0.0001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.0126)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>LDL-cholesterol (mmol/L)</td>
<td>0.0426</td>
<td>0.3400</td>
<td>&lt; 0.001</td>
<td>0.0038</td>
<td>0.1923</td>
<td>0.001</td>
<td>-0.000</td>
<td>-0.0169</td>
<td>0.660</td>
<td>-0.005</td>
<td>-0.0193</td>
<td>0.596</td>
</tr>
<tr>
<td>(mmol/L)</td>
<td>(0.0053)</td>
<td>(0.0012)</td>
<td></td>
<td>(0.0001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.0101)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>HDL-cholesterol (mmol/L)</td>
<td>-0.006</td>
<td>-0.1111</td>
<td>0.013</td>
<td>-0.000</td>
<td>-0.0483</td>
<td>0.416</td>
<td>-0.000</td>
<td>-0.0189</td>
<td>0.639</td>
<td>-0.004</td>
<td>-0.0333</td>
<td>0.379</td>
</tr>
<tr>
<td>(mmol/L)</td>
<td>(0.0022)</td>
<td>(0.0005)</td>
<td></td>
<td>(0.0000)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.0042)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Triglycerides (mmol/L)</td>
<td>0.0202</td>
<td>0.1390</td>
<td>0.002</td>
<td>0.0007</td>
<td>0.0290</td>
<td>0.631</td>
<td>-0.000</td>
<td>-0.0420</td>
<td>0.302</td>
<td>-0.036</td>
<td>-0.1134</td>
<td>0.003</td>
</tr>
<tr>
<td>(mmol/L)</td>
<td>(0.0065)</td>
<td>(0.0014)</td>
<td></td>
<td>(0.0001)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.0122)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

β coefficients (standard error) are for change per one unit for body weight, VFA and MFI; for 10 m change in the Cooper test, *and for 0.1mmol/L change in lipoproteins.
Fig. 3. Associations between changes (Δ) in body weight and aerobic fitness and
changes in cardiovascular risk factors. Multiple linear regression analysis for the association between change in body weight, cardiovascular risk factors, and adjusted for muscle fitness index (MFI). Association between change in Cooper test and cardiovascular risk factors, and as adjusted for change in body weight. (Article IV, published by permission of Elsevier). (R and p values in parentheses)

5.6 Summary of the novel results

1. In the whole study population, the prevalence of MetS was 3.5% and 6.8%, according to the ATPIII and IDF definitions, respectively. The prevalence increased in parallel with increasing BMI and it was 30 (ATPIII) and 55% (IDF) in obese military conscripts.

2. The mean body weight of the military conscripts increased 0.5 kg during the military service period. The body weight and the amount of adipose tissue increased among under- and normal-weight military conscripts. The mean weight of overweight and obese service men decreased 3.7, and 8.2 kg, respectively. They also lost the greatest amount of adipose tissue. Even though the mean weight of under- and normal-weight service men increased, the amount of VFA decreased approximately 40% in every BMI group. The military service period resulted in most beneficial changes in body composition in overweight and previously physically inactive service men.

3. The beneficial changes in body composition were related to improvement in aerobic fitness during the military service. The association with improvement in aerobic fitness was seen especially in the reduction of weight and the amount of visceral fat.

4. The beneficial changes in cardiovascular risk factors were related to improvement in physical fitness, especially aerobic fitness.
6 Discussion

6.1 Prevalence of metabolic syndrome

It is alarming that one third of the service men had a BMI exceeding 25 kg\(\text{m}^{-2}\), i.e. were overweight (25%) or obese (8%). The mean BMI of the study subjects at the baseline was 23.9 kg\(\text{m}^{-2}\), which is in line with previous Finnish military studies in which the mean BMI of the conscripts has recently varied between 21.9 and 24.6 kg\(\text{m}^{-2}\) (Mattila et al. 2007, Santtila et al. 2008).

