

*Maria Hagnäs*

HEALTH BEHAVIOR OF  
YOUNG ADULT MEN AND  
THE ASSOCIATION WITH  
BODY COMPOSITION AND  
PHYSICAL FITNESS DURING  
MILITARY SERVICE

UNIVERSITY OF OULU GRADUATE SCHOOL;  
UNIVERSITY OF OULU,  
FACULTY OF MEDICINE;  
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*MARIA HAGNÄS*

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SERVICE**

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### ***Abstract***

The prevalence of overweight and obesity among adolescents has increased worldwide at the population-level, reflecting inactive lifestyle and excessive energy intake. The comorbidities of obesity, e.g. impaired glucose tolerance and high blood pressure increase the risk for cardiovascular diseases. The first manifestation of cardiovascular diseases can be detected in young adulthood, and prevention should be focused to those at highest risk.

This study was aimed to evaluate the changes in body weight and body composition, physical fitness and cardiometabolic risk factors, associated with physical exercise during military service. Furthermore, this study investigated the association of antenatal and lifestyle factors with the body composition and physical fitness among young men.

The material of this study consisted of 1046 men (mean age 19.2 years) who began their compulsory military service in the Sodankylä Jaeger Brigade in 2005. The conscripts' cardiometabolic risk factors, body weight, body composition, fitness, and lifestyle habits were evaluated at baseline and after 6–12 months military service. The data on the participants' mothers' antenatal and participants' childhood period was available for 508 offsprings, who belonged to the 1986 Northern Finland Birth Cohort.

During the military service the prevalence of metabolic syndrome decreased in the overall cohort from 6.1% to 3.6%, and the reduction was present among overweight and obese conscripts. The reduction in metabolic syndrome was associated with the reduction in waist circumference, weight loss and improvement in muscle fitness. Some lifestyle factors e.g. maternal smoking during pregnancy and conscripts' smoking, alcohol consumption and binge drinking were associated with the conscripts' body composition and fitness test results. Military service was especially beneficial for those reporting weekly binge drinking, who showed the greatest reduction in body weight and fat, and improvements in physical fitness and lifestyle habits.

This study shows that unbeneficial lifestyle habits can be seen as detrimental to the body composition and fitness levels of young men. Furthermore, the physical exercise is in important role for reducing the metabolic syndrome, already present in young men. Maternal smoking during pregnancy was associated with reduced aerobic fitness in the subjects, underlining its long-standing consequences on offspring's health.

**Keywords:** body composition, health behavior, lifestyle factors, maternal smoking, military, obesity, physical fitness, young men



## **Hagnäs, Maria, Nuorten miesten terveystietäytymisen yhteys kehonkoostumukseen ja fyysiseen kuntoon varusmiespalvelusaikana.**

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### ***Tiivistelmä***

Väestötutkimusten perusteella nuorten ylipaino ja lihavuus ovat yleistyneet, liittyen inaktiiviseen elämäntapaan ja liialliseen energiansaantiin. Lihavuuden liittännäissairaudet, kuten heikentynyt sokerinsieto ja kohonnut verenpaine lisäävät riskiä sydän- ja verisuonisairauksille. Sydän- ja verisuonisairauksien ensimmäiset ilmentymät voidaan havaita nuorella aikuisiällä ja sairauden ehkäisystrategiat tulisi kohdentaa riskiryhmiin.

Tässä tutkimuksessa arvioitiin varusmiespalvelukseen liittyvän liikunnan aikaansaamia muutoksia kehonpainossa, kehonkoostumuksessa, fyysisessä kunnossa sekä sydän- ja verisuonisairauksien riskitekijöissä. Lisäksi tutkimus arvioi äidin raskausaikaan liittyvien tekijöiden ja elintapojen yhteyttä nuorten miesten kehonkoostumukseen ja fyysiseen kuntoon.

Tutkimusaineisto koostui 1046 miehestä (keski-ikä 19.2 vuotta), jotka astuivat varusmiespalvelukseen Sodankylän Jääkäriprikaatissa vuonna 2005. Varusmiesten sydän- ja verisuonisairauksien riskitekijät, kehonpaino, kehonkoostumus, kunto ja elintavat arvioitiin palveluksen alussa ja lopussa (seuranta-aika 6–12 kk). Varusmiesten äitien raskaudenaikaiset ja varusmiesten varhaislapsuuden tiedot olivat käytettävissä 508:lta tutkittavalta, jotka kuuluivat Pohjois-Suomen syntymäkohorttiin 1986.

Varusmiespalveluksen aikana metabolisen oireyhtymän vallitsevuus väheni koko aineistossa 6.1 %:sta 3.6 %:iin, ja väheneminen oli havaittavissa ylipainoisten ja lihaviin joukossa. Metabolisen oireyhtymän väheneminen oli yhteydessä vyötärön ympäröityksen ja painon laskuun sekä lihaskunnon paranemiseen. Elintavat, kuten äidin raskaudenaikainen tupakointi ja varusmiehen ruokavalio, tupakointi, alkoholin kulutus ja humalahakuinen juominen olivat yhteydessä varusmiehen kehonkoostumukseen ja fyysiseen kuntoon. Varusmiespalveluksesta hyötyivät erityisesti ne, jotka raportoivat viikoittaista humalahakuista juomista; heillä havaittiin myönteisiä muutoksia kehonkoostumuksessa, fyysisessä kunnossa ja elintavoissa. Tämän tutkimuksen perusteella voidaan myös todeta, että äidin raskaudenaikainen tupakointi vaikuttaa jälkeläisen heikompaan aerobiseen kuntoon.

Tutkimus osoittaa epäterveellisten elämäntapojen vaikutukset epäedulliseen kehonkoostumukseen ja heikompaan fyysiseen kuntoon nuorilla miehillä. Lisäksi liikunnan merkitys nuorten miesten sydän- ja verisuonisairauksien riskitekijöiden hoidossa on oleellista.

*Asiasanat:* elintavat, kehonkoostumus, lihavuus, liikunta, nuoret miehet, terveystietäytyminen, varusmiespalvelus, äidin raskaudenaikainen tupakointi





*To my beloved ones*



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Maria Hagnäs

## Abbreviations

AGA	appropriate for gestational age
BIA	bioimpedance analysis
BMI	body mass index
Body fat %	body fat percentage
CVD	cardiovascular disease
CT	computed tomography
DEXA	dual-energy x-ray absorptiometry
E%	energy fat percentage
FM	fat mass
GWG	gestational weight gain
HDL	high-density lipoprotein
IDF	International Diabetes Federation
IOM	Institute of Medicine
LDL	low-density lipoprotein
LGA	large for gestational age
LTPA	leisure-time physical activity
MetS	metabolic syndrome
MFI	muscle fitness index
MRI	magnetic resonance
NFBC 1966	Northern Finland Birth Cohort 1966
NFBC 1986	Northern Finland Birth Cohort 1986
PA	physical activity
SD	standard deviation
SLBM	skeletal lean body mass
SGA	small for gestational age
SMM	skeletal muscle mass
VFA	visceral fat area
VO <sub>2max</sub>	maximal oxygen uptake
WC	waist circumference
WHO	World Health Organization
WHR	waist-to-hip-ratio



## List of original articles

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

- I Hagnäs MP, Cederberg H, Mikkola I, Ikäheimo T, Jokelainen J, Laakso M, Härkönen P, Peitso A, Rajala U & Keinänen-Kiukaanniemi S. (2012) Reduction in metabolic syndrome among obese young men is associated with exercise-induced body composition changes during military service. *Diabetes Res Clin Pract* 98:312-319.
- II Hagnäs MP, Cederberg H, Jokelainen J, Mikkola I, Rajala U & Keinänen-Kiukaanniemi S. (2015) Association of maternal smoking during pregnancy with aerobic fitness of offspring in young adulthood: a prospective cohort study. *BJOG*. DOI: 10.1111/1471-0528.13789.
- III Hagnäs MP, Jokelainen J, Cederberg-Tamminen H, Niemelä S, Härkönen P, Rajala U & Keinänen-Kiukaanniemi S. (2016) Alcohol consumption frequency and binge drinking as predictors of body composition changes during an exercise intervention among young men. Manuscript.

Some unpublished results will also be presented.





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# 1 Introduction

The current increase in obesity has been referred to as an epidemic; in 2014 the prevalence of overweight was 39% and that of obesity 13% of the world's adult population (World Health Organization 2011). The increasing weight of adolescents and young adults in Finland is also a cause for concern (Kautiainen *et al.* 2002). Decreased levels of physical fitness and increased weight have also been observed among young adult men in Finland (Santtila *et al.* 2006).

A complex of obesity risk factors, such as unhealthy diet, physical inactivity and sedentary behavior has been observed among adolescents (Leech *et al.* 2014), however the association of these factors with obesity is not yet completely characterized. Adolescents performing vigorous physical activity (PA) have been shown to consume a healthier diet and fewer unhealthy food items (Storey *et al.* 2009, Durksen *et al.* 2015). Healthy diet, active lifestyle (Cuenca - Garcia *et al.* 2014) as well as better cardiorespiratory fitness in adolescence have been associated with a reduced risk for cardiovascular disease (CVD) (Carnethon *et al.* 2004).

Lifestyle interventions including dietary modifications and increased PA play a significant role in the treatment of the obesity and related disorders such as impaired glucose intolerance, type 2 diabetes and hyperlipidemia, (Tuomilehto *et al.* 2001, Perk *et al.* 2012). The primary manifestations of CVD can already be detected in young adulthood (Raitakari *et al.* 2003). Therefore it is important to identify CVD risk factors in young persons with metabolic abnormalities with high risk of progression, as almost 50% of middle aged men have abnormal glucose tolerance (Saaristo *et al.* 2008). Increased PA in the intervention studies has resulted in beneficial changes in body composition, by reducing the amount of total and visceral fat (Kay & Singh 2006), also without weight loss (Pratley *et al.* 2000). Many adolescents do not meet the health-related recommendations for sufficient PA (Tammelin *et al.* 2007), and the decline in the amount of PA has been observed from adolescence to young adulthood (Telama & Yang 2000). Therefore, these factors may be associated with the increase in body weight and reduction in physical fitness recently observed among young Finnish men (Santtila *et al.* 2006).

In future, by identifying persons at particular risk of developing CVD and supplying early health counseling and lifestyle interventions, it could be possible to prevent later detrimental cardiometabolic diseases. The influence of diet, PA and obesity on the body composition of adolescents and young adults has been

studied previously. However, the role of antenatal and pre-military lifestyle factors as modifiers for body composition and physical fitness changes during military service among a population-based sample of healthy, young men have not been studied previously. Therefore, the current study is of great worth. Studying conscripts performing Finland's compulsory military service offers an opportunity to unravel the metabolic profile and fitness of the young adult men, while the military service itself acts as a lifestyle intervention.

## **2 Review of the literature**

### **2.1 Health behavior of adolescent and young adult men**

Health-promoting behavior is considered mainly to consist of the maintenance of PA, a high-quality diet, non-smoking and healthy weight (Pronk *et al.* 2004).

PA has been noted to decrease when an individual moves from childhood to adolescence (Nader *et al.* 2008), and this tendency may extend into the threshold of adulthood (Biddle *et al.* 2010). A person's diet may change detrimentally from childhood to adolescence and young adulthood when family influence attenuates. However, balanced and appropriate eating habits early in life reduce immediate health problems and are linked with greater likelihood for maintaining them in adulthood. (Currie *et al.* 2004) Late adolescence is a period with various changes in social, biological, physical, psychosocial and physiological factors, and additionally a time period with associated alcohol consumption for many adolescents (Brown *et al.* 2008).

#### **2.1.1 Physical activity and inactivity**

PA can be described as bodily movement produced by skeletal muscles, which increases energy expenditure. PA includes sports and exercise, but also normal daily activities including daily living, work and leisure activities. (Caspersen *et al.* 1985) By contrast, physical inactivity can be described as “a state in which bodily movement is minimal” or “not engaging in any regular pattern of physical activity beyond daily functioning” (United States. Department of Health 1996). Exercise can be defined as planned, structured and repetitive PA, which has an objective to maintain or improve physical fitness (Caspersen *et al.* 1985).

The increased levels of physical inactivity have been observed worldwide in many countries (World Health Organization 2010). A review by Bauman *et al.* (2009) compared internationally the prevalence of low physical activity, varying from 9% to 43% (Bauman *et al.* 2009). During recent decades the global decrease in the aerobic performance of 6–19-year olds has been observed in several countries (Tomkinson & Olds 2007), although some studies have not detected a diminution of PA among young people (Samdal *et al.* 2007, Li *et al.* 2010, Raustorp & Ekroth 2010, Ekelund *et al.* 2011). Furthermore, among young adult men the aerobic fitness (Dyrstad *et al.* 2006, Santtila *et al.* 2006) and muscle

fitness (Santtila *et al.* 2006) have been observed to decline during last 15–20 years in Norway and Finland (Santtila *et al.* 2006).

Sedentary behavior is defined as activity that includes little PA movement such as sitting, watching television, using electronic devices, and is closely related with physical inactivity (Owen *et al.* 2010). Sedentary behavior has been shown to associate with lower levels of PA (Tammelin *et al.* 2007) and a less healthy diet (Pearson & Biddle 2011) among adolescents.

### *Recommendations for physical activity and physical fitness*

Recommendations for PA and exercise include propositions on the quality and quantity of the PA. Cardiorespiratory, resistance, flexibility and neuromotoral exercise training are important factors for maintaining and improving physical fitness. The intensity of the exercise can be defined e.g. moderate-intensity exercise, which can be defined as fairly light to somewhat hard exertion with 40–59% of the heart rate reserve. In contrast, vigorous exercise is perceived to be somewhat hard to very hard exertion, for 60–89% of the heart rate reserve that results in being out of breath or sweating. (Garber *et al.* 2011)

There are no specific recommendations for the sufficient PA level for young adults aged 18–24 years and therefore this review of the literature will deal separately the recommendations for children/adolescents and those for adults.

For children and young people aged 5–17 years, it is recommended to perform at least 60 minutes of moderate to vigorous-intensity PA daily, and most of it should be aerobic (World Health Organization 2010). The recommendations for sufficient PA for school-aged children recommends that 13–18 year-old adolescents should perform a minimum of 1–1,5 hours' PA daily, including several periods of vigorous PA, each lasting at least 10 minutes. Muscle strength training three times a week and bone health promoting exercise is also recommended, and continuous sitting periods lasting more than two hours should be avoided. (Ahonen *et al.* 2008) In a review article, Sisson *et al.* (2008) reported that in most studies examining PA among youth, the definitions of PA used included  $\geq 60$  minutes of moderate-to-vigorous PA for at least five of the previous seven days or  $\geq 20$  min of vigorous PA in three of the previous seven days (Sisson *et al.* 2008).

The World Health Organization (WHO) recommends that adults aged 18–64 perform  $\geq 150$  minutes of moderate-intensity,  $\geq 75$  minutes of vigorous-intensity aerobic PA throughout the week, or a combination of the two. (World Health



Organization 2010) The American College of Sports Medicine recommends that most adults perform moderate-intensity cardiorespiratory exercise for  $\geq 30$  minutes on five days each week for a total of  $\geq 150$  minutes per week, vigorous-intensity cardiorespiratory exercise training for  $\geq 20$  minutes per day on at least three days a week. Resistance and neuromuscular training are also recommended. (Garber *et al.* 2011) These recommendations are in line with the Finnish (Physical activity and exercise training: Current Care Guidelines, 2016), Canadian (Kesäniemi *et al.* 2010) and British (O'Donovan *et al.* 2010) guidelines for sufficient PA.

### *Measurements of physical activity and physical fitness*

There are various ways by which PA can be measured. These methods may be subjective (e.g. logs, physical diaries, questionnaires and recalls) or objective (e.g. activity monitors, indirect calorimetry, doubly-labeled water, heart rate monitors and pedometers) methods. There is no gold standard method for evaluating PA. In large epidemiological studies the assessment of PA is largely based on validated questionnaires, although the validity coefficients are modest concerning the most habitual physical activities ( $r=0.3$  to  $0.5$ ) when compared to direct or indirect measurements of PA. The terms PA, physical fitness, exercise and sports are used interchangeably which might cause confusion, additionally the normal variation in daily PA behavior may complicate the assessment of PA. (Hu 2008)

Physical fitness is a precondition for performing daily activities with vigor, and without fatigue, and it can be considered to comprise the following attributes: cardiorespiratory fitness, muscle strength and endurance, body composition and flexibility, agility and reaction time, balance and power. These attributes are health- or skill-related, which can be measured with specific tests. (Caspersen *et al.* 1985) An individual's physical fitness is determined by their previous PA, sex, age, genetics and state of health (Hu 2008).