In the present study, the prevalence of MetS was 3.5% (75/1099) according to the criteria by ATPIII. In other studies concerning adolescents and young adults, the prevalence of MetS varied between 1.4 and 18.3% (Afkhami-Ardekani et al. 2010, Cook et al. 2003, Duncan et al. 2004, Ferreira et al. 2007, Mattsson et al. 2007, Raiko et al. 2010, Rodriguez-Moran et al. 2004, Saito et al. 2007, Yoo et al. 2004). The wide variation is due to differences in study samples, age (12–45 years), gender and ethnic background. For example, in a Japanese study, the MetS prevalence was 1.4% (Saito et al. 2007), while in the Bogalusa Heart Study in the U.S, 15.5% of the young men met the MetS criteria of ATPIII (Yoo et al. 2004).

In the only European MetS study on young adults conducted prior to the present study (Article I), the MetS prevalence was 18.3% in a sample of Dutch adults (Ferreira et al. 2005) according to the ATPIII criteria. However, it should be noted that they were considerably older (36 years) than the present study population. In the Finnish studies conducted after the present study (Article I), the MetS prevalence was 9.6–15% (ATPIII) among adults aged 30–45 years (Raiko et al. 2010) and 13% among adults 24–39 years of age (Mattsson et al. 2007) according to the ATPIII criteria. Also these studies comprised of older subjects than the present study, and they also included females, which may explain the difference between the prevalence figures.

According to the IDF criteria, 6.8% (39/1099) of young 19-year-old men had MetS in the present study. At the time, this was the first study (Article I) presenting the prevalence of MetS in young Europeans according to the definition provided by IDF in 2005. Afterwards, in other studies the prevalence of MetS according to these criteria has varied between 1.6% and 18.4% in European, U.S and Iranian studies (Afkhami-Ardekani et al. 2010, Goodman et al. 2007, Mattsson et al. 2007, Pirkola et al. 2008, Raiko et al. 2010). Also these studies differ from each other with regards to age and ethnicity of their study subjects.
The age of the study subjects in those trials varied between 14 and 45 years and included subjects of both sexes from Iran, the U.S. and Finland.

Regardless of the definition criteria, in this study the MetS prevalence increased in parallel with increasing BMI. One of the novel findings was that by using IDF criteria, the prevalence of MetS was even higher than 50% in young obese males. According to the ATPIII criteria, approximately one third of the obese military conscripts had MetS. This is in line with other MetS prevalence studies, in which prevalence varied between 30–50% among obese adolescents in Iran and the U.S. (Afkhami-Ardekani et al. 2010, Cook et al. 2003). It is of note that in the present study, MetS was also present (3.3–8.8%) in overweight young men (BMI 25–29.9 kgm$^{-2}$).

The definitions of abdominal obesity and high fasting plasma glucose differ between the IDF and ATPIII criteria, while the definitions of the other components of MetS are the same. In addition, the IDF criteria presuppose the presence of abdominal obesity. Thus, stricter criteria for normal values of WC and fasting plasma glucose or the prerequisite of abdominal obesity could lie behind the higher prevalence of MetS as defined by IDF.

In the present study, smoking did not affect the prevalence of MetS. This is in line with the findings of Katano et al. who reported that smoking was not associated with the number of MetS diagnostic components (Katano et al. 2010). However, opposite data exist: current smoking was observed to be associated with increased odds of MetS on population level in a study of Park et al. (Park et al. 2003). The reason for these conflicting findings remains unclear.

Low HDL-cholesterol is the most common MetS component in heart failure (Karadag & Akbulut 2009). In general, favourable changes in young adults’ lipoproteins have been reported in Finland during recent years (Raiko et al. 2010). However, it is noteworthy that in the present study, low HDL-cholesterol is a feature of three the most common combinations of MetS components, comprising 79% of the MetS cases according to ATPIII criteria.

To summarize, regardless of the criteria for MetS applied, a high MetS prevalence in young men was observed. The prevalence of MetS was the highest in obese military conscripts.

### 6.2 Body composition changes during military service

Obese and overweight young men benefit most from the lifestyle changes associated with military service regarding their body composition and fitness. In
obese men the mean body weight (−8.2 kg, −7.7%) and FM (−9 kg, −25%) reduction was the greatest, with no marked changes in lean tissue. Furthermore, the beneficial changes in body composition were the most pronounced among previously inactive overweight and obese males, who lost 4.7 kg and 9.7 kg of FM, respectively.