Cardiorespiratory fitness (aerobic fitness) is a measure of the capability of the circulatory and respiratory systems to supply oxygen in the body (United States. Department of Health 1996). The gold standard for the assessment of cardiorespiratory fitness is via the measurement of maximal oxygen uptake ( $VO_{2max}$ ,  $mlkg^{-1}min^{-1}$ ) during exercise. The  $VO_{2max}$  constitutes of the maximal volume of oxygen that muscles consume during exercise (Keskinen 2014). A subject's  $VO_{2max}$  is evaluated using an automatic respiratory gas analyser during

vigorous PA, such as cycling or running, until exhaustion on a treadmill or bicycle ergometer.

Indirect, but reasonably accurate, submaximal exercise tests have been developed for the estimation of the  $VO_{2max}$ . For instance, the correlation of the Canadian Aerobic Fitness test with the treadmill  $VO_{2max}$  is quite high ( $r=0.90$ ) (Cox *et al.* 1992). For large populations the assessment of the cardiorespiratory fitness can be made by field-tests, such as the 12-minute running test (Cooper test) (Cooper 1968), and the 2 km walking test (UKK walk test) (Oja *et al.* 1991). In these field tests, the participants are asked to walk or run for a certain time or distance. A largely used submaximal test in the U.S is the 1.5 mile (2.4 km) run test, which presents a correlation of 0.95 with measured  $VO_{2max}$  (Hartung *et al.* 1993). Cardiorespiratory fitness can also be estimated by non-exercise models objectively based on self-reported PA questionnaires (Matthews *et al.* 1999). The direct measurements of aerobic fitness are expensive, time-consuming and require special equipment, therefore their implementation in large epidemiologic studies is challenging (Hu 2008).

The strength-related features of muscular performance can be divided into maximal, velocity and endurance strength. Different muscular tests can evaluate any improvement resulting from training, or they may be used as part of a scientific evaluation. (Keskinen 2014)

### *The prevalence of physical activity and inactivity*

The prevalence of PA and inactivity may vary depending on which measurements and definitions are used to gather and interpret the data. According to an international review article approximately 35% of 13-year-old Finnish boys met the criteria for sufficient PA in 2008. (Sisson & Katzmarzyk 2008) When PA in the NFBC 1986 was evaluated via questionnaires 59% of boys aged 15–16 years reported PA for at least an hour daily, and 23% reported participation in moderate-to-vigorous PA for at least 7 hours per week (Tammelin *et al.* 2007). Eleven percent reported no PA at all (Tammelin *et al.* 2007).

In an international survey of health behavior in children aged 11–15 years, 56% of Finnish boys performed PA for at least four hours a week (Samdal *et al.* 2007) and 27% of the 15-year-old Finnish boys reported performing  $\geq 60$  min/day of PA at least five days/week (Roberts *et al.* 2004). From these results one can conclude that the majority of Finnish adolescents perform a sufficient amount of PA as defined by recommendations.

Higher proportion of adults than adolescents meet the recommended PA criteria. However, the PA recommendations are different in different age group. According to the WHO (World Health Organization 2014b) 60.0–79.9% of adolescent boys in Finland aged 11–17 years old in 2010 were insufficiently physically active (less than 60 minutes of PA per day). According to the WHO the prevalence of insufficient PA in Finland 2010 among adult males  $\geq 18$  years was 20.0–29.9%, having less than 150 minutes of moderate-intensity PA per week (World Health Organization 2014b).

### *The health consequences of physical activity and fitness*

Physical activity is an important factor for health development and psychosocial wellbeing in adolescents (Hills *et al.* 2007). Physical activity positively affects the neural and muscular systems, increases muscle mass, and has an effect on the structure and performance of muscle cells. Physical activity intensifies energy metabolism and enhances the ability of motoric units to activate. (Vuori 2005) Among adolescents the PA has been shown to positively effect the mass, strength and structure of the bone, and it has also been related to the improvement of the musculoskeletal organs. Physical activity also has a beneficial effect on the cardiorespiratory system, supporting the myocardial growth, contractility and local vascular regulation. (Vuori 2005)

Among adolescents the relationship of PA with hypertension has been shown to be weak (Carnethon *et al.* 2005), nonetheless, an association has been reported between level of aerobic fitness and blood pressure (Nielsen & Andersen 2003). Exercise intervention studies examining changes in blood pressure in young people have shown significant, but modest reductions in the blood pressure (Kesäniemi *et al.* 2010).

Significant relations between low fitness levels and CVD risk factors have been observed among young people (Carnethon *et al.* 2005). Also a graded negative association has been observed between the clustered CVD risk and PA in 9–15 year olds (Andersen *et al.* 2006). Interventions with aerobic exercise have been shown to improve the changes in metabolic syndrome components, primarily as fasting insulin and insulin resistance (Janssen & LeBlanc 2010). Increased amounts of PA, especially vigorous PA, have been linked with lower risk for obesity (Janssen *et al.* 2004, Patrick *et al.* 2004, Fogelholm 2008b) and central adiposity (Ortega *et al.* 2007) in young people.

High levels of cardiorespiratory fitness and PA have been shown to associate positively with high self-rated health in adolescents (Kantomaa *et al.* 2015) and with good aerobic and muscular fitness with lower stress and higher mental capacity among young men (Kettunen *et al.* 2014).

Although a relationship between PA and mental wellbeing is apparent, evidence for an association between PA and reduced depression, anxiety, and improved cognitive functioning is still weak and limited (Biddle & Asare 2011).

In adults sufficient PA has been linked with a lower likelihood of later cancers, treatment for the cardiovascular risk factors and diseases, and musculoskeletal problems (Haskell *et al.* 2007).

### *The health consequences of physical inactivity*

The health consequences of the physical inactivity have been widely reported, and it has been stated that physical inactivity is responsible for 6% of the leading global risks for mortality in the world (World Health Organization 2009). In adults physical inactivity has been associated with breast and colon cancer, type 2 diabetes and CVD (World Health Organization 2009).

Although cardiovascular events are not generally present in adolescents, the development of deleterious cardiovascular processes may potentially begin in adolescence and progress over the course of time (Raitakari *et al.* 1997).

Among young people an association has been observed between lower levels of PA and being overweight (Patrick *et al.* 2004), and having risk factors for CVD (Carnethon *et al.* 2005, Janssen & LeBlanc 2010) and hypertension (Mountjoy *et al.* 2011). U.S. male adolescents aged 12–19 years with low fitness status had a greater likelihood of hypercholesterolemia and overweight (Carnethon *et al.* 2005).

### *Physical activity and metabolic syndrome*

An inverse association between PA and prevalence of metabolic syndrome (MetS) has been observed among adolescents and young adults in cross-sectional studies (Stabelini Neto *et al.* 2011, Lopez-Martinez *et al.* 2013). In young adults a higher amount and intensity of PA has been shown to reduce the risk of MetS (Salonen *et al.* 2015). MetS is a cluster of risk factors for CVD and type 2 diabetes. In previous decades propositions have been made by different organizations for the categorization of MetS. The major component of the MetS criteria is abdominal

obesity, which is also underlined in the International Diabetes Federation (IDF) criteria. (Alberti *et al.* 2009) Additionally, the IDF criteria for MetS include two or more of the following: elevations in blood pressure, triglyceride-levels or fasting plasma glucose; low levels of high-density lipoprotein (HDL) cholesterol (Alberti *et al.* 2006).

### **2.1.2 Diet**

A healthy diet is important for maintaining good health, and it is composed of diverse food choices and regular dietary patterns. Finnish nutritional recommendations (2014) are based on the Nordic Nutrition Recommendations, in which one can observe the influence of national dietary culture (Fogelholm *et al.* 2014). A diet that includes excessive sugar, salt and saturated fat increases disease frequency, and can be considered as an unhealthy diet. The diet as a whole should be balanced; no single macronutrient promotes or attenuates the effect of a diet on health. (Fogelholm *et al.* 2014) However, the excessive energy intake may lead to a positive energy balance and thereby obesity (Drenowatz *et al.* 2014). Food behavior and food choices are shaped in childhood and adolescence, and therefore may affect food choices in adulthood (Mikkilä *et al.* 2005). A 2006 study found a high level of consumption of snacks by Finnish adults, which is cause for concern because it is a dietary behavior that leads to a higher energy intake alongside lower micronutrient content (Ovaskainen *et al.* 2006).

An individual's diet can be assessed based on their individual intake of foods, nutrients and total energy. In population-based studies diet can be evaluated by 24-hour recalls, food-frequency questionnaires, diet history, food records and biomarkers. (Hu 2008)

#### ***Recommendations for a healthy diet***

The Nordic Nutrition Recommendations 2014 state that a diet should include fruits and berries, nuts, vegetables, whole grain products, fish and seafood, vegetable oils and low-fat dairy products (Nordic Council 2014). The Finnish recommendations for healthy eating include regular meals with moderate portions of diverse food containing different nutrients. The daily dietary total energy amount is recommended to consist of the following proportions of nutrient: total fat intake 25–40 energy fat percentage (E%), carbohydrate intake 45–60 E%, fibre intake 25–35 grams/day and protein intake 10–20 E%. For a man aged 18–30

years (with estimated mean body mass index (BMI) 23 kg/m<sup>2</sup> and low levels of PA), the daily energy intake recommendation is 11.7 MJ (approximately 2700–2800 kcal/day). (Fogelholm *et al.* 2014)

### *Population patterns of healthy and unhealthy diets*

According to the Health Behavior in School-Aged Children Study (2001–2002) 66.4% of the 15-year old boys in the European region ate breakfast on school days. Fruit and vegetables were consumed daily by 13.5% and 14.3%, respectively and 11.5% reported daily consumption of soft drinks and 9.2% of sweets. (Vereenken *et al.* 2004) In Europe in 2004 the mean fruit and vegetable intake was 376 grams/day among persons aged ≥15years (World Health Organization 2009).

Nutritional recommendations have changed during recent decades, and this has, at least partially resulted in positive changes in food choices. In Finland, total fat intake has decreased and the type of fat consumed has changed, while the consumption of fruit and vegetables has increased. (Männistö *et al.* 2010) Although some positive changes have occurred, some of the unhealthy behavior of snacks-dominating meal pattern has been observed (Ovaskainen *et al.* 2006).

In a 2007 study 81% of 14-year old Finnish boys reported daily breakfast consumption: 28% reported eating fresh vegetables daily and 23 % eating fruit daily. In this population, the intakes of proteins, carbohydrates and total fat were within the recommended ranges, but the sucrose and saturated fat intakes were higher and the fibre intake lower than recommended. The consumption of sugary drinks and snacks at school was common among 14-year olds, and snacks covered 41% of their daily energy. (Hoppu *et al.* 2010)

A 2007 study of 18–20 year old men entering military service in the Armoured and Kainuu Brigades found that 5% of participants consumed fruit or berries daily, 8% uncooked vegetables and 1% cooked vegetables. Unhealthy food items such as pizza, french fries and hamburgers were consumed more often than every other day. (Jallinoja *et al.* 2008)

In 2015 according to the Finnish National Institute for Health and Welfare's School Health Survey, 68% of adolescent high-school boys ate breakfast daily, and the corresponding percentage was 46% of the boys in vocational schools. Among high-school boys 11% reported daily consumption of fruit or berries and 12% fresh or cooked vegetables during the previous week, and among vocational school boys these proportions were 6% for fruit or berries and 5% for fresh and

cooked vegetables. Approximately 60% of the boys reported consumption of sweets and approximately 47% of sugar-sweetened drinks during 1–2 days of the previous week (National Institute of Health and Welfare 2015). Sugar-sweetened drinks contain often large amounts of sugars such as fructose and sucrose, and therefore the consumption of sugar-sweetened drinks may contribute to the overall energy density, although they may not provide nutritional value.

### *The health consequences of unhealthy diet*

A healthy and high nutritional quality diet is particularly important in adolescence and young adulthood, when the physiological need for nutrients increases (Vereenken *et al.* 2004). If healthy eating habits are adopted in early life, they are more likely to persist into adulthood, reducing the risks for chronic diseases, such as CVD, overweight, type 2 diabetes and osteoporosis. (World Health Organization 2009).

In adults sugar-sweetened beverages might increase the type 2 diabetes risk (Sonestedt *et al.* 2012), and in adolescents, the daily consumption of higher sugar-sweetened beverages may be associated with weight gain (Berkey *et al.* 2004), and increased waist circumference (WC) and BMI (Bremer *et al.* 2009).

In adults, an inverse association between high fruit and vegetable consumption and incidence of CVD and mortality has been reported (Hung *et al.* 2004, Martínez-González *et al.* 2011). The low-fat and high-fibre content of the diet has been shown to associate with decreased risk for type 2 diabetes (Lindström *et al.* 2006). In adults high consumption of red meat has been linked with higher risk for colon cancer, type 2 diabetes, obesity and CVD (Fogelholm *et al.* 2012). The effects of single dietary factors on body weight are partially controversial in adults. Therefore, for optimal health benefits, it is important to focus on controlling total caloric intake and maintaining an overall healthy eating pattern (Hu 2008).

### **2.1.3 Smoking**

In the Health Behavior in School-Aged Children Study of the European region (2001–2002) 28.3% of 15-year old boys reported smoking at least once a week, and 22.1% daily (Godeau *et al.* 2004).

According to the National Institute of Health and Welfare's results of the School Health Survey indicated that the prevalence of daily smoking of boys in

the high school in Finland was 5% in 2015, while the corresponding prevalence was 11% in 2006/2007. The prevalence of smoking among boys in vocational school was more common, 28% of the respondents reported daily smoking (National Institute for Health and Welfare 2015).

The “Health 2015- public health program” (Ministry of Social Affairs and Health 2008) reached its target that by the year 2015 less than 15% of the 16–18-year old adolescents would be daily smokers (Kinnunen *et al.* 2015). The decrease in tobacco smoking during recent years has also been observed in The European School Survey Project on Alcohol and Other Drugs, which reported a positive change in the smoking habits of 15–16 year-olds in Finland in the 21<sup>st</sup> century (Raitasalo *et al.* 2012).

The Finnish Adolescent Health and Lifestyle Survey 2015 reported the prevalence of daily tobacco smoking was 22.3% among 18-year old boys (Kinnunen *et al.* 2015). Additionally, the survey conducted by the WHO in Finland (2012), which stated that the prevalence of daily smoking in men aged  $\geq 15$  years was 20-29 % (World Health Organization 2014b).

### *The health consequences of smoking*

Tobacco use is the second leading risk factor for mortality in the world (World Health Organization 2009). The harmful effects of smoking on adults have been widely recognized: it has been associated with elevated risks of lung, liver and colorectal cancers, of respiratory diseases including chronic obstructive pulmonary disease and asthma, of CVD and of type 2 diabetes (US Department of Health and Human Services 2014).

Tobacco smoking may be associated with respiratory symptoms (Hamari *et al.* 2010, Janson *et al.* 2001) and the risk of asthma in adolescence (US Department of Health and Human Services 2014). In adolescents and young adults tobacco smoking has been shown to associate with atherosclerotic changes (Pathobiological Determinants of Atherosclerosis in Youth Research Group 1990). Likewise, physical fitness is impaired in young smokers (Bernaards *et al.* 2003, Hamari *et al.* 2010). Nicotine, a drug in tobacco, is not only an addictive substance, but exposure may affect the brain development of adolescents (US Department of Health and Human Services 2014).



### **2.1.4 Alcohol**

Based on the definition by the National Institute on Alcohol Abuse and Alcoholism (National Institute on Alcohol Abuse and Alcoholism 2016), binge drinking can be defined as drinking five or more alcohol drinks (14 grams/servings) in about 2 hours.

In the Health Behavior in School-Aged Children Study (2001–2002) 18.1% of Finnish 15-year old boys reported drinking any alcoholic beverages weekly, and beer was the most commonly used (Schmid *et al.* 2004).

In 2015, 8% of Finnish high-school aged boys and 5% if girls reported weekly consumption of alcohol and 20% of boys and 17% of girls reported binge-drinking at least once a month. Alcohol consumption was more common among boys in vocational school where 16% reported weekly alcohol consumption and 32% reported at least monthly binge-drinking (National Institute for Health and Welfare 2015).

Based on the WHO survey the prevalence of heavy episodic drinking at least monthly was  $\geq 30$  % among adolescents aged 15–19 years in Finland in the year 2010 (World Health Organization 2014a). In 2015, 64% of 18-year old Finnish boys consumed alcoholic beverages at least once a month, and 26% consumed weekly. Of the 18-year old boys 26% reported monthly and 4% weekly binge drinking (Kinnunen *et al.* 2015). Nevertheless, in Finland alcohol consumption and binge drinking has decreased among adolescents during recent years (Raitasalo *et al.* 2012, Kinnunen *et al.* 2015, National Institute for Health and Welfare 2015).

#### ***The health consequences of alcohol consumption***

The time of late adolescence is characterized by various cognitive, biological and social changes and the escalation of alcohol consumption and related consequences may occur (Brown *et al.* 2008). Alcohol consumption by adolescents under 18 years old is considered to be risk behavior, and the alcohol consumption in adolescence predicts alcohol consumption and addiction (Bonomo *et al.* 2004) and related harms in adulthood (Winqvist *et al.* 2006).

Alcohol related harms are linked with the drinking habits, both in terms of quantity and patterns of drinking (World Health Organization 2009). Binge drinking may result in intoxication, lack of motor control and reduced levels of

inhibition. Alcohol-related harms can be defined as consequences of drinking, including injuries, accidents, and social and health problems (Little *et al.* 2012).

According to the dietary guidelines for adult men 0–2 alcohol servings per day can be considered as moderate alcohol consumption, which is not likely to cause health problems (Fogelholm *et al.* 2014). In adults higher alcohol consumption has been associated with esophageal and liver cancer, liver cirrhosis, neurological and psychiatric conditions (World Health Organization 2009).

## **2.2 Traits of maternal health behavior in childhood and adolescence**

According to the Finriski 2012 study, the mean BMI of the women aged 25–34 years was 23.6 kg/m<sup>2</sup> in Finland. 75.6% of the women had a BMI under 25.0 kg/m<sup>2</sup>, and 24.5% of women were considered to be overweight or obese (BMI  $\geq$ 25.0 kg/m<sup>2</sup>). (Männistö *et al.* 2015)

Maternal pre-pregnancy body weight has been linked with short- and long-term outcomes of the offspring (Institute of Medicine and National Research Council Committee to Reexamine IOM Pregnancy Weight Guidelines, US 2009). Higher maternal pre-pregnancy BMI has been noted to associate with overweight and abdominal obesity in the offspring during adolescence (Laitinen *et al.* 2012). A positive association has been detected between the maternal pre-pregnancy body weight and the adult offspring's cardiometabolic risk factors, via increased blood pressure and insulin and triglyceride levels (Hochner *et al.* 2012). The possible mechanisms behind the association between maternal pre-pregnancy BMI and offspring BMI might include a shared environment and genetic predisposition, but the developmental overnutrition hypothesis (Drake & Reynolds 2010, Poston 2012) is also a possible factor. During the pregnancy of an obese woman, the fetus is exposed to an increased nutrient supply leading to an elevated risk for fetal macrosomia (Poston 2012). High maternal glucose, free fatty acid and amino acid concentrations may induce changes in appetite control, neuroendocrine functioning and energy metabolism in the fetus (Drake & Reynolds 2010).

Maternal gestational weight gain (GWG) has been linked with various short- and long-term health consequences in the offspring. The Institute of Medicine (IOM) 2009 (Institute of Medicine and National Research Council Committee to Reexamine IOM Pregnancy Weight Guidelines, US 2009) include recommendations for the appropriate GWG for each BMI class: underweight

(<18.5 kg/m<sup>2</sup>) 12.5–18 kg, normal weight (18.5–24.9 kg/m<sup>2</sup>) 11.5–16 kg, overweight (25.0–29.9 kg/m<sup>2</sup>) and obese (≥30.0 kg/m<sup>2</sup>) 7–11.5 kg and 5–9 kg. The maternal GWG has shown to be associated with birth weight for gestational age (Poston 2012). A direct association between excessive GWG and the fat mass (FM) of the newborn (Hull *et al.* 2011) and childhood obesity have been observed (Institute of Medicine and National Research Council Committee to Reexamine IOM Pregnancy Weight Guidelines, US 2009). Excessive GWG increases the risk of adiposity and accompanying risk of metabolic and CVD later in life for the offspring (Mamun *et al.* 2009, Drake & Reynolds 2010).

The prevalence of maternal smoking has declined in the Nordic countries during the past 20 years, apart from Finland where the prevalence of maternal smoking remains 10–15 % (Ekblad *et al.* 2014). The harmful consequences to the unborn child of maternal smoking have been recognized, although the mechanisms between maternal smoking and offspring health outcomes are not clearly established. Nicotine, which is also transferred via the placenta, has been shown to act centrally and peripherally in humans, by reducing appetite and body weight (Oken *et al.* 2008). Animal tests have shown that maternal smoking during pregnancy may alter the structure of the offspring's lungs and reduce the capacity for gas exchange. Maternal smoking may also have an influence on fetal pulmonary development and result in impaired function of the offspring's lungs. (Chen & Morris 2007, Harding & Maritz 2012)

Previous studies have linked maternal smoking with a higher risk for several obstetrical complications, including abortion, intrauterine infections and growth restriction and preterm birth (Poston 2012, Mund *et al.* 2013). In addition, higher risk for offspring gastrointestinal diseases, fetal congenital heart defects, impacts on psychological and neurology behavior, and respiratory infections have all been shown to correlate with maternal smoking (Harding & Maritz 2012, Mund *et al.* 2013)

The association of maternal smoking with lower birth weight and risk of obesity for the offspring has been observed (Oken *et al.* 2008, Poston 2012, Mund *et al.* 2013). Children with low birth weight have an elevated risk for catch-up growth, insulin resistance and thereby obesity in adulthood (Barker *et al.* 2009). Maternal smoking during pregnancy has been shown to associate with an elevated offspring risk for obesity between the ages of 3–33 years (Oken *et al.* 2008). A meta-analysis of data gathered in the Nordic countries showed an association between both lower and higher birth weight with a likelihood of performing less leisure-time physical activity (LTPA) in adolescence or adulthood. In the normal

birth weight range the association between birth weight and LTPA was weak. (Andersen *et al.* 2009)

The association between maternal smoking and offspring adolescent smoking status was observed to be pronounced if mother smoked in late pregnancy and continued to smoke when the adolescent offspring was 14 years old (O'Callaghan *et al.* 2006). Also childhood and adolescent maternal smoking exposure has been shown to relate with risk for smoking in adulthood (Paul *et al.* 2008).

## **2.3 The association of health behavior with anthropometrics, fitness and body composition**

### **2.3.1 Health behavior with anthropometrics and fitness**

The term anthropometrics can be defined as the measurement of parts of the human body (Nienstedt 2007) and in epidemiological studies widely used measurements of the adiposity include BMI, WC, waist-to-hip-ratio (WHR) (Hu 2008). Health behaviors of adolescents and young adults have been shown to relate with anthropometric measurements, body composition and fitness.

#### *Relationship of physical activity and physical fitness with anthropometrics*

The recent studies evaluating the association of PA and physical fitness with anthropometric measurements in adolescents and young adults are presented in Table 1. Several studies have reported an inverse relationship between physical fitness on overweight among adolescents (Deforche *et al.* 2003, Pate *et al.* 2006, Fogelholm *et al.* 2008a), but the relationship between PA and overweight is less clear (Rauner *et al.* 2013).

Physical activity can be measured objectively or subjectively. In large epidemiological studies the assessment of PA is largely based on validated questionnaires. (Hu 2008) The PA can be divided into LTPA, occupational PA and commuting PA (Vaara *et al.* 2014). Therefore, not only the measurement method, but the type and intensity of the PA may give rise to challenging comparisons concerning the association between PA and overweight.

In some studies overweight, measured as BMI or WC, has not been associated with objectively measured PA (Aires *et al.* 2010b, Ortega *et al.* 2010), and similar results have also been observed with subjectively measured PA

(Deforche *et al.* 2003). Ortega *et al.* (2007) did not discover any association between the subjectively measured PA and BMI or WC in male adolescents (Ortega *et al.* 2007). On contrary high PA has been shown to associate inversely with WC (Bremer *et al.* 2009, Vaara *et al.* 2014, Zaccagni *et al.* 2014) and BMI, WHR, triceps and biceps skinfolds among Italian university students (Zaccagni *et al.* 2014).

Several studies have reported the inverse association between overweight and cardiorespiratory fitness (Deforche *et al.* 2003, Pate *et al.* 2006, Ortega *et al.* 2007, Fogelholm *et al.* 2008b, Kvaavik *et al.* 2009, Aires *et al.* 2010b, Huotari *et al.* 2010, Leyk *et al.* 2012). In addition, a longitudinal study by Aires *et al.* (2010) showed a negative association between BMI and fitness levels. A high fitness level at baseline predicted the lowest positive changes in BMI, and a low fitness level at baseline predicted increased BMI (Aires *et al.* 2010a).

Overall PA was associated positively with muscular (Paalanne *et al.* 2009) and aerobic (Pate *et al.* 2006) fitness, and in particular, high LTPA has been related to improved aerobic (Huotari *et al.* 2010, Vaara *et al.* 2014) and muscular (Vaara *et al.* 2014) fitness.

Two longitudinal studies performed in young adults have investigated the association between changes in PA and BMI and changes in fitness (Aires *et al.* 2010a) and the association between PA, fitness and metabolic risk (Camhi *et al.* 2013).

Aires *et al.* (2010) studied a population of 11–19 year-old Portuguese high-school students for a 3-year follow-up period, to evaluate whether changes in PA and BMI levels were associated with changes in fitness. Changes in PA levels associated positively and independently with the changes in fitness at years 1, 2 and 3. Changes in BMI were associated with changes in fitness at the 3-year follow-up. (Aires *et al.* 2010a)

In their longitudinal study (CARDIA) Camhi *et al.* (2013) reported an association between metabolic risk and 20-year PA or fitness trajectories in young adults. At baseline 4161 participants were aged 18–30 years, and of whom 978 were white men. The mean age of the participants was 45 years at the final follow-up. At baseline those who had elevated metabolic risk, had significantly lower PA and fitness levels compared with those who had normal metabolic risk. PA and fitness levels declined over 20-years' follow-up. However, the difference in PA and fitness levels between the normal and elevated metabolic risk groups remained however significant throughout follow-up. (Camhi *et al.* 2013)

**Table 1. The relation of physical activity and physical fitness with anthropometric measurements in adolescents and young adults in recent cross-sectional studies (Adapted from Rauner *et al.* 2013 )**

Reference	Country	Age (yrs)/ N, Gender	Anthropometrics	Cardiorespiratory/ Muscular fitness	PA and OW	Fitness and OW
Vaara <i>et al.</i> 2014	Finland	26/ 846, M	WC	Cycle ergometer test / Muscle tests	Neg. association	NA
Zaccagni <i>et al.</i> 2014	Italy	22/ 380, M	BMI, WC, WSR, skinfold thickness	- / Hand grip strenght	Neg. association	NA
Leyk <i>et al.</i> 2012	Germany	18-25/ 4611, M	BMI, WC	Running test 1 km / Chin up	NA	Neg. Association
Ortega <i>et al.</i> 2010	Sweden	15/ 518, M+F	BMI, WC, skinfold thickness	Maximal cycle ergometer test / -, <sup>1</sup>	No association	Neg. association
Huotari <i>et al.</i> 2010	Finland	13-18/ 292, M	BMI	Running test 2 km / -	NA	Neg. association
Aires <i>et al.</i> 2010	Portugal	11-18/ 111, M+F	BMI	Shuttle run / -, <sup>1</sup>	No association	Neg. association
Fogelholm <i>et al.</i> 2008b	Finland	15-16/ 1167, M	BMI	Shuttle run / Muscle tests	No association	Neg. association
Ortega <i>et al.</i> 2007	Spain	13.5-18.5/ 1445, M	BMI, WC	Shuttle run / -	No association	Neg. association
Pate <i>et al.</i> 2006	U.S.	12-19/ 1686, M	BMI	Submaximal treadmill exercise test/-	NA	Neg. association
Deforche <i>et al.</i> 2003	Belgia	12-18/ 3214, M+F	BMI, 5 skinfold thickness	Shuttle run / Muscle tests	No association	Neg. association

The subjective PA assessed from questionnaires. <sup>1</sup>Objectively measured PA. BMI: Body mass index, F: Female, M: Male, NA: not applicable, N: number, OW: overweight, PA: Physical activity, WC: waist circumference, WSR: Waist-to-stature ratio.

### *Relationship of diet with anthropometrics*

The results of studies examining the effects of diet on anthropometrics and fitness in young adults are inconsistent and challenging to compare.

The regular higher consumption of dietary fiber has been shown to associate negatively with BMI and WC among college students (Byrd-Williams *et al.* 2009) and young adult men entering military service (Bingham *et al.* 2012a), but also with overweight among adolescent boys (Patrick *et al.* 2004).

Increased WC and BMI was shown to be associated with the consumption of sugar-containing food items in young adults (Bingham *et al.* 2012a) and of higher sugar-sweetened beverages in male adolescents aged 12–19 years in the U.S. National Health and Examination Survey (Bremer *et al.* 2009).

The beneficial effects of fruit and vegetable consumption on anthropometrics have also been observed. An Austrian study showed that adolescents and young adults (aged 15–29 years) were most likely to have an exclusively vegetarian diet compared with older age groups, and in the overall study population the consumption of vegetarian and carnivorous diet rich in fruits and vegetables was associated with lower BMI (Burkert *et al.* 2014). In a longitudinal study the consumption of no single macronutrient in adolescence associated with overweight at the mean age of 15 years, while in the 10-year follow-up at the mean age of 25 years the increased consumption of vegetables was protective of overweight (Quick *et al.* 2013). A higher consumption of low-fat dairy products was associated with beneficial weight and WC changes among college students. However, when fruit consumption was included in the analyses the association was non-significant (Poddar *et al.* 2009).

To summarize, the consumption of a varied diet including low-fat dairy products, and a high proportion of vegetables, fruits and fibre sources could have beneficial effects on overweight, as assessed using anthropometric measurements.

### *Relationship of smoking and alcohol consumption with anthropometrics and fitness*

In adult populations an inverse association between smoking and body weight has been observed generally (Akbarbartoori *et al.* 2005, Berlin 2008, Sherrill-Mittleman *et al.* 2009), however among adolescents the results have been inconsistent. Some studies showed positive relationship and other no relationship

between smoking and body weight in adolescents (Potter *et al.* 2004). In a 4-year longitudinal study among 5,863 adolescents in England smoking was inversely associated with BMI and WC (Fidler *et al.* 2007). Research performed in young adult men showed a non-significant inverse association between the smoking and BMI (Akbarbartoori *et al.* 2005), however in adults contrary results have been reported. Dvorak *et al.* (2009) concluded that tobacco smoking and BMI were positively associated, although when physical inactivity was examined as a mediator, the association was no longer significant, suggesting that physical inactivity mediates the effect of smoking on the BMI (Dvorak *et al.* 2009). An observation was made among a U.S. military population of young white male adults, that those who smoked daily weighed significantly less than non-smokers (Sherrill-Mittleman *et al.* 2009) and a similar, but non-significant negative association with smoking and BMI was seen among conscripts in Norway (Stea *et al.* 2009). However, in the same study, smoking was significantly negatively associated with the running test (aerobic fitness), but not with muscular fitness (Stea *et al.* 2009).

In a study by Nies *et al.* (2012) among 199 college students evaluated the association of BMI with the stages of change in the alcohol consumption, number of drinks and consequences of alcohol consumption. Alcohol consumption was shown to positively associate with BMI in male students, particularly in subjects in the precontemplation stage (Nies *et al.* 2012).

### **2.3.2 Health behavior and body composition**

Measurement of body composition gives a more accurate evaluation of adiposity than anthropometric measurements. Methods used in small-scale studies include underwater weighing, dilution methods, dual-energy x-ray absorptiometry (DEXA), computed tomography (CT) and magnetic resonance (MRI), which give reference to body composition methods or calibrate anthropometric measures. Bioelectrical impedance analysis (BIA) is an appropriate method for evaluating body composition in large epidemiological studies. (Hu 2008)

#### ***Relationship of physical activity with body composition***

Subjectively measured PA was inversely associated with FM and body fat% (body fat percentage) in a study of 17-year-old males (Ekelund *et al.* 2005). In another



study, high PA levels also correlated negatively with body fat% and FM in male university students (Zaccagni *et al.* 2014).

A study performed by Smith *et al.* (2013) showed that light PA was inversely associated with total and visceral adipose tissue measured by CT in young men, but the results must be interpreted with caution due to the small number of participants. In a further study, moderate-to-vigorous PA correlated negatively with body fat% among 27-year-old adults (Drenowatz *et al.* 2014).