In general, a reduction in the amount of adipose tissue, an increase in the amount of lean tissue and a modest weight loss was observed in the entire population during the military service. These findings are in line with previous military studies (Lee et al. 1994, Lieberman et al. 2008, Mattila et al. 2009), where varying amounts of weight loss and increases in lean tissue have been observed depending on the type and duration of military training. In the present study, the average FM reduction of 9.7% is in accordance with the previous results showing reductions in amount of the adipose tissue of 2.7–16.3% during the military training period (Croteau & Young 2000, Patton et al. 1980, Santtila et al. 2008).

The weight loss and reduction in the amount of adipose tissue were most pronounced in overweight and obese men. Compared to previous training studies among obese individuals (Jakicic et al. 2008), the present study detected a more significant weight loss. This might be due to the higher amount of strenuous physical activity during military service compared to the training outside the military service in previous studies. Among underweight and normal-weight men, on the other hand, weight gain and an increase in the amount of adipose tissue were observed. The increase in the amount of adipose tissue and also in lean tissue was most marked in underweight subjects. It is probably due to their increased energy intake during military service compared with civil life. Thus, rather homogenous lifestyle circumstances during military service, which include high amounts of physical activity and regular meals, bring the extremes, the “thinnest” and “fattest” young men a bit closer together.

Considering that especially the amount of visceral fat is a major risk factor for several serious public health concerns, the finding of a decreased amount of visceral fat in this study is important. Although the amount of adipose tissue increased among under- and normal-weight subjects, VFA still decreased markedly, approximately 40%, in all BMI groups. It is possible that this reduction was due to the regular physical activity during the military service. This is supported by the finding that strenuous physical training reduces visceral adipose tissue (Mourier et al. 1997) while weight loss is not necessarily observed (Pratley et al. 2000). In a previous review article, training interventions were shown to
result in reductions in amount of visceral fat varying 5.5–30.4% (Kay & Fiatarone Singh 2006) depending on the type and intensity of the training, as well as individual characteristics. The reduction of visceral fat among obese conscripts in the present study was in accordance with studies of Boudou et al. and Mourier et al. in which decreases in visceral fat varied between 44 and 48% (Boudou et al. 2003). However, in those studies the study subjects were older, obese and diabetic patients and the training interventions were shorter and probably of smaller frequency than in the present study. It is also of note that the present study was not an intervention study, but one monitoring the changes occurring during military service.

In the present study, the amount of reported previous physical activity during the preceding month was associated with changes in body composition during military service. It is known that physical activity is independently and inversely associated with FM in young males (Ekelund et al. 2005). In the present study, conscripts who reported no previous physical activity showed slightly more beneficial changes in body composition during military service compared with those who reported moderate or high physical activity.

6.3 Physical fitness and related fat distribution changes

6.3.1 Improvement in physical fitness

In the present study, aerobic fitness measured by the Cooper test improved on average by 7–9% during the 6–12-month military service, and the improvement was more pronounced among higher BMI groups. On average, also muscular fitness improved as well. The improved fitness is supposed to be related to high amount of physical activity, especially endurance training during military service.

Regarding recruited military trainees, these results are in accordance with previous military training studies showing improvements in aerobic fitness by 6–10% (Croteau & Young 2000, Mattila et al. 2009, Popovich et al. 2000). However, the earlier studies differ from the present one by having either considerably older study subjects (mean age 29.8 years) (Croteau & Young 2000) or by addressing recruited or selected military trainees (Popovich et al. 2000). Our results are also in accordance with a Finnish study of 140 randomly selected military trainees, where the Cooper test result improved by 150 metres after 6 months of training (Mattila et al. 2009). In contrast, in a Norwegian study of 107 military conscripts
performing compulsory military service for one year, the VO2max did not change during the military training period (Dyrstad et al. 2006). In Norway, the amount of obligatory physical training is 8.5 hours per week during the basic training period, and 35% less afterwards. However, it has been assumed that the actual amount of physical training is less than required by regulations in Norway (Dyrstad et al. 2006). Therefore, in the present study, the amount and/or intensity of exercise may be assumed to be higher than in Norway explaining the improvement in conscripts’ aerobic fitness.