### *Relationship of diet with body composition*

An inverse association between the healthy eating index and body fat% was observed in a study of 407 27-year old adults in the U.S.. Additionally, an inverse relationship with the protein intake and body fat% was observed (Drenowatz *et al.* 2014).

In a Finnish military population of young men the consumption of fibre-rich food items has been inversely associated with FM and body fat% (Byrd-Williams *et al.* 2009, Bingham *et al.* 2012a). The consumption of sugar-containing food items by young Finnish men showed a surprising inverse association with FM and body fat%. In addition, fat index was not associated with body composition (Bingham *et al.* 2012a) at the beginning of the military service.

The higher consumption of low-fat dairy products was associated with beneficial truncal and total body changes in a study of college students, although when fruit consumption was taken into account the associations were non-significant (Poddar *et al.* 2009). Also, a small study stated that no single dietary component predicted changes in either visceral or subcutaneous adipose tissue in young overweight men (Bailey *et al.* 2010).

As a summary, diet including low-fat dairy products, and high consumption of vegetables, fruit and fibre sources may have beneficial effects on the body composition.

### *Relationship of smoking and alcohol consumption with body composition*

There are few studies evaluating the effect of smoking and alcohol consumption on body composition in young adults. In a large Korean population aged of 19–79 years, smoking was associated with a larger area of higher visceral adipose tissue evaluated by CT (Lee *et al.* 2012a).

## **2.4 Military service**

In Finland national defence is substructured on the civic duty of military service. Military service is compulsory for men aged 18–29 years, and the civic duty is obligatory until the men reach the age of 60 years. The usual participation age is 19 to 20 years. Voluntary participation is considered for women.

Yearly approximately 25,000 (80% of the age group) of young men accomplish the military service. Military service is given in three defence branches: Air Force, Army and Navy. Military service begins twice a year in January and July. The duration of the service is 6, 9 or 12 months depending on the service's demands and specialization of the tasks. Approximately 10% of the conscripts are excused military service due to physical or mental disabilities (Multimäki *et al.* 2005), which are detected in pre-medical examinations. Civilian service is an option in lieu of military service.

Elsewhere in Europe, military service is compulsory in Estonia, Denmark, Norway and Austria, among others. By contrast, in other countries, for example Sweden and the U.S., military forces are based on the voluntary service men and therefore may consist of selected populations. Therefore, the comparison of the health behavior changes and association with anthropometrics, body composition and fitness during military service may differ between countries with differing strategies for recruiting military personnel and therefore comparison of the results should be made with caution.

### **2.4.1 Physical activity during military service**

Finnish military service begins with an 8-week basic training period, during which conscripts perform sports-related training (such as running, Nordic walking, cross-country skiing, swimming, and strength and recovery training) (Santtila *et al.* 2008). After the basic training period the amount of PA varies depending on assigned military tasks. In garrison circumstances, the daily duration of service is approximately 10 hours. By contrast, in encampment circumstances longer daily periods of service are required, possibly around the clock.

### **2.4.2 Diet during military service**

Military service offers conscripts regular, nutrient-rich meals with intended content of energy 3400–3800 kcal/day, supplied as 50% carbohydrates, 17% proteins and 33% fat (Bingham *et al.* 2009) in garrison days. Conscripts are allowed to consume extra food items such as soft drinks, sweets and chocolate in their spare time (Bingham *et al.* 2012a). The regular dining events (breakfast, lunch and dinner) are part of compulsory service, and the meal courses are planned based on the national nutrition recommendations. It has been assessed that 75% of conscripts' energy is normally supplied by the garrison canteen, with the assumption that extra food items cover the remaining 25% of the daily energy intake.

### **2.4.3 Health behavior changes during military service**

When examining studies regarding the effects of military service on changes in health behavior it is important to pay attention to whether the setting is compulsory or recruited military service. Furthermore, some of the military studies described below include study-specific interventions and therefore do not necessarily reflect authentic military circumstances.

#### ***Physical activity and physical fitness***

In a study of U.S. Army personnel, it was detected that individually performed physical training increased during periods of deployment (Anderson *et al.* 2015). Subjects with poorer PA at the beginning of Croatian military service showed a significant improvement in aerobic and muscular fitness during a 5-week training program (Sporis *et al.* 2014). Conscripts with lower  $VO_{2max}$  at the beginning of Norwegian military service showed the greatest improvement in  $VO_{2max}$  (Dyrstad *et al.* 2006).

In a one-year study against the background of compulsory military service in Lithuania, the physical fitness of the conscripts decreased. The majority (71.1%), of conscripts were normal weight at baseline. However, after one year of military service the increased weight of the conscripts during follow-up was observed as an increased proportion of overweight and decreased proportion of normal weight conscripts (Dregval & Vaicaitiene 2006).

## *Diet*

In a study performed in two garrisons (the Armoured Brigade in Southern Finland and the Kainuu Brigade in Northern Finland) in 2007–2009, 5% of conscripts reported daily consumption of fruit and vegetables and 8% consumed fresh vegetables or salad at the beginning of their military service, which is below the national recommendations (Bingham *et al.* 2010).

A significant increase in consumption of sweet food items i.e. candies, chocolate, pastries was seen during military service (Jallinoja *et al.* 2011, Bingham *et al.* 2012b). A self-reported increase in the consumption of snacks, doughnuts, soft drinks and confectionery was also observed in a study performed among military conscripts in Northern Finland (Tähtinen *et al.* 2001).

On contrary, a significantly reduced consumption of fat-containing ingredients, for example, french fries and hamburgers, has been observed during military service, alongside increased consumption of cereal products, fruit and vegetables (Bingham *et al.* 2012a). In a study performed in the U.S. diet quality improved during the basic training period, especially among those with a lower-quality diet at baseline. Poorer diet was also associated with smoking (Lutz *et al.* 2013).

Attention has been paid to weight increase in Finnish conscripts during recent years (Santtila *et al.* 2006). Although regular military service is been beneficial for the body composition of most young Finnish men who participate (Absetz *et al.* 2010), the National Institute for Health and Welfare together with the Finnish defence forces started an intervention study (Study to change conscripts' dietary habits, VARU-intervention) in 2006 to investigate the eating habits of conscripts (Jallinoja *et al.* 2008).

## *Smoking and alcohol*

During the years 2007–2009 the prevalence of current regular smoking among Finnish military conscripts has varied from 30.0% to 46.5% (Jallinoja *et al.* 2008, Bingham *et al.* 2010, Hamari *et al.* 2010).

In a Norwegian cross-sectional study unbeneficial changes during military service were seen in conscripts' smoking habits, and the changes correlated with physical inactivity and regular alcohol consumption. Of those who smoked, 55.7% increased their consumption during military service and 7.8%, of those who did not previously smoke, began to smoke in the course of their military

service. (Schei & Sogaard 1994) The prevalence of current smoking among Swiss conscripts was 48% in 2005 (Miedinger *et al.* 2006).

In U.S. military populations the prevalence of smoking has varied between 23.3 to 56.0% depending on the service, the type of the deployment and combat exposures, with smoking more common during deployment (Bray & Hourani 2007, Anderson *et al.* 2015). In their study of 48,304 U.S. military participants, Smith *et al.* (2008) reported that smoking rates increase during deployment, especially among those who had previously smoked and subsequently ceased smoking.

A limited amount of research has been performed on alcohol consumption and binge drinking among military personnel and during military service in the European region. In a study by Bingham *et al.* (2010), at the beginning of military service smokers consumed more unhealthy food items than non-smokers. Also those conscripts who drank beer 2–7 days/week consumed higher amounts of unhealthy food items including the least healthy (Bingham *et al.* 2010). The prevalence of heavy alcohol use among active duty personnel in the U.S. military in the year 2005 varied from 10.3% to 25.4% (Ames *et al.* 2007, Bray & Hourani 2007).

#### **2.4.4 The association of health behavior with anthropometrics, body composition and fitness during military service**

The health behavior changes in conscripts during recent years is reflected in changes to their anthropometrics, body composition and fitness. In Finland during the years 1993–2004 the mean weight of the conscripts increased significantly from 70.2 kg to 75.2 kg and the results in the 12-minute running test decreased by 12% during the years 1979–2004 (Santtila *et al.* 2006). The inverse association of PA with the increased BMI has also been detected in South Korea between 2002 to 2008 (Bae *et al.* 2011).

##### ***Physical activity and physical fitness***

During military service in the Sodankylä Jaeger Brigade 2005–2006, conscripts' previous PA was associated with body composition changes, especially among those who were overweight or obese (Mikkola *et al.* 2009). In the group of overweight and obese with no reported previous PA the changes in weight, BMI, FM, body fat% and visceral fat area (VFA) were more pronounced than those

who reported vigorous exercise. (Mikkola *et al.* 2009) In the overweight group significant reductions were observed in mean weight -3.7 kg (-4.4%), FM -4.0 kg (-20.5%), body fat% -3.9% (-17%) and VFA -43.8 cm<sup>2</sup> (-44.4%). Similar changes occurred among the obese group: weight -8.2 kg (-7.7%), FM -8.9 kg (-24.9%), body fat% -6.4% (-19.0%) and VFA -68.5 cm<sup>2</sup> (-40.1%). Increases in weight, BMI, FM and body fat% were observed in the under- and normal weight conscripts. VFA also decreased in the under- and normal weight conscripts (Mikkola *et al.* 2009). The improvement in aerobic and muscular fitness correlated significantly with the decreases in weight, WC, BMI, FM, body fat% and VFA in the whole study population (Cederberg *et al.* 2011).

A study conducted in the setting of 7-weeks of standard military training among conscripts in Switzerland detected improvements in both muscular and aerobic fitness, and an even greater improvement was observed in a comparison group with standard and additional circuit fitness training for once a week for 60 minutes (Hofstetter *et al.* 2012). Similar results have also been observed in Norwegian Home Guard personnel (Aandstad *et al.* 2014), U.S. Army personnel (Harman *et al.* 2008, Heinrich *et al.* 2012), Croatian Military recruits (Sporis *et al.* 2014) and British Army personnel (Williams 2005).

In a study by Warr *et al.* (2013) the greatest improvement in muscular fitness and reduction in body fat% (-16%) was observed among soldiers of National Guard, especially among those reporting aerobic and strength training at least three times a week during deployment. In a study of Croatian conscripts, low levels of physical fitness at baseline associated with the improvement in both aerobic and muscular fitness during a 5-week training program of basic military training and continuous endurance and relative strength training (Sporis *et al.* 2014). A study of 140 Finnish conscripts observed a significant inverse correlation between aerobic and muscular fitness with BMI, FM and body fat% (Mattila *et al.* 2007)

A study set against the background of a 6-month active operational deployment of British military personnel observed mean reductions in BMI (-1.4 kg/m<sup>2</sup>,) and body fat% (-2.6%) over the six months. The aerobic fitness level remained stable, while muscular fitness improved. The study was performed in a strict and severe environment, with daily energy expenditure being higher than energy intake. (Fallowfield *et al.* 2014) A further study that employed restricted calorie intake was performed in a group undergoing an 8-week period of intensive military training for the U.S. Army Rangers. Body mass and FM decreased by -

13% and -50%, respectively. However, the unfavorable result of weakening of muscle fitness was also seen (Nindl *et al.* 2007).

### ***Diet***

In a study with a Finnish military setting the consumption of unhealthy food items (candy, chocolate, soft drinks, fast food) was inversely correlated with conscripts' BMI at the beginning of the military service. Participants with lower BMI consumed unhealthy food items more often than those with higher BMI. (Bingham *et al.* 2010) At baseline the consumption of fiber-rich and sugary products correlated negatively with BMI, WC and body fat%, and additionally sugary products correlated negatively with weight and FM, which was surprising finding of this study. The PA and young age may be potentially compensate the unbeneficial effects of consumed unhealthy food (Bingham *et al.* 2012a). At the 6-month follow-up the conscripts' consumption of fiber-rich and sugary products correlated negatively with FM. The usage of sugar-rich food correlated negatively with weight, BMI, WC and muscle mass. (Bingham *et al.* 2012a). In a small randomized trial performed in active-duty members in U.S. Air Force a significant reduction in BMI and an improvement in maximum oxygen consumption were detected in participants subject to both exercise and dietary intervention, the results were more pronounced in these participants than in those who were subject to exercise alone (Gambera *et al.* 1995).

### ***Smoking***

Smoking has been shown to be inversely associated with aerobic fitness (Stea *et al.* 2009) and  $VO_{2max}$  (Dyrstad *et al.* 2005) in Norwegian conscripts. In a recent study by Hamari *et al.* (2010) performed among a military population in Northern Finland, mean BMI was slightly higher in regular smokers than in non-smokers (23.6 kg/m<sup>2</sup> vs. 23.1 kg/m<sup>2</sup>) and Cooper test results significantly lower (2376.6 m vs. 2537.1 m). Similar results were recorded in a study of 18,537 U.S. Navy personnel (Macera *et al.* 2011). Furthermore, the cardiorespiratory fitness of the smokers decreased over four years to a significantly greater extent than non-smokers who served as reference (Macera *et al.* 2011). There are studies reporting the opposite as current smokers tend to be leaner than to non-smokers (Miedinger *et al.* 2006, Sherrill-Mittleman *et al.* 2009). In the Sodankylä Jaeger Brigade

study there were no significant differences between smokers and non-smokers in terms of body composition changes during military service (Mikkola *et al.* 2009).



### **3 Aims of the study**

The aim of this study was to evaluate the changes in conscripts' body composition, physical fitness and cardiometabolic risk factors during military service. Additionally, the aim was to investigate antenatal and pre-military lifestyle factors as modifiers for physical fitness and body composition among young men.

More precisely the aims of this study were as follows:

1. To evaluate whether changes in body composition during military service are associated with a reduction in the prevalence of metabolic syndrome, and whether the prevalence change of MetS is dependent on baseline BMI (I).
2. To determine whether maternal pre-pregnancy BMI, gestational weight gain and maternal smoking during pregnancy are associated with the aerobic fitness of young males entering the military service (II).
3. To investigate the role of pre-military lifestyle factors and changes in diet, alcohol consumption, smoking and physical exercise habits on changes in body composition during military service (III).



## **4 Methods**

### **4.1 The Sodankylä study population**

In 2005 1,467 men began their military service in the Sodankylä Jaeger Brigade, Finland. Data were collected at the beginning of military service and at the end (after 6, 9 or 12 months, depending on the duration of service). The entire study population was of Caucasian origin with a mean age of 19.2 years (standard deviation, SD 1.0, range 18–28). A total of 1,160 (79%) of all the invited conscripts attended the baseline visit and gave their written consent for the use of collected data for scientific purposes. During the follow-up period 140 discontinued their military service, mainly due to physical or psychological reasons. These conscripts did not differ significantly by BMI from the study cohort (Mikkola *et al.* 2009). All female participants (n=15) were invited to participate in the current study, however due to small number of female participants they were excluded from the analysis. Evaluable data were available for between 983 and 1046 participants, depending on the measured parameter.

The service time depends on the training and tasks required from each conscript. Of our study cohort, 58% served the minimum of 6 months (privates), 9% for 9 months (soldiers requiring special knowledge and skills) and 33% for 12 months (officers, non-commissioned officers, and soldiers requiring special professional skills).

### **4.2 Study protocol**

Data on participants' background and health behavior (PA, diet, smoking and alcohol consumption) were collected via questionnaires during a baseline visit that also included a clinical examination. Data from anthropometric, body composition, biochemical and fitness tests were collected both at the baseline and 6, 9 and 12 months follow-up visits by trained personnel.

#### **4.2.1 Anthropometric measurements**

Waist circumference (cm) was measured midway between the lowest rib and the iliac crest. Weight was measured in light clothing to within 0.1 kg accuracy and height was measured to within 5 mm accuracy. BMI was calculated by dividing

body weight (kg) with the square of the height (m<sup>2</sup>) to provide a value expressed in kg/m<sup>2</sup>.

#### **4.2.2 Body composition**

Body composition was evaluated using the InBody720 multifrequency bioelectric impedance analysis device (Biospace, Korea). BIA is a suitable method for analysing body composition in large epidemiological studies, due to its cost effectiveness, simple implementation and non-invasive nature. (Hu 2008)

The device measures the electrical resistances of parts of the subject's body, normally within the range of frequencies from 1 kHz to 1 MHz. A lower level of frequencies (1–50 kHz) is considered to flow within the extracellular compartment, and higher frequencies ( $\geq 200$  kHz) into the intracellular compartment. For analysis purposes, the body is considered to be formed of five interconnecting cylinders (arms, trunk and legs) and the analysis is based on assessing the four components of the body: total body water, proteins, minerals and body fat, using a tetrapolar eight-point tactile electrode system. (Ling *et al.* 2011) Further variables can then be extrapolated from the initial analysis: fat mass (FM, kg), body fat percentage (fat %), skeletal muscle mass (SMM, kg) and skeletal lean body mass (SLBM, kg).

Participants' personal information (measured height, gender and age) was entered into the BIA device at the beginning of the measurement. During the 1.5 minute of measurement, participants were instructed to grasp the device's hand electrodes so that the thumb was placed on top of the handgrip, while the fingers were holding the bottom of it. The participants were asked to straighten their elbows, and to leave some space between the armpits and the body (at an approximately 15 degree lateral abduction) and to stand silently in place.

The BIA method is considered to be accurate as compared to DEXA (Malavolti *et al.* 2003). It is also a good method for analysis of total body water (Bedogni *et al.* 2002). A good correlation ( $r=0.87$ ) of total body fat % has been observed with BIA as compared to DEXA (Pietrobelli *et al.* 2004).

#### **4.2.3 Biochemical measurements**

Physicians and trained medical assistants took venous blood samples after overnight fasting, centrifuged them at 1500 x g for 15 min to separate serum from blood and then froze them at – 20 C. Biochemical assessments were performed in

the laboratory of the Oulu Deaconess Institute using a commercially available hexokinase (HK) assay (glucose), homogenous enzymatic test (HDL cholesterol), enzymatic calorimetric test (triglyceride) and other enzymatic tests (total and low-density lipoprotein (LDL) cholesterol) (Konelab™ analyzers, Thermo Electron Oy, Vantaa, Finland) according to national quality standards.

#### **4.2.4 Blood pressure**

Blood pressure (systolic and diastolic) levels were measured by a trained observer with an automated device (Omron Healthcare, model HEM-757, Japan) after subjects had rested for 10 minutes in a sitting position.

#### **4.2.5 Health behavior**

##### *Physical activity*

Physical activity at the beginning of military service was evaluated by questionnaires (Jackson *et al.* 1990). The participants were instructed to evaluate their PA during the previous month and rate the PA on a scale of 0–7. PA was rated as follows: no regular PA=0–1, moderate intensity activity=2–3 and vigorous intensity activity=4–7 (Matthews *et al.* 1999).

##### *Diet*

Diet was evaluated with a six-point food frequency questionnaire (Laitinen *et al.* 2004). A healthy diet index was formed based on the frequency of consumption of rye bread/crisp bread, porridge, low-fat cheese, fish, chicken, fresh or cooked vegetables, cooked potatoes, fruit and fresh or frozen berries (10 food items). The frequency of consumption of healthy foods was defined as follows:  $\geq 2$  times/week for berries and fish and 5–6 times/week or more often for other items (Jääskeläinen *et al.* 2015). The unhealthy diet index was composed of frequent consumption of doughnuts, hamburgers, pizzas, snacks, sugar-sweetened beverages, chocolate and candies. Unhealthy food items consumed  $\geq 2$  times/week was defined as frequent consumption. The unhealthy and healthy eating diet index was calculated based on the sum of the components: less frequent consumption (zero points) or more frequent consumption (one point).

## *Smoking*

Smoking status was determined with a questionnaire. The assessment was based on four smoking-related questions: “Have you ever smoked?”; “Have you ever smoked regularly, almost daily for at least a year?”; “Do you currently smoke?” and “When was the last time you smoked?”. The respondents were classified as current smokers and non-smokers based on their smoking status at baseline. The definition of the groups was as follows: those who smoked regularly or whose last smoke was today or yesterday were considered current smokers. Those who had quit smoking more than a month ago were considered non-smokers. Those who had never smoked regularly for at least a year were considered non-smokers.

## *Alcohol consumption*

Alcohol consumption was evaluated from questionnaires, with a continuous (grams/week) and categorical variable (not at all, at least once a month and at least once a week) (Sourander *et al.* 2012). The assessment was based on questions related to alcohol consumption: “How often do you drink alcohol beverages?” and “How many alcohol beverages do you usually drink at a time?”. Conscripts reported their alcohol consumption (beer, cider, wine and spirits), drinking frequency and number of units. Based on questionnaire data, binge drinking was categorized as consumption of  $\geq 6$  units of alcohol at a time, as one unit containing approximately 12 grams of pure alcohol.

### **4.2.6 Physical fitness**

#### *Aerobic fitness*

Aerobic fitness was measured with the standardized 12-minute running test (Cooper test), which was primarily developed for military purposes. The participants were advised to run 12 minutes with maximal effort and the test result was reported within 10 meters' accuracy (Cooper 1968). The correlation coefficients are 0.84–0.92 relative to maximal exercise and direct gas analyses (Cooper 1968, Grant *et al.* 1995), providing a good estimation of the  $\dot{V}O_{2\max}$ . Participants' aerobic fitness was categorized as ‘very good’ (Cooper test  $\geq 3,000$  m); ‘good’ (Cooper test 2,600 – 2,999 m); ‘satisfactory’ (Cooper test 2,200 – 2,599) and ‘poor’ (Cooper test  $<2,200$  m).

## ***Muscular fitness***

The muscle fitness index (MFI) is calculated based on the result of five muscle tests (Santtila *et al.* 2006). A back-muscle test and sit-ups were used to assess the endurance of abdominal, hip-flexor and back muscles. Explosive muscle strength was assessed with a standing long jump test, and push- and pull-ups were used to assess the upper extremities. Each within one-minute the participants were instructed to perform the maximum amount of repetitions of sit-ups, back-muscle test, push-ups and pull-ups, and their longest jump in the standing long jump was also recorded. (Taanila *et al.* 2010) The results were recorded to the accuracy of the nearest repetition and for the long jump, to the nearest one cm. A five-minute recovery break was taken between the individual components. For study purposes, muscle fitness was categorized for each test component as: 0=poor, 1=satisfactory, 2=good, 3=very good. Total MFI was calculated as the sum of components and categorized as 0–4=poor, 5–8=satisfactory, 9–12=good and 13–15=very good. (Santtila *et al.* 2006)

### **4.2.7 Metabolic syndrome**

Metabolic syndrome was defined using the International Diabetes Federation criteria (Alberti *et al.* 2006). The components of the IDF criteria for MetS included blood pressure  $\geq 130/85$  mmHg, HDL cholesterol level  $< 1.03$  mmol/l, total triglyceride level  $\geq 1.7$  mmol/l, or fasting plasma glucose  $\geq 5.6$  mmol/l. Abdominal obesity was defined as WC  $\geq 94$  cm. The criteria for having MetS was defined as the presence of abdominal obesity with two or more of the other components.

### **4.2.8 Ethical consideration**

Participants were given oral and written information about the aims and methods of the study. They gave their written consent for using the collected data for scientific purposes. The study protocol was approved by the Ethics Committee of Lapland Central Hospital, Rovaniemi, Finland.

### **4.3 The Northern Finland Birth Cohort 1986 study population**

The Northern Finland 1986 Birth Cohort is a longitudinal, population-based cohort of participants who were expected to be born in the two northernmost provinces of Finland between July 1, 1985 and June 30, 1986. The number of live-born infants in the cohort numbered 9432. In the year 2005, 508 participants of the NFBC 1986 began their military service at Sodankylä Jaeger Brigade, and comprise of the subpopulation in Article II.

### **4.4 The Northern Finland Birth Cohort 1986 study protocol**

Data for the NFBC 1986 were collected antenatally from the 12th gestational week onwards, at birth and follow-up at the age of 15–16 years. Females were excluded from the current analyses, as the prospective analysis was based on data on males.

#### **4.4.1 Pre- and postnatal factors**

At pre- and postnatal visits at the maternity clinics data were collected concerning: maternal pre-pregnancy weight (kg), GWG (kg), gestational weeks, smoking status during pregnancy, birth weight (kg), paternal smoking status (yes/no) and maternal education level (comprehensive school, vocational school and secondary school graduate). Appropriate GWG was defined based on pre-pregnancy BMI using the IOM 2009 recommendations: recommended GWG for underweight ( $<18.5 \text{ kg/m}^2$ ) 12.5–18 kg; normal weight ( $18.5 - 24.9 \text{ kg/m}^2$ ) 11.5 - 16 kg, overweight ( $25.0 - 29.9 \text{ kg/m}^2$ ) 7 - 11.5 kg and obese ( $\geq 30.0 \text{ kg/m}^2$ ) 5 - 9 kg, (Institute of Medicine and National Research Council Committee to Reexamine IOM Pregnancy Weight Guidelines, US 2009). For the purposes of the present study, maternal GWG was categorized as ‘appropriate’ (within the limits) or ‘excessive’.

Maternal smoking was categorized into three groups: non-smoking, stopped smoking during pregnancy, or continued smoking during pregnancy (one or more cigarettes/day). Extent of maternal smoking during pregnancy was defined as the number of smoked cigarettes per day at the end of the second gestational month. The birth size was classified by the  $\pm 2$  SDs of the sex- and gestational age-specific cohort distributions as appropriate for gestational age (AGA), small- (SGA) or large- (LGA) for gestational age. (Pirkola *et al.* 2010)



#### **4.4.2 Follow-up examination at the age of 15–16 years**

At the follow-up in 2001–2002 the clinical examination was conducted when the offspring reached the age of 15–16 years, and reported a participation rate of 80%. Data on health behavior were collected by questionnaires. Smoking exposure during adolescence (yes/no) was evaluated from adolescent and parent questionnaires (including own smoking at 15–16 years age, spending time in a smoky environment >0 h/day and maternal or paternal smoking).

The amount of previous PA was asked with the question "How much do you participate in a) brisk and b) light physical activity outside school hours?" Brisk activity was classified as PA that caused at least some sweating and shortness of breath. Light activity was considered as PA that causes no sweating or shortness of breath. These values were changed to hours per week and moderate-to-vigorous PA was classified into five categories: inactive (less than half an hour of brisk PA and less than two hours of light PA/week), lightly active (one hour of brisk PA or less than half an hour of brisk PA together with more than two hours of light PA/week), moderately active (two to three hours of brisk PA/week), active (four to six hours of brisk PA/week) and very active (more than six hours of brisk PA/week). (Auvinen *et al.* 2007)

#### **4.4.3 Ethical consideration**

The NFBC 1986 study was approved by the ethical committee of the Northern Ostrobothnia Hospital District, Finland.

### **4.5 Statistical analysis**

#### *Changes in prevalence of metabolic syndrome (Article I)*

BMI was categorized according to World Health Organisation as follows: underweight (BMI <18.5 kg/m<sup>2</sup>), normal weight (BMI 18.5 - 24.9 kg/m<sup>2</sup>), overweight (BMI 25 - 29.9 kg/m<sup>2</sup>) and obese (BMI ≥30 kg/m<sup>2</sup>) The presence of MetS during follow-up was categorized into four subgroups based on the IDF criteria: no MetS, recovered from MetS, developed MetS and maintained MetS from baseline to follow-up.

Changes in body composition, physical fitness and biochemical measurements from baseline to follow-up in different MetS and BMI subgroups

were evaluated with paired t-tests. Continuous variables are presented as mean (standard deviation [SD]), and categorical variables are presented as percentages.

A continuous MetS Z- score was calculated by transforming the original metabolic variables (i.e. WC, HDL, systolic and diastolic blood pressure, and log-transformed glucose and triglycerides) into standardized Z-scores for each individual and then summing the Z-scores. Linear regression analysis was performed to examine the association of weight, BMI, body fat% and FM, smoking and exercise performance with MetS Z-score. A p value <0.05 was considered statistically significant. Multiple testing adjusted p-values (also known as false discovery rate q values) were computed using Benjamini-Hochberg (BH) corrections (Benjamini Y. 1995). Statistical analysis was performed using SAS version 9.2 for Windows (SAS Institute, Inc. Cary, NC).

### *Associations between gestational factors and offspring aerobic fitness (Article II)*

Data are presented as mean and SD or mean and 95% confidence interval (CI) for continuous variables and as proportions for categorical variables. The student's two-tailed test and analysis of variance (ANOVA) were used to assess the significance of differences in continuous variables. A test for linear trends was performed using contrast analysis.

Multivariate linear regression was used to analyze associations between of Cooper test results (dependent variable) and the following independent variables: maternal BMI and GWG, maternal and paternal smoking status during pregnancy, maternal education level, smoking exposure during youth, PA at the age of 15–16 years, conscript's BMI, and conscript's smoking habits. Maternal pre-pregnancy BMI, GWG and conscript's BMI were centred for their mean values in the model. The Sobel test (Sobel 1982) was used to assess the mediation (direct effect, indirect effect and total effect were calculated for each mediation model).

A p-value <0.05 was considered statistically significant. The statistical analyses were performed using SAS (version 9.3) software for Windows.

### *Associations between lifestyle factors and body composition changes (Article III)*

The characteristics of the study population are reported as frequencies and percentages. Continuous variables are presented as mean and SD or as median

and interquartile range. Relative weight change (%) was calculated as weight at baseline minus weight at follow-up, divided by weight at baseline.

The Kruskal-Wallis test was applied to alcohol consumption frequency and binge drinking data and Mann-Whitney U-test to smoking data in order to compare continuous variables. A  $X^2$ -test was used for categorical variables. Changes from baseline to the end of military service were evaluated using the paired t-test. Changes in body composition, alcohol consumption, diet, fitness and smoking were tested by ANCOVA adjusted for the baseline value of the pertinent variable. In pairwise comparison, subjects who reported no tobacco use, alcohol consumption or no binge-drinking served as control groups for pairwise comparison with subjects who reported these behaviors. Adjustments for multiple comparisons were performed using the Dunnett post hoc test.

Mediation analysis (Preacher & Hayes 2008) was used to evaluate associations between binge drinking and alcohol consumption frequency (independent variables) with changes in body fat% and relative weight (dependent variables) with Cooper test result, unhealthy diet and alcohol consumption (grams/week) as mediators of potential modifying effects. Direct and indirect effects were calculated for each mediation model. Indirect effects and 95% CIs were calculated from 5000 bootstrapping samples. The mediation analysis was also performed with the following confounding factors: smoking, baseline BMI and length of service. Length of service was categorized as two groups: 6 (reference) and 9–12 months.

Multivariate linear regression was used to analyse the association between changes in body fat% and relative weight (%) and alcohol consumption frequency and binge drinking. The following confounding factors were included in the model: smoking, change in Cooper test result, change in unhealthy diet, change in alcohol consumption (grams/week), baseline BMI and length of service. The statistical analyses were performed using SAS 9.4 (SAS Institute, Inc., Cary, NC) and Stata 13 (Stata Corp. 2013. Stata: Release 13. Statistical Software. College Station, TX: Stata Corp LP) for Windows. A p value < 0.05 was considered statistically significant.



## 5 Results

### 5.1 The characteristics of the study population (Articles I and III)

The mean age of the participants was 19.2 years (SD 1.0, age range 18–28) and evaluable data were available for between 983 and 1046 participants, depending on the measured parameter. The participants were distributed into BMI classes as follows: underweight 3%, normal weight 63%, overweight 25% and obese 9%. Table 2 presents the study populations' anthropometrical measurements, body composition and physical fitness measurements at baseline and changes at follow-up. A slight non-significant reduction in the prevalence of overweight (from 25% to 24%,  $p=0.463$ ) was observed, however, the prevalence of obesity decreased during military service from 9% to 5% ( $p<0.001$ ).

**Table 2. Characteristics of the Sodankylä Jaeger Brigade study population at baseline and changes during follow-up.**

Variable	Baseline (SD)	Change (SD)
Weight (kg)	75.2 (14.0)	-0.4 (5.2)
Height (cm)	177.2 (6.3)	0.7 (1.2)
BMI (kg/m <sup>2</sup> )	23.9 (4.1)	-0.3 (1.7)
Waist circumference (cm)	81.8 (10.4)	0.1 (5.8)
Fat mass (kg)	13.6 (9.4)	-1.3 (4.7)
Body fat%	16.9 (8.3)	-1.1 (4.6)
Skeletal muscle mass (kg)	34.9 (4.3)	0.6 (1.5)
Skeletal lean body mass (kg)	58.2 (6.8)	0.8 (2.3)
12-min running test (m)	2475 (417)	172 (268)
Muscle fitness index (points)	8.0 (3.9)	1.5 (2.3)
Push-ups	31.7 (12.4)	4.6 (9.7)
Pull-ups	7.6 (4.9)	0.7 (2.7)
Back muscle test	61.8 (16.8)	7.4 (17.8)
Sit-ups	36.3 (10.3)	3.5 (8.1)
Standing long jump (cm)	214.5 (28.1)	1.5 (24.9)

BMI, body mass index. All data are mean (SD) unless otherwise specified.