In the present study, the improvement of aerobic fitness was highlighted in service men who served for 6 months. In previous Finnish (Mattila et al. 2009) and Norwegian (Dyrstad et al. 2006) military training studies it has been observed that the basic training period at the beginning of military service has the most beneficial effects on body composition and physical fitness. This may indicate that the amount of physical training after the basic training period may not be enough to maintain the beneficial changes achieved during the basic training period. In the present study, assessments were not done after the basic training period. However, the differences between service men who served for 6 months and all service men (6–12 months of service) may be explained by the longer time that had elapsed since the basic training period.

The findings of the present study suggest that the overweight and obese conscripts - who were also in the worst shape at the baseline – benefited most from lifestyle changes associated with military training by improving their aerobic fitness by 14% both. The result is in accordance with previous military training studies, suggesting more pronounced improvements in aerobic fitness during military service among obese (ca. 12–14%) men compared with normal-weight men (Lim & Lee 1994, Mattila et al. 2009).

In the present study, the muscular fitness also improved during the military service, which has also been documented in previous military training studies (Knapik et al. 1980, Kraemer et al. 2004, Mattila et al. 2009). The MFI improved by 1.5 points (from 8 to 9.5) in the present study, which is slightly less than in a previous Finnish military study, where this score improved by 2.6 points (Mattila et al. 2009). It is of note, however, that in the study of Mattila et al. the baseline MFI was slightly lower (6.5 points) than in the present study. The improvement of muscular fitness is easier to achieve and more pronounced among those conscripts who are in worse shape at baseline.
6.3.2 The association between improved aerobic fitness and beneficial body composition changes

Significant associations between beneficial body composition changes and improved aerobic fitness during the military service were observed. These changes occurred especially during the first six months of training and were particularly pronounced in overweight and obese conscripts.

Both aerobic and muscular fitness improved during the military training period, and both of them led to a significant reduction in weight, the amount of adipose tissue and abdominal obesity. Weight loss and beneficial body composition changes were more related to improvement in aerobic than in muscular fitness.

Considering that the prevalence of obesity and overweight has increased during the recent decades in conjunction with decreased physical fitness among young adults (Dyrstad et al. 2005, Santtila et al. 2006), the high amount of physical activity associated with military service is especially beneficial for overweight and obese young men. An application for reduction in adipose tissue at the population level may be by improving physical (especially aerobic) fitness by increasing energy expenditure through physical activity, even without dietary restriction. The finding is significant from the public health perspective in reducing obesity-related morbidity in this age group and could also be applied in civilian life.

6.4 Changes in cardiometabolic risk factors and blood pressure

The weight loss, reduction in VFA as well as improvement in physical fitness, were associated with a decrease in BP levels and favourable changes in serum lipoproteins. The effect of improved physical fitness on lowering BP and altering lipoproteins was, however, mainly attributable to weight loss and reduction in VFA. This is most likely due to increased energy expenditure induced by physical training.

Studies regarding changes in single cardiometabolic risk factors in response to physical activity have been controversial. The American College of Sports Medicine and the American Diabetes Association emphasized that the data on the effects of training on lipoproteins and BP are conflicting in people with prediabetes (Yates et al. 2007). Training has not lowered BP in some of the previous studies (Church et al. 2007, Ilanne-Parikka et al. 2010). However, three
meta-analyses have reported that aerobic exercise lowered blood pressure levels both in hypertensive and normotensive individuals (Cornelissen & Fagard 2005, Dickinson et al. 2006, Whelton et al. 2002). In the present study of a non-diabetic population-based sample of young men, improvement in aerobic fitness was associated with a reduction in sBP level.