### 5.2 Prevalance of metabolic syndrome and change during military service (Article I)

Evaluable MetS data at both baseline and follow-up were available for 1046 subjects. At baseline the prevalence of MetS in the overall cohort was 6.1%

(64/1046) and it was present only in overweight (7.7%) and of obese (52.4%) subjects, in addition completely absent in under- and normal-weight subjects.

The prevalence of MetS in the overall cohort decreased significantly from 6.1% to 3.6% during the 6–12 month follow-up period ( $p<0.001$ ). The prevalence of MetS among overweight young men fell from 7.7% to 3.8%, and in obese subjects from 52.4% to 31.5% ( $p<0.001$ ). Only two participants (0.3%) of the normal weight category developed MetS during the follow-up, and it appeared in none of the underweight participants.

### ***5.2.1 Changes in metabolic syndrome categories during military service (Article I)***

MetS status was divided into four categories: No MetS ( $n=965$ ), recovered from MetS ( $n=43$ ), developed MetS ( $n=17$ ) and maintained MetS ( $n=21$ ). Table 3 shows anthropometric measurements, body composition, biochemical measurements and physical fitness by the categories of MetS status at baseline and change from baseline.

There were observed a significant weight loss among participants who recovered from MetS and those with MetS ( $p=0.002$ ). A significant decrease in body fat % and FM was observed among all subgroups ( $p\leq 0.019$ ). The mean baseline weight of the conscripts who maintained MetS was 105.7 kg and the mean weight loss was 5.0 kg. The Cooper test and MFI improved significantly in all groups except in the group who maintained MetS in the follow-up.

**Table 3. Anthropometrics, body composition, biochemical measurements and physical fitness at baseline and change from baseline by metabolic syndrome status. (Article I, published by permission of Elsevier).**

Variable	No MetS throughout follow-up (N=965)			Developed MetS during follow-up (N=17)			Recovered from MetS during follow-up (N=43)			MetS throughout follow-up (N=21)		
	Baseline	Change	p <sup>1</sup>	Baseline	Change	p <sup>1</sup>	Baseline	Change	p <sup>1</sup>	Baseline	Change	p <sup>1</sup>
	Weight (kg)	72.8 (11.3)	0.0 (4.7)	0.837	102.4 (15.8)	-2.0 (7.8)	0.424	99.6 (10.1)	-8.1 (6.4)	0.002	105.7 (9.2)	-5.0 (5.1)
Waist circumference (cm)	79.9 (8.3)	0.5 (5.5)	0.008	100.6 (12.8)	0.1 (8.4)	0.944	101.8 (6.1)	-8.0 (5.5)	0.004	103.6 (6.8)	-2.0 (6.4)	0.236
Body fat%	15.4 (6.9)	-0.7 (4.4)	0.001	30.4 (7.9)	-2.8 (3.9)	0.012	31.3 (5.1)	-7.0 (4.2)	0.001	32.9 (5.9)	-5.3 (3.9)	0.001
Fat mass (kg)	11.8 (6.9)	-0.8 (4.2)	0.001	32.0 (12.4)	-4.1 (6.2)	0.019	31.3 (7.5)	-8.8 (5.5)	0.001	35.1 (8.8)	-7.0 (5.5)	0.001
Skeletal muscle mass (kg)	34.5 (4.2)	0.6 (1.5)	0.004	40.0 (4.7)	1.0 (2.3)	0.105	38.8 (3.9)	0.4 (1.5)	0.105	40.2 (3.0)	1.3 (1.7)	0.006
Lean Body mass (kg)	57.7 (6.6)	0.7 (2.3)	0.004	66.4 (7.6)	1.5 (3.5)	0.127	64.3 (6.2)	0.5 (2.3)	0.149	66.6 (4.6)	1.8 (2.7)	0.012
Systolic blood pressure (mmHg)	128.0 (13.3)	-1.8 (13.2)	0.002	133.2 (12.5)	4.6 (10.6)	0.128	139.7 (10.4)	-8.8 (12.1)	0.002	141.9 (12.5)	-4.0 (14.5)	0.215
Diastolic blood pressure (mmHg)	69.0 (9.4)	2.4 (9.9)	0.004	75.1 (9.4)	2.9 (6.8)	0.131	78.2 (8.6)	-3.9 (9.9)	0.028	81.5 (9.3)	-1.0 (11.6)	0.704
Total serum cholesterol (mmol/l)	3.9 (0.8)	0.4 (0.8)	0.002	3.9 (0.8)	0.7 (0.7)	0.002	4.2 (1.1)	0.3 (1.1)	0.097	4.5 (1.0)	0.1 (1.0)	0.577
LDL-cholesterol (mmol/l)	2.2 (0.7)	0.2 (0.6)	0.004	2.4 (0.8)	0.1 (0.6)	0.707	2.7 (0.9)	0.1 (0.8)	0.707	2.9 (0.9)	-0.2 (0.9)	0.552
HDL-cholesterol (mmol/l)	1.3 (0.3)	0.1 (0.3)	0.002	1.1 (0.1)	0.2 (0.3)	0.043	1.0 (0.2)	0.2 (0.3)	0.002	0.9 (0.2)	0.1 (0.2)	0.047
Triglycerides (mmol/l)	0.8 (0.3)	0.4 (0.7)	0.004	0.9 (0.3)	1.1 (1.2)	0.004	1.1 (0.7)	0.2 (1.1)	0.209	1.2 (0.5)	0.9 (1.2)	0.008
Fasting plasma glucose (mmol/l)	5.2 (0.4)	0.2 (0.6)	0.004	5.3 (0.3)	0.3 (0.4)	0.004	5.5 (0.4)	-0.1 (0.5)	0.202	5.5 (0.4)	0.3 (0.8)	0.141
12-min running test (m)	2529 (388)	166 (317)	0.001	2053 (327)	183 (178)	0.001	2089 (243)	277 (228)	0.001	2005 (300)	136 (505)	0.283
Muscle fitness index (points)	8.4 (3.8)	1.5 (2.4)	0.002	3.6 (3.7)	2.3 (3.1)	0.024	4.2 (2.8)	2.1 (1.9)	0.002	4.2 (2.5)	0.9 (1.8)	0.060

Values are mean, SD. P from independent samples T-test. N=1046. <sup>1</sup>Multiple testing adjusted p-values were computed using Benjamini-Hochberg corrections.

### **5.2.2 Changes in anthropometrics, body composition, biochemical and physical fitness measurements in overweight and obese groups with recovery from metabolic syndrome during military service (Article I)**

Table 4 shows the changes from baseline in anthropometric measurements, body composition, biochemical measurements and physical fitness among the normal weight, overweight and obese groups with MetS status during follow-up. Significant weight loss, reduction in WC, FM and body fat% were seen in subjects in both the overweight and obese categories who recovered from MetS ( $p \leq 0.002$  for all; Table 4).

A significant reduction in systolic blood pressure was observed in all groups presented in Table 4. HDL cholesterol increased significantly and the improvement in aerobic and muscular fitness was also more pronounced ( $p < 0.05$ ) in the overweight and obese groups with recovery from MetS.

Body weight in the overweight and obese groups with no MetS fell by 3.0 kg and 9.9 kg, respectively during military service. The body fat% decreased by 3.3% in the overweight group and by 7.3% in the obese group with no MetS during follow-up. The Cooper test result improved by 215 m and the MFI improved by 1.8 points in subjects in the overweight group with no MetS. The Cooper test result improved by 319 m and the MFI improved by 2.9 points in the obese group with no MetS.



**Table 4. Changes in anthropometrics, body composition, biochemical measurements and physical fitness in overweight and obese groups with recovery from MetS during follow-up, and in normal-weight participants free of MetS. (Article I, published by permission of Elsevier).**

Variable	Normal weight (BMI=18.5-24.9 kg/m <sup>2</sup> )		Overweight (BMI=25-29.9 kg/m <sup>2</sup> )		Obese (BMI ≥ 30 kg/m <sup>2</sup> )	
	No MetS (N=665)		MetS recovered (N=16)		MetS recovered (N=27)	
	Change	p <sup>1</sup>	Change	p <sup>1</sup>	Change	p <sup>1</sup>
Weight (kg)	1.4 (3.4)	0.001	-8.5 (4.3)	0.001	-7.9 (7.4)	0.001
Waist circumference (cm)	1.7 (4.5)	0.001	-8.2 (4.1)	0.001	-7.9 (6.2)	0.001
Body fat%	0.4 (3.7)	0.010	-8.1 (4.0)	0.002	-6.3 (4.3)	0.002
Fat mass (kg)	0.4 (2.9)	0.001	-9.2 (4.3)	0.001	-8.5 (6.1)	0.001
Skeletal muscle mass (kg)	0.7 (1.5)	0.003	0.5 (1.2)	0.246	0.3 (1.7)	0.445
Lean Body mass (kg)	0.9 (2.3)	0.003	0.6 (1.8)	0.366	0.5 (2.6)	0.500
Systolic BP (mmHg)	-1.6 (13.3)	0.002	-12.9 (9.5)	0.004	-6.3 (13.0)	0.024
Diastolic BP (mmHg)	3.1 (9.9)	0.003	-6.1 (8.9)	0.030	-2.6 (10.4)	0.283
Total serum cholesterol (mmol/l)	0.5 (0.7)	0.003	0.3 (1.2)	0.500	0.3 (1.1)	0.226
LDL-cholesterol (mmol/l)	0.2 (0.6)	0.003	0.0 (0.9)	0.953	0.1 (0.7)	0.729
HDL-cholesterol (mmol/l)	0.1 (0.3)	0.003	0.2 (0.3)	0.013	0.2 (0.2)	0.002
Triglycerides (mmol/l)	0.4 (0.8)	0.003	0.5 (1.2)	0.216	0.0 (0.9)	0.937
Fasting plasma glucose (mmol/l)	0.2 (0.6)	0.003	-0.1 (0.5)	0.500	-0.1 (0.5)	0.500
12-min running test (m)	148 (309)	0.001	360 (262)	0.001	224 (191)	0.001
Muscle fitness index (points)	1.4 (2.4)	0.003	1.9 (2.1)	0.004	2.2 (1.8)	0.002

Values are presented as mean changes ( $\Delta$ ), SD. <sup>1</sup>Multiple testing adjusted p-values were computed using Benjamini-Hochberg corrections.

### ***5.2.3 Association between changes in the metabolic syndrome Z-score and changes in anthropometrics, body composition and physical fitness (Article I)***

Associations between changes in the metabolic syndrome Z-score (MetS Z-score) and changes in anthropometrics (weight, BMI), body composition (body fat%, FM) and physical fitness (12-minute running test, MFI) were evaluated by multivariate regression analysis (Table 5). The association between the reduction in the MetS Z-score with the weight loss and reduction in adiposity (body fat% and FM) was significant and remained so after adjustment for length of service, smoking and change in physical fitness ( $p < 0.001$ ). The association between improved MFI and reduction in MetS Z-score was statistically significant after the adjustment for length of service, smoking, weight change, and change in aerobic fitness (Cooper test) ( $p = 0.014$ ).

**Table 5. The association of changes in the metabolic syndrome Z-score with the changes in anthropometrics (weight, BMI), body composition (body fat%, fat mass) and physical fitness (12-minute running test, MFI) (Article 1, published by permission of Elsevier).**

Dependent variable	Unadjusted				Adjusted for smoking, length of service and change in weight and length of service				Adjusted for smoking, length of service and change in weight and Cooper/MFI			
	$\beta$	B (SE)	p		$\beta$	B (SE)	p		$\beta$	B (SE)	p	
MetS z-score												
Weight (kg)	0.317	0.179 (0.017)	<0.001	0.324	0.182 (0.017)	<0.001	-	-	0.344	0.201 (0.019)	<0.001	
BMI	0.301	0.501 (0.050)	<0.001	0.307	0.512 (0.050)	<0.001	-	-	0.332	0.568 (0.056)	<0.001	
Body fat%	0.301	0.186 (0.190)	<0.001	0.309	0.194 (0.019)	<0.001	-	-	0.307	0.191 (0.021)	<0.001	
Fat mass (kg)	0.298	0.188 (0.019)	<0.001	0.301	0.190 (0.020)	<0.001	-	-	0.313	0.207 (0.022)	<0.001	
12-min running test (per 100m)	-0.054	-0.062 (0.036)	0.089	-0.042	-0.048 (0.037)	0.198	0.048	0.037 (0.054)	0.139	0.064 (0.038)	0.090	
MFI (points)	-0.117	-0.149 (0.041)	<0.001	-0.129	-0.165 (0.041)	<0.001	-0.075	-0.097 (0.040)	0.016	-0.102 (0.041)	0.014	

Analyses are adjusted for baseline value of the independent variable, smoking, length of service and changes in weight (for MFI and 12-min running test), 12-min running test (for MFI, weight and fat mass) and MFI (for 12-min running test, weight and fat mass). Effect size is B coefficient (standard error, SE) and standardized beta ( $\beta$ ), calculated from linear regression analysis.

### 5.3 The baseline characteristics of the subpopulation (Article II)

The baseline characteristics of the subpopulation of the Sodankylä Jaeger Brigade study are presented in Table 6. Subpopulation of 508 offsprings' with parental and offspring characteristics demonstrate that 17% of mother's were overweight or obese in the beginning of the pregnancy, and 32% gained excessively weight during pregnancy. 12% of the mother's continued to smoke  $\geq 1$  cigarette/day during pregnancy. At the age of 16 years 43% of the adolescent's were physically very active or active.

In the beginning of the military service 28% of the participants were overweight or obese, and 40% of the participants smoked.

**Table 6. Baseline characteristics of the study subpopulation (n=508).**

Variable	n	%
Maternal BMI		
Underweight	43	8
Normal weight	382	75
Overweight	64	13
Obese	18	4
Excessive maternal weight gain during pregnancy		
No	353	68
Yes	164	32
Maternal smoking during pregnancy		
No	342	69
Stopped smoking	95	19
$\geq 1$ cigarette/day	59	12
Paternal smoking during pregnancy		
No	274	58
Yes	198	42
Maternal education level		
Comprehensive school	170	33
Vocational school	232	45
Secondary school graduate	115	22
Smoking exposure during youth		
No	126	31
Yes	279	69

Variable	n	%
Physical activity of the offspring at 16 years of age		
Very active	73	19
Active	94	24
Moderately active	109	28
Lightly active	96	24
Inactive	22	5
BMI on entrance to military service		
Underweight	17	4
Normal weight	324	68
Overweight	102	21
Obese	35	7
Smoking on entrance to military service		
No	266	60
Yes	178	40

### ***5.3.1 Anthropometrics and fitness measurements at the beginning of the military service (Article II)***

The mean weight, WC and Cooper test result of the young men varied significantly when stratified by maternal pre-pregnancy BMI group ( $p < 0.001$ ) (Table 7). The prevalence of maternal underweight and normal weight was 8.2% and 74.1%, respectively. The prevalence of overweight mothers were 13.7% and 4.0% were obese. The higher the maternal BMI before pregnancy, the higher the mean weight and WC of the young men were observed at the beginning of their military service.

The weight of conscripts whose mothers were overweight or obese before pregnancy and gained excessive weight during pregnancy was higher (83.9 kg, SD 18.0) than that of those whose mothers who were overweight or obese before pregnancy and whose weight gain was appropriate during pregnancy (74.6 kg, SD 18.0) ( $p = 0.008$ ) (Table 8).

**Table 7. Baseline variables presented as weight, waist circumference and physical fitness of conscripts according to maternal pre-pregnancy BMI-classification.**

Variable	Underweight		Normal weight		Overweight		Obese		ANOVA p-value			
	N=41 (8.2%)		N=369 (74.1%)		N=68 (13.7%)		N=20 (4.0%)		Overall	Underweight vs. Normal	Overweight vs. Normal	Obese vs. Normal
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)					
Weight (kg)	67.4 (10.8)	74.0 (13.5)	79.3 (16.6)	81.1 (16.5)	<0.001	0.004	0.004	0.004	0.027			
Waist circumference (cm)	77.5 (8.6)	81.1 (9.9)	84.5 (13.2)	86.4 (13.9)	0.001	0.035	0.017	0.017	0.028			
12-min running test (m)	2523 (294)	2496 (383)	2448 (353)	2235 (338)	0.024	0.647	0.348	0.348	0.004			
Muscle fitness index (points)	8.2 (3.8)	8.2 (3.7)	7.3 (3.8)	6.7 (3.8)	0.147	0.991	0.086	0.086	0.098			

P values present the differences between groups. Comparison to normal BMI was performed with Dunnett's post-hoc test.