Previous training studies have observed an overall beneficial effect on serum lipoproteins, particularly with respect to HDL-cholesterol as well as triglycerides, but the effect has been variable and overall small across the studies (Kodama et al. 2007, Kondo et al. 2006, Leon & Sanchez 2001). The type, dose and intensity of training required to achieve the desired changes in the lipid profile remain unclear (Kraus & Slentz 2009). Furthermore, it has also been unclear as to whether these effects are independent of the changes in body composition. In the present study, beneficial changes in lipoprotein concentrations related to weight loss and reduction in VFA were observed. The findings suggest that the effect of increased aerobic fitness on the lipoprotein profile is mediated by changes in body weight and body composition.

Abdominal obesity provides the theoretical link between the improvement in physical fitness and reduction in cardiovascular risk factors. Visceral fat has an independent curvilinear association with mortality (Kuk et al. 2006) and correlating with cardiometabolic risk factors (Despres et al. 2001) and presence of MetS (Park et al. 2003). Abdominal obesity has also been linked with elevated sBP, and a decreased amount of visceral fat has been associated with a reduction in BP (Dickinson et al. 2006, Rexrode et al. 1998). Increased amounts of adipose tissue and particularly visceral fat are associated with qualitative and quantitative changes in lipoproteins, such as increases in total cholesterol and TG and decreases in HDL-cholesterol concentration (Howard et al. 2003). This study is in agreement with these findings showing that the military service period including increased physical activity for most conscripts, reduced VFA and resulted in beneficial change in HDL-cholesterol.

In previous studies, conflicting data exist about the effects of military training on cardiometabolic risk factors. One study suggests that military training results in favourable changes in blood lipoprotein concentrations (Lieberman et al. 2008), whereas unfavourable changes in total and LDL-cholesterol were observed in a Finnish military study by Tähtinen et al. (Tähtinen et al. 2000). In that study, however, the study sample was smaller, and the associations between physical fitness variables and cardiometabolic risk factors were not studied. Furthermore, the Finnish defence forces have paid more attention to healthiness of the food
served for the service men during the 21st century. However, the mean LDL-cholesterol, TG and total cholesterol increased also in the present study. This may be due to unfavourable changes in service men’s diet during military service (Tähtinen et al. 2000).

6.5 Methodological considerations

6.5.1 Strengths of the study

Due to conscription, about 80% of the age group completes military service in Finland. Thus, studying military conscripts provides a large, representative sample of young men. For example, the mean body weight and mean distance covered in the Cooper test by all Finnish military conscripts in 2004 were 75.2 kg and 2,434 m, respectively (Santtila et al. 2006). In the present study, corresponding figures were 75.1 kg and 2,482 m, respectively, and the present sample therefore corresponds to Finnish population of 19-year-old males in terms of physical features. The results of the present study can thus be applied at population level to Caucasian young male adults undergoing military service.

The military training period provides a possibility to investigate the influence of a physical activity period on young men’s health. The circumstances during the service period are rather homogenous regarding sleep, diet and physical activity during the time spent in service. Military service does not include energy restriction. The diet of the service period is rather hyperenergetic: the energy intake is about one fourth higher than the energy need in civilian men of similar age (Rehunen 1996). It is difficult, if almost impossible, to conduct similar and equally representative population studies examining the effects of a high amount of physical activity on body composition, physical fitness and cardiovascular risk factors in a nearly population-based sample of young men.

A slight selection may occur because ca. 10% of men are exempted from military service during medical examinations due to medical reasons, and ca. 7% of eligible men choose to perform non-military service (Mattila et al. 2007). However, it can be assumed that the prevalence of smoking, obesity and MetS in the present study are not overestimates, since those with the most serious physical and psychiatric disorders were excluded from military service.

In the present study, the blood samples were taken and assessments of other relevant measurements were conducted by physicians or trained assistants under
identical procedures. Furthermore, all the blood samples were analysed in the same laboratory by the same method.

6.5.2 Limitations of the study

The study was limited by the fact that only male subjects were included. In Finland, military service is voluntary for females. In 2005 only 15 female military conscripts attended military service in the Sodankylä Jaeger Brigade. They were all invited to participate in the present study, but due to their small number, statistical analyses would not have been feasible for them and, consequently, they were excluded from the study. Furthermore, due to the study design, there is no control group. However, when examining changes occurring during the military service, the conscripts served as their own controls.

In the present study, one limitation concerning the prevalence of MetS (Article I) is that the BP of the conscripts was measured only once due to the predetermined military health care protocol. Therefore, it can be assumed that many conscripts had, regardless of their BMI, an elevated BP at the beginning of their military service due to the stressful assessment situation. It is, however, worth mentioning that high BP was more common in persons suffering from overweight and obesity. Furthermore, although many of the conscripts with normal weight also had high BP, none of them met the criteria for MetS according to the IDF definition (and even with ATPIII criteria no more than 0.7% of them were identified as suffering from MetS).

The present study assessed aerobic fitness by using the Cooper test (Cooper 1968), which has been used by the Finnish defence forces for decades. The Cooper test has been developed for military use and its prediction of VO\textsubscript{2max} is good (Cooper 1968, Grant \textit{et al.} 1995). However, it only provides an estimate of VO\textsubscript{2max}. The present large population study did not allow the use of individual maximal testing for assessments of VO\textsubscript{2max}. The strength of the assessment of physical fitness, both aerobic and muscular is, however, that the measuring circumstances were standardized (except for weather) and that the tests were conducted following the predetermined protocol of the defence forces. In addition, all supervisors of the fitness tests were highly trained and experienced.

Self-reporting questionnaires are known to present a good estimate for physical activity and VO\textsubscript{2max} without exercise testing. It should be noted, however, that the questionnaire used in the present study covers only a short period of time.
prior to military service. Study subject bias (e.g. imprecise recall) is possible in questionnaires.

This study is weakened by the fact that the amount and intensity of the training and physical activity during the military service are not known. The estimated amount of physical training is at minimum 4 hours sports-related exercise per week during the military service, but varies between companies. The type of training is assumed to be mostly aerobic, but it also includes strength training. The training is assumed to be of high volume. Additionally, inevitable changes in diet and environment associated with military service may have had some effects on body fat distribution, body weight or serum lipoproteins. Another limitation was that adverse events, such as injuries, during the training period were not recorded. In previous military studies poor running fitness (Bell et al. 2000) and overweight (Mattila et al. 2007) have been observed to increase injury risk. It is thus possible that the initially most unfit and obese conscripts had more injuries than non-obese and fit service men.

The limitation of the body composition and fat distribution measurements in the present study is that VFA was evaluated by the bioimpedance method. More studies are needed to validate this method in different ethnic groups regarding VFA. However, rather than absolute values, we were interested in detecting the change after the training period which the repeated sampling allowed.
7 Summary of the findings and conclusions

It is alarming that one in every three young Finnish men was already overweight or obese at the mean age of 19. Furthermore, MetS was highly prevalent among obese subjects, but it also occurred already in slightly overweight service men, the overall prevalence being 3.5–6.8%.

The military training period resulted in beneficial changes in body fat distribution and aerobic fitness, especially in overweight and obese subjects, i.e. the subjects who really needed these kinds of improvements. This was due to the high amounts of physical activity during the training period.

Even though under- and normal-weight subjects gained weight and had an increase in the amount of body fat, an average decrease in VFA of about 40% was detected in all BMI categories. Given that visceral fat is the type of adipose tissue that is especially harmful for health, this observation is important. Furthermore, beneficial changes in physical fitness and body fat distribution were related to observed improvements in cardiometabolic risk factors and blood pressure, even though the mean LDL-cholesterol, total cholesterol, triglycerides and diastolic blood pressure increased.

7.1 Research implications

Considering that most - but not all - obese service men had MetS, it would be important to study the differences between the subjects with and without MetS. What are the features of the obese non-MetS service men? Is their physical fitness perhaps better than that of those with MetS? Correspondingly, it would be beneficial to identify those service men who did not improve their cardiometabolic profile, physical fitness or body composition during the military service. How did they differ from the others at the baseline? What did they do differently from those who benefitted from the training period? This knowledge would be important for the defence forces for tailoring of the military training period.