**Table 8. Conscript's weight, waist circumference and physical fitness according to maternal pre-pregnancy BMI-classification and gestational weight gain at the baseline.**

Variable	Underweight		Normal weight		Overweight and obese		p
	Adequate <sup>1</sup> N=32 (78.0%) Mean (SD)	Excessive <sup>2</sup> N=9 (22.0%) Mean (SD)	Adequate <sup>1</sup> N=265 (71.8%) Mean (SD)	Excessive <sup>2</sup> N=104 (28.2%) Mean (SD)	Adequate <sup>1</sup> N=40 (45.5%) Mean (SD)	Excessive <sup>2</sup> N=48 (54.5%) Mean (SD)	
Weight (kg)	68.5 (10.9)	63.5 (9.9)	73.2 (13.2)	76.1 (14.2)	74.6 (13.0)	83.9 (18.0)	0.008
Waist circumference (cm)	78.1 (9.4)	75.3 (4.7)	80.7 (9.8)	82.2 (10.2)	81.6 (10.9)	87.6 (14.5)	0.034
12-min running test (m)	2539 (313)	2469 (222)	2528 (358)	2416 (430)	2537 (323)	2285 (351)	0.001
Muscle fitness index (points)	8.0 (3.8)	9.1 (3.8)	8.3 (3.7)	8.0 (3.9)	8.0 (3.8)	6.5 (3.8)	0.095

GWG: gestational weight gain: adequate<sup>1</sup> and excessive<sup>2</sup> P values present the differences between groups.

### 5.3.2 Associations between parental and offspring lifestyle factors and the aerobic fitness of offspring (Article II)

Associations between parental and offspring lifestyle factors and aerobic fitness at the beginning of military service are presented in Table 9.

Several factors were associated with the Cooper test result of offspring: Maternal pre-pregnancy BMI, excessive GWG, parental smoking during pregnancy, maternal education level, smoking exposure during adolescence, adolescents' PA at the age of 16 years, and conscript's BMI and smoking at the beginning of military service.

The mediation analysis showed that the associations of maternal pre-pregnancy BMI and GWG with the Cooper test result were mediated by the conscript's own BMI. The direct effect of maternal pre-pregnancy BMI on the Cooper test result of the conscript was 28% (regression coefficient of direct effect, -4.07,  $p=0.394$ ; regression coefficient of total effect, -14.02,  $p<0.001$ ). The direct effect of GWG on the Cooper test result of the conscript was 60% (regression coefficient of direct effect, -5.51,  $p=0.092$ ; regression coefficient of total effect, -9.20,  $p=0.011$ )

**Table 9. Conscript's baseline Cooper-test results by parental and offspring characteristics. (Article II, published by permission of John Wiley and Sons).**

Variable	n	Mean m (95 % CI)	p
Birth weight for gestational age			0.488
Small (SGA)	14	2476 (2323-2628)	
Appropriate (AGA)	448	2498 (2464-2532)	
Large (LGA)	16	2386 (2171-2602)	
Maternal BMI			0.003
Underweight	43	2523 (2433-2613)	
Normal weight	382	2502 (2466-2538)	
Overweight	64	2448 (2360-2537)	
Obese	18	2235 (2067-2403)	
Excessive weight gain during pregnancy			<0.001
No	353	2526 (2489-2564)	
Yes	164	2399 (2344-2454)	



Variable	n	Mean m (95 % CI)	p
Smoking during pregnancy			<0.001
No	342	2537 (2499-2574)	
Ceased smoking	95	2385 (2311-2459)	
≥1 cigarettes/day	59	2356 (2265-2446)	
Paternal smoking during pregnancy			<0.001
No	274	2522 (2478-2567)	
Yes	198	2424 (2377-2471)	
Maternal education level			0.001
Comprehensive school	170	2434 (2381-2486)	
Vocational school	232	2472 (2423-2520)	
Secondary school graduate	115	2592 (2530-2655)	
Smoking exposure during youth			0.002
No	126	2586 (2521-2651)	
Yes	279	2464 (2424-2505)	
Physical activity of the offspring at 15–16 years age			<0.001
Very active	73	2693 (2603-2783)	
Active	94	2531 (2459-2603)	
Moderately active	109	2502 (2442-2561)	
Lightly active	96	2406 (2340-2472)	
Inactive	22	2297 (2181-2414)	
BMI on entrance to military service			<0.001
Underweight	17	2577 (2433-2721)	
Normal weight	324	2593 (2556-2629)	
Overweight	102	2351 (2292-2409)	
Obese	35	1955 (1875-2035)	
Smoking on entrance to military service			<0.001
No	266	2563 (2518-2607)	
Yes	178	2419 (2369-2468)	

Anova was used for comparison between groups.

According to the multivariate linear regression analysis a significant independent association was observed between maternal smoking and a lower Cooper test result ( $p=0.038$ ) (Table 10.). A lower Cooper test result was also independently associated with lower PA at the age of 16 years and conscripts' smoking and BMI.

**Table 10. Association between the change in the Cooper test result with parental and offspring lifestyle factors. (Article II, published by permission of John Wiley and Sons).**

Variable	B (95% CI)	$\beta$	p
Intercept	2817.0 (2663.2 – 2970.8)		<0.001
Maternal pre-pregnancy BMI, kg/m <sup>2</sup> <sup>1</sup>	4.5 (-8.7 – 17.7)	0.04	0.500
Gestational weight gain, kg <sup>1</sup>	-1.0 (-9.3 – 7.4)	-0.01	0.820
Maternal smoking			
Ceased smoking	-88.0 (-190 – 13.9)	-0.09	0.090
$\geq 1$ cigarettes/day	-140.6 (-273.1 – -8.0)	-0.11	0.038
Paternal smoking	-20.1 (-103.7 – 63.5)	-0.03	0.636
Maternal education level			
Comprehensive school	-57.3 (-169 – 54.3)	-0.06	0.313
Vocational school	-45.6 (-137.7 – 46.6)	-0.06	0.331
Smoking exposure during adolescence	-61.8 (-148.3 – 24.7)	-0.08	0.161
Physical activity in adolescence			
Active	-119.9 (-236.8 – -3.1)	-0.13	0.044
Moderately active	-129.8 (-241.6 – -17.9)	-0.15	0.023
Lightly active	-209.0 (-322.7 – -95.3)	-0.24	<0.001
Inactive	-247.2 (-445.4 – -49.0)	-0.14	0.015
BMI of conscript, kg/m <sup>2</sup> <sup>1</sup>	-39.4 (-49.0 – -29.8)	-0.43	<0.001
Smoking of conscript	-102.5 (-181.1 – -23.9)	-0.13	0.011

Effect size is B coefficient (95% confidence interval) and standardized beta ( $\beta$ ), calculated by linear regression. <sup>1</sup>Centered for mean of the study population (maternal BMI 22.3 kg/m<sup>2</sup>, gestational weight gain 14.1 kg, own BMI 23.6 kg/m<sup>2</sup>).

#### **5.4 The lifestyle characteristics of the study population (Articles I and III)**

The health behaviors of the Sodankylä Jaeger Brigade study population are presented in Table 11.

45.2% of the conscripts smoked at the beginning of military service, and alcohol consumption and binge drinking at least once a week were observed among 37.4% and 29.8 %, respectively.

**Table 11. Baseline characteristics of the study population (n=983) categorized according to lifestyle factors.**

Variable	n	%
Smoking		
No	530	54.8
Yes	437	45.2
Alcohol consumption frequency		
Not at all	240	24.4
≥ Once a month	375	38.1
≥ Once a week	368	37.4
Alcohol consumption (grams/week), median (IQ)	58.8 (16.8 - 156.4)	
Binge drinking		
Not at all	352	35.8
≥ Once a month	338	34.4
≥ Once a week	293	29.8
Leisure time physical activity		
Active	572	58.9
Moderately active	247	25.3
Inactive	154	15.8
Healthy diet index (points), median (IQ)	2.0 (1.0 - 3.2)	
Unhealthy diet index (points), median (IQ)	1.0 (0.0 - 3.0)	

Data are presented as number and percentage of the population, except for alcohol use, healthy and unhealthy diet index (given as median and interquartile range(IQ)).

#### **5.4.1 Body composition, fitness and lifestyle characteristics of the study population at baseline and changes during military service (Article III)**

During the study period, significant reductions were observed in BMI: 0.3 kg/m<sup>2</sup> (SD 1.7) and body fat%: 1.2% (SD 4.6) (Table 12.). In the group with binge drinking at least once a week at baseline, mean weight was 76.3 kg (SD 14.1) and mean body fat% was 14.6%. During the study, this group's weight fell significantly by 1.8 kg, body fat% by 2.3% and their median alcohol consumption decreased by 19.6 grams/week.

At baseline, the Cooper test result and MFI were lowest among those with binge drinking at least once a week (2434.6 m, SD 368.2 and 7.8 points, SD 3.7 respectively), though aerobic and muscular fitness improved most in the same

group during follow-up. The consumption of unhealthy food items was highest in the group with binge drinking at least once a week at the baseline, but the same group increased their consumption of healthy food items the most during military service. The prevalence of smoking in the group with binge drinking at least once a month was 46.2% and at least once a week 62.1%.

**Table 12. Smoking and alcohol consumption according to body composition, physical fitness, diet and alcohol consumption (grams/week) at baseline and change during military service.**

Variable	Weight (kg)		Body fat%		Cooper (m)		MFI (points)	
	Baseline	Change	Baseline	Change	Baseline	Change	Baseline	Change
Smoking								
No	74.6 (13.3)	0.2 (4.9) <sup>2</sup>	13.1 (8.8)	-0.8 (4.1)	2558 (432)	13.1 (25.3)	8.7 (4.0)	1.2 (2.2)
Yes	75.5 (14.3)	-1.4 (5.5) <sup>1</sup>	13.7 (9.6)	-2.1 (5.2) <sup>1</sup>	2441 (360) <sup>1</sup>	20.5 (26.3)	7.6 (3.7) <sup>1</sup>	1.8 (2.3) <sup>1</sup>
Alcohol consumption frequency								
Not at all	73.2 (13.4)	0.7 (4.9)	12.0 (8.9)	-0.4 (4.6) <sup>2</sup>	2603 (442)	13.1 (25.6)	8.6 (4.1)	1.3 (2.4)
≥ Once a month	75.7 (13.9) <sup>1</sup>	-0.4 (5.3) <sup>2</sup>	13.5 (9.4)	-1.4 (4.7) <sup>1</sup>	2500 (360) <sup>1</sup>	16.8 (24.9)	8.4 (3.8)	1.3 (2.1)
≥ Once a week	75.8 (13.9) <sup>1</sup>	-1.3 (5.2) <sup>1</sup>	14.3 (9.1) <sup>1</sup>	-2.0 (4.6) <sup>1</sup>	2448 (372) <sup>1</sup>	18.1 (27.1)	7.9 (3.8)	1.7 (2.3)
Binge drinking								
Not at all	73.5 (13.0)	0.7 (5.0)	12.3 (8.8)	-0.4 (4.5) <sup>2</sup>	2595 (431)	13.0 (25.9)	8.4 (4.1)	1.2 (2.4)
≥ Once a month	75.8 (14.2)	-0.6 (5.2) <sup>1</sup>	13.6 (9.4)	-1.6 (4.6) <sup>1</sup>	2474 (368) <sup>1</sup>	18.2 (25.1)	8.4 (3.8)	1.4 (2.2)
≥ Once a week	76.3 (14.1) <sup>1</sup>	-1.8 (5.2) <sup>1</sup>	14.6 (9.2) <sup>1</sup>	-2.3 (4.7) <sup>1</sup>	2435 (368) <sup>1</sup>	18.3 (26.6)	7.8 (3.7)	1.8 (2.3)

Variable	Alcohol consumption (grams/week)		Healthy diet (points)		Unhealthy diet (points)	
	Baseline	Change	Baseline	Change	Baseline	Change
<b>Smoking</b>						
No	46.2 (9.3,98.5)	0.0 (-10.5,23.6) <sup>2</sup>	2.7 (1.9)	0.4 (1.8)	1.6 (1.6)	0.5 (1.7)
Yes	102.9 (37.8,194.6) <sup>1</sup>	0.4 (-39.6,51.8) <sup>2</sup>	2.2 (1.7) <sup>1</sup>	0.7 (1.9)	1.9 (1.6) <sup>1</sup>	0.4 (1.8)
<b>Alcohol consumption frequency</b>						
Not at all	0.7 (0.0,9.8)	0.0 (0.0,14.7)	2.8 (2.0)	0.3 (1.9)	1.6 (1.5)	0.6 (1.7)
≥ Once a month	51.8 (32.2,81.9) <sup>1</sup>	9.1 (-12.1,40.1)	2.5 (1.7)	0.5 (1.8)	1.6 (1.6)	0.5 (1.7)
≥ Once a week	176.4 (116.2,279.1) <sup>1</sup>	-11.9 (-81.2,40.1)	2.2 (1.8) <sup>1</sup>	0.7 (1.8)	1.9 (1.7) <sup>1</sup>	0.4 (1.9)
<b>Binge drinking</b>						
Not at all	7.7 (0.0,18.9)	0.0 (0.0,21.0)	2.7 (2.0)	0.4 (1.8)	1.5 (1.4)	0.6 (1.6)
≥ Once a month	64.8 (46.4,92.4) <sup>1</sup>	5.6 (-19.6,49.0)	2.5 (1.8)	0.5 (1.9)	1.7 (1.7)	0.4 (1.8)
≥ Once a week	198.1 (158.9,350.7) <sup>1</sup>	-19.6 (-116.2,39.9) <sup>1</sup>	2.1 (1.6) <sup>1</sup>	0.7 (1.8)	2.0 (1.8) <sup>1</sup>	0.3 (1.9)

Values present the mean (SD) in baseline and change (except for the alcohol consumption median and interquartile range). Pairwise comparison with 'no' or 'not at all' group as control, <sup>1</sup>p<0.05. The change was adjusted for baseline value of current variable. <sup>2</sup>The significance of the change (within groups) during military service is marked as non-significant, otherwise significant. Abbreviations: Body fat%; body fat percentage, Cooper: 12-minute running test, MFI: muscle fitness index.

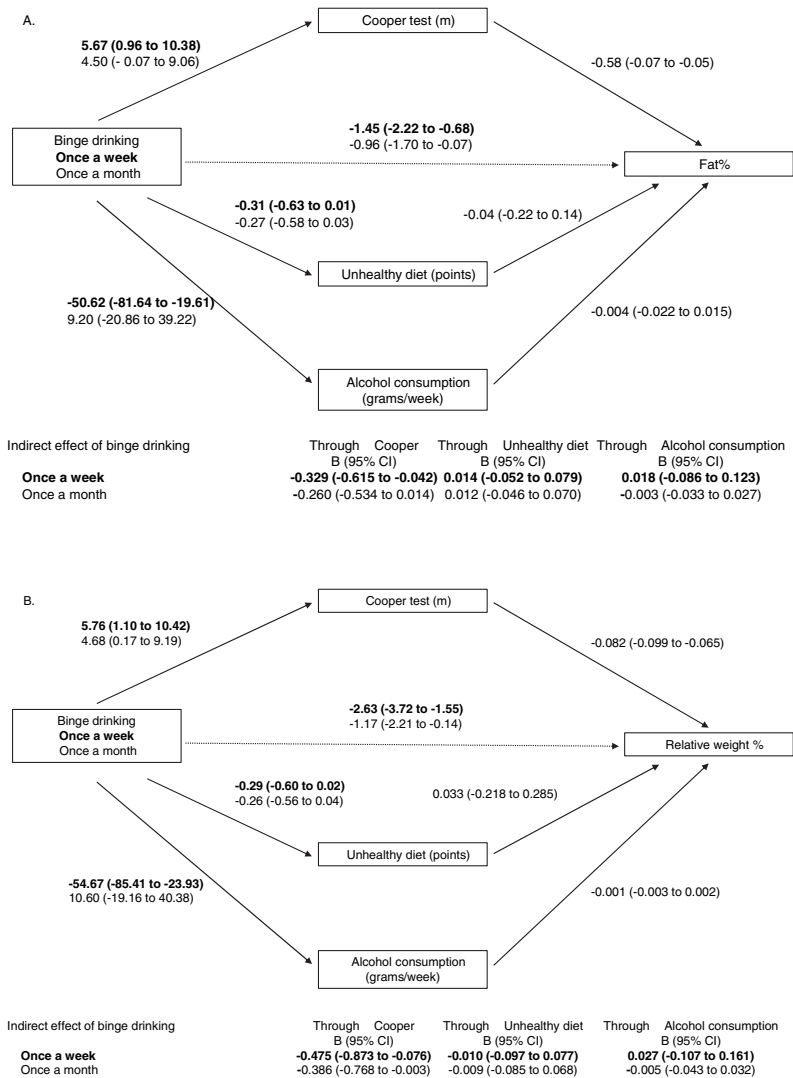
#### **5.4.2 Association between alcohol consumption frequency and binge drinking and changes in body fat% and relative weight during military service (Article III)**

In the mediation analysis, the association of weekly binge drinking with the change in body fat% (Figure 1A) was mediated by changes in Cooper test result (regression coefficient -0.329, 95% CI -0.615 to -0.042). The association of binge drinking with relative weight change (Figure 1B) was significantly mediated by change in Cooper test result (binge drinking at least once a week -0.475, 95% CI -0.873 to -0.076, and at least once a month regression coefficient of indirect effect -0.386, 95% CI -0.768 to -0.003, respectively). Changes in Cooper test result did not mediate the association of alcohol consumption frequency with changes in body fat% and relative weight. Additionally, changes in unhealthy diet and alcohol consumption did not mediate the association between binge drinking or alcohol consumption frequency and changes in body fat% and relative weight (Figure 1 and 2).