It is noteworthy that in the present study, the agreement between the prevalence of MetS defined by IDF and ATPIII criteria was only moderate. This means that by using these definitions one may find different individuals to suffer from MetS. What matters is, however, that the definition that produces the best prediction of cardiovascular disorders and type 2 diabetes deserves to be looked at to determine the direction of further investigations and prospective follow-up.
studies. MetS according to the ATPIII criteria has proved to be a good predictor of these disorders (Dekker et al. 2005, Sundstrom et al. 2006). The IDF criteria have also been shown to predict cardiovascular mortality (Qiao & DECODE Study Group 2006), but more comparative data on the prediction accuracy of these definitions are needed.

Since 2009, Finnish defence forces have divided service men into three fitness categories at the beginning of military service, providing targeted physical training for each group. It is very important to study the effects of the military training period on physical fitness in these fitness categories.

There are limited data about the amount of physical activity and type of training during the Finnish military service. Investigating this issue would provide an important tool for future research. Maintaining the achieved beneficial physical fitness and fat distribution changes is a major concern of the present study population. Therefore, a follow-up study would provide additional information.

7.2 Clinical, practical and public health implications

In Finland, metabolic abnormalities related to increased amounts of adipose tissue are very common in middle-aged men (Saaristo et al. 2008). Abdominal obesity is associated with these abnormalities within each BMI category, including normal-weight subjects. (Saaristo et al. 2008)

The present study shows that the prevalence of the visceral obesity-related cluster of cardiovascular risk factors (MetS) is also relatively high already among younger males. Therefore, assessments of body fat distribution in addition to measuring weight and BMI in clinical practice is crucial. Furthermore, assessment of lipoproteins, BP and glucose are important. Performing these actions is already relevant among young patients. Early identification and treatment of the individuals who suffer from MetS may reduce their future risk for developing the major public health concerns - cardiovascular disease and type 2 diabetes.

In the present study, the beneficial changes in body composition and cardiovascular risk factors associated with improvement in aerobic fitness. Therefore, physical fitness of the population or patients deserves more attention on the part of their physicians. In Finland, these data could easily be available because nearly all children and adolescents perform physical fitness tests in school. Further, it could be proposed that municipalities or employers should also pay attention on people’s physical fitness.
In the present epidemic of obesity and related co-morbidities, primary care personnel cannot concentrate only on individual counselling. The main interest of managing this relevant public health problem should be at the population level applications. Therefore, physicians in primary health care should be aware of all the existing means to combat obesity and possible associated comorbidities in different age groups. This study indicates that among young healthy men, one population-level application to combat obesity and related cardiovascular risk factors is by increasing physical fitness. This is possible by being physically active and training, concentrating especially on aerobic fitness. In the modern society there are plenty of possibilities for physical exercise. The problem is that there are also plenty of other forms of entertainment, which predispose to physical inactivity.

Moreover, physical inactivity is a common challenge for society as a whole, and should be taken into account e.g. within the school system, municipal planning and leisure time activity possibilities. However, military service is a special period in life, and achieving and maintaining the same level of physical activity in civilian life may be impossible. Still, the military service period provides a great opportunity to offer health education, when almost the whole age group of young male adults gathers together. This opportunity could possibly be more carefully utilized by defence forces and may-be even the civilian public health care system.

In 2006, the Finnish defence forces set stricter criteria for drafted service men: for example, men with BMI exceeding 30 kgm\(^{-2}\) could be more easily excluded from military service due to obesity. This study indicates, however, that especially obese individuals would benefit from the high amount of physical activity associated with military service. Therefore, it can be recommended that primary care physicians in pre-military call-up examinations reconsider excluding obese but motivated men from military service. Even though the primary objective of military service is national defence, the health implications of the “training period” for the whole age group cannot be ignored. The most relevant question is, however: how do we get our boys to be more physically active in their civilian life, before and after the military service?
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PREVALENCE OF METABOLIC SYNDROME AND CHANGES IN BODY COMPOSITION, PHYSICAL FITNESS AND CARDIOVASCULAR RISK FACTORS DURING MILITARY SERVICE