Binge drinking had a direct effect on changes in body (Figure 1A) (at least once a week; regression coefficient -1.45, 95% CI -2.22 to -0.68, and at least once a month regression coefficient -0.96, 95% CI -1.70 to -0.07), and also on relative weight (Figure 1B) (at least once a week; regression coefficient -2.63, 95% CI -3.72 to -1.55, and at least once a month regression coefficient -1.17, 95% CI -2.21 to -0.14).

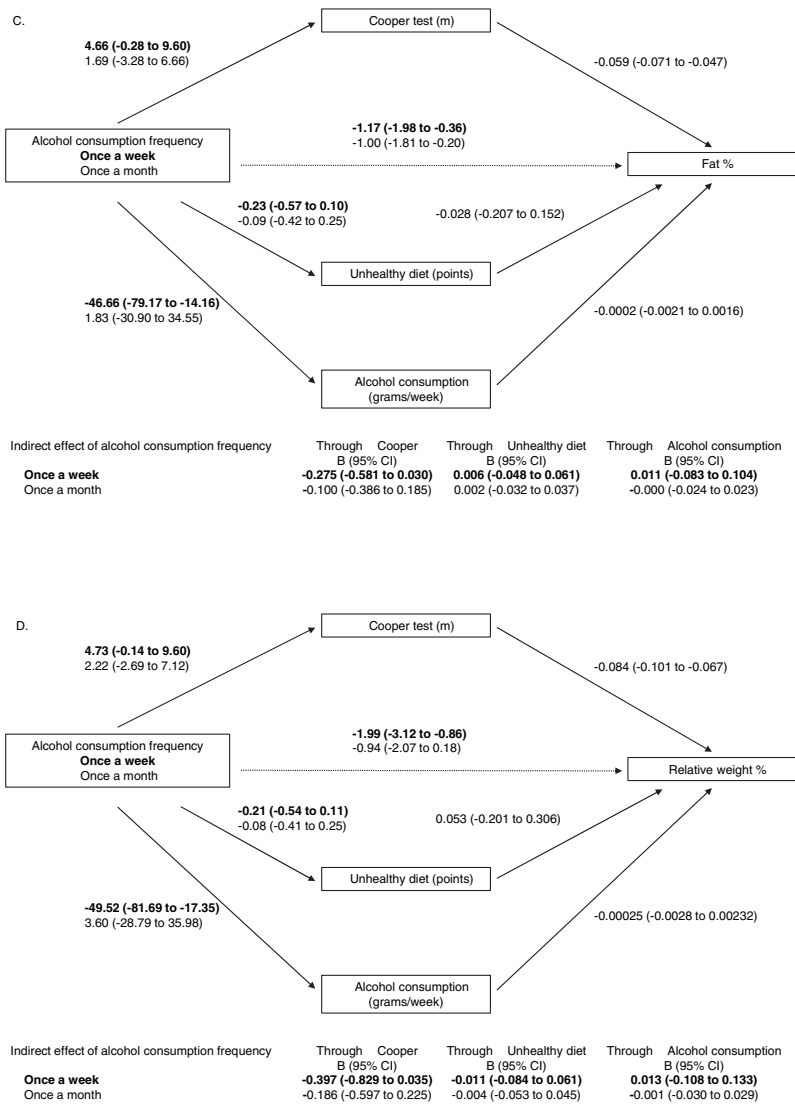
The possible mediating effect of changes in Cooper test result on the association between binge drinking and relative change in fat and weight was non-significant when changes in alcohol consumption and unhealthy diet, baseline BMI, duration of military service and smoking were considered as confounding factors in the mediation analysis.

The multivariate linear regression analysis showed that binge drinking at least once a week was associated with changes in body fat% and relative weight was independent of smoking, changes in Cooper test, unhealthy diet index and alcohol consumption, baseline BMI and length of service (regression coefficient for body fat%: -0.68, 95% CI -1.35 to -0.01,  $p=0.049$  and for relative weight -1.39, 95% CI -2.32 to -0.45,  $p=0.004$ , respectively) (Table 13). Smoking, change in Cooper test, baseline BMI and duration of military service were also independently associated with changes in body fat% and relative weight.



**Fig. 1. The effect of binge drinking on the change ( $\Delta$ ) in body fat% (A.) and relative weight % (B.) as mediated by the changes ( $\Delta$ ) in the Cooper test result; unhealthy diet and alcohol consumption. Regression coefficient is B (95% confidence interval) calculated by linear regression analysis.**





**Fig. 2. The effect of alcohol consumption frequency on the change ( $\Delta$ ) in body fat% (C.) and relative weight % (D.) as mediated by the changes ( $\Delta$ ) in the Cooper test result; unhealthy diet and alcohol consumption. Regression coefficient is B (95% confidence interval) calculated by linear regression analysis.**

**Table 13. Associations between alcohol consumption frequency and binge drinking and changes in body fat% and relative weight (%) during military service.**

Variable	Change in body fat%			Relative weight change (%)		
	$\beta$	B (95 % CI)	p-value	$\beta$	B (95 % CI)	p-value
Alcohol consumption frequency						
≥ Once a month	-0.04	-0.36 (-1.04 to 0.32)	0.298	-0.01	-0.08 (-1.02 to 0.86)	0.868
≥ Once a week	-0.05	-0.47 (-1.16 to 0.22)	0.189	-0.07	-0.87 (-1.83 to 0.09)	0.077
Smoking <sup>1</sup>	-0.09	-0.80 (-1.35 to -0.26)	0.004	-0.13	-1.62 (-2.34 to -0.86)	<0.001
Change in Cooper test	-0.21	-0.04 (-0.05 to -0.03)	<0.001	-0.19	-0.05 (-0.06 to -0.03)	<0.001
Change in unhealthy diet index	-0.01	-0.02 (-0.17 to 0.13)	0.816	0.02	0.06 (-0.15 to 0.27)	0.580
Change in alcohol consumption	-0.02	0 (-0.01 to 0)	0.547	-0.02	0 (-0.02 to 0.01)	0.600
Baseline BMI	-0.53	-0.58 (-0.64 to -0.51)	<0.001	-0.54	-0.83 (-0.92 to -0.75)	<0.001
Duration of military service <sup>2</sup>	0.07	0.58 (0.02 to 1.15)	0.044	0.08	0.98 (0.19 to 1.76)	0.016

Variable	Change in body fat%			Relative weight change (%)		
	$\beta$	B (95% CI)	p-value	$\beta$	B (95% CI)	p-value
Binge drinking						
$\geq$ Once a month	-0.04	-0.41 (-1.04 to 0.22)	0.203	-0.03	-0.40 (-1.23 to 0.48)	0.370
$\geq$ Once a week	-0.07	-0.68 (-1.35 to -0.01)	0.049	-0.10	-1.39 (-2.32 to -0.45)	0.004
Smoking <sup>1</sup>	-0.08	-0.72 (-1.27 to -0.17)	0.011	-0.12	-1.48 (-2.25 to -0.72)	<0.001
Change in Cooper test	-0.21	-0.04 (-0.05 to -0.03)	<0.001	-0.19	-0.05 (0.006 to -0.03)	<0.001
Change in unhealthy diet index	-0.01	-0.02 (-0.18 to 0.13)	0.751	0.01	0.05 (-0.15 to 0.26)	0.631
Change in alcohol consumption	-0.02	0 (-0.01 to 0.02)	0.486	-0.02	0 (-0.22 to 0.14)	0.518
Baseline BMI	-0.53	-0.58 (-0.64 to -0.51)	<0.001	-0.53	-0.83 (-0.92 to -0.74)	<0.001
Duration of military service <sup>2</sup>	0.06	0.56 (-0.00 to 1.13)	0.053	0.07	1.00 (0.16 to 1.73)	0.019

Analyses were adjusted for smoking, change in Cooper test, unhealthy diet index and alcohol consumption (grams/week), baseline BMI and duration of the military service. Effect size is B coefficient (95% confidence interval) and standardized beta ( $\beta$ ), calculated by linear regression. Non-smokers<sup>1</sup> and 6 months of military service<sup>2</sup> being as reference.



## 6 Discussion

### 6.1 Reduction in metabolic syndrome among young men in military service

This study evaluated the change in MetS prevalence longitudinally among young adults, in different BMI categories. One of the findings was that the prevalence of MetS decreased from 6.1% to 3.6% during 6–12 months' military service in the whole Sodankylä Jaeger Brigade cohort population, and from 52.4% to 31.5% in the obese subpopulation. The reduction in adiposity and improvement in aerobic and muscular fitness was observed in all MetS subgroups, despite the fact that not all participants with MetS at baseline recovered. Although the change in prevalence MetS was non-significant in other BMI groups, beneficial body composition changes were also observed, particularly among those who recovered from MetS during military service.

The prevalence of MetS among adolescents in the U.S. has been shown to increase over the years (Ogden *et al.* 2007), and the prevalence of MetS according to the IDF criteria among 12–32-year-olds has shown to vary between 1.7% to 14.3% in studies performed in Finland and the U.S. (Goodman *et al.* 2007, Mattsson *et al.* 2007, Pirkola *et al.* 2008, Raiko *et al.* 2010, Salonen *et al.* 2015). The prevalence of MetS (defined by IDF criteria) in the Sodankylä Jaeger Brigade cohort is in line with the findings of previous studies.

MetS has several risk factors including elevated blood pressure and triglyceride levels, dysglycemia, low HDL-levels and obesity, for the CVD and type 2 diabetes (Salonen *et al.* 2015). However, the presence of MetS does not constitute an absolute cardiovascular risk evaluation, because the criteria do not take age, sex, smoking or LDL-levels into account. There has been debate as to the existence of MetS; whether it a true syndrome or a mixture of unrelated phenotypes. The syndrome can be defined as a clustering of factors which appear simultaneously more often than incidentally, and the source of these factors is often uncertain. (Alberti *et al.* 2009) Nevertheless, the presence of MetS has also been associated with an elevated long-term risk for CVD and type 2 diabetes. Physical inactivity, abdominal obesity and insulin resistance contribute for the development of metabolic risk profile, though the mechanisms behind MetS are not yet well understood. (Alberti *et al.* 2009)

The evaluation of the MetS has been observed to be a useful instrument for clinicians and researchers to form a CVD and type 2 diabetes risk estimation. In previous decades various criteria have existed for the categorization of the MetS by different organizations, which may have caused some confusion. In the present study the IDF criteria were used for MetS, a selection that reflects expert consensus. (Alberti *et al.* 2009). The IDF underlines the presence of abdominal obesity as the the key criterion, since it is a marker for metabolically active and lipolytic intra-abdominal fat (Kahn *et al.* 2006). The authors of the criteria note that WC is specific to population and ethnicity (Alberti *et al.* 2009).

### **6.1.1 Associations between reduction in metabolic syndrome and physical fitness and adiposity**

Based on the previous literature the prevalence of MetS increases in accordance with increasing BMI in adolescents (Rappaport 2007, Pirkola *et al.* 2008) and young adults (Raiko *et al.* 2010). This is confirmed by the results of the present study. None of the underweight or normal weight conscripts had MetS at the beginning of their military service. Cross-sectional studies among adolescents and young adults have found an association between lower levels of PA and higher prevalence of MetS (Stabelini Neto *et al.* 2011, Lopez-Martinez *et al.* 2013). The higher intensity and amount of PA has been shown to be beneficial for the risk of MetS in young adults (Salonen *et al.* 2015). Furthermore, there is an inverse association between MetS and lower fitness performance (Stabelini Neto *et al.* 2011, Lopez-Martinez *et al.* 2013).

The Cardiovascular Risk in Young Finns Study study included participants aged 24–39. It found that an increased amount of PA is linked with a reduction in MetS over a 9-year follow-up (Yang *et al.* 2008). Moderate-to-vigorous PA has been shown to be beneficial for the prevention of MetS (Lakka & Laaksonen 2007). Findings from the present study are in line with the previous literature. In the Finnish Diabetes Prevention Study among middle-aged participants with impaired glucose tolerance, performance of moderate-to-vigorous LTPA was associated with a lower risk for the development of, and a higher likelihood of resolution of, MetS (Ilanne-Parikka *et al.* 2010).

In the present study PA was evaluated not only using questionnaires, but also with fitness tests, a feature that strengthens the results. The aerobic and muscular fitness of the participants with no MetS at the beginning of the military service

was significantly better than those with MetS. However, the greatest improvement in aerobic and muscular fitness was observed among the subjects in the overweight and obese groups who recovered from MetS during their military service. The improved physical fitness levels may be due to the high amount of physical training performed in the basic training period, which includes high amount of physical training, comprising at least 4 hours of sports-related and 12 hours of military-related physical training per week. Improvements in cardiovascular risk factors correlate with improvements in aerobic and muscular fitness, as has been shown previously in the Sodankylä Jaeger Brigade study (Cederberg *et al.* 2011). Therefore, based on these results it could be concluded that military service serves as a lifestyle intervention for obese conscripts, with additional beneficial results.

The reduction in the prevalence of metabolic syndrome in this study was associated with the reductions in weight and WC, and improvement in muscle fitness. As seen previously in the Sodankylä Jaeger Brigade study (Mikkola *et al.* 2009), the weight loss was comprised mainly of reductions in total and visceral fat. The distribution of the fat, especially intra-abdominal fat is considered to be a risk for the development of metabolic abnormalities (Kahn *et al.* 2006). Therefore a reduction in the amount of intra-abdominal fat may have the beneficial effect of lowering metabolic risk.

Resistance training has been shown to reduce MetS risk factors (Ilanne-Parikka *et al.* 2010, Strasser *et al.* 2010). Aerobic training has resulted in the reduction of the abdominal fat (Lee *et al.* 2012b), as well as improvement in MetS (Katzmarzyk *et al.* 2003). The differing effects on MetS of resistance, aerobic and combined training were evaluated in an 8-month exercise program, performed by previously sedentary, overweight dyslipidemic adults (Bateman *et al.* 2011). The aerobic training and combined training were effective for the improvement of MetS, while on the contrary, resistance training did not change the components of MetS (Bateman *et al.* 2011). We observed that the reduction in MetS was associated with the improvement in muscle fitness, after adjusting for smoking, length of service, weight change and improvement in aerobic fitness. One possible explanation for the association between the reduction in MetS and the improvement in muscle fitness, is an improvement in insulin sensitivity. The association of resistance exercise with the improved insulin sensitivity has been observed also among obese adolescent boys (Lee *et al.* 2012b). As the aerobic training have been associated with weight loss (Donnelly *et al.* 2003, Lee *et al.* 2012b), the effects of the aerobic training on the reduction of the MetS in this

study may be partially explained by the reduced amount of abdominal obesity, which is substantive part of the IDF criteria.

## **6.2 Associations between maternal pre-pregnancy BMI, gestational weight gain and smoking and offspring outcomes**

### **6.2.1 Maternal pre-pregnancy BMI and offspring health outcomes**

The prevalence of overweight and obesity have become more common, and it is estimated that in the year 2030 more than half of the world's adult population will be considered as overweight or obese (Kelly *et al.* 2008)

In Finland 24.5% of women aged 25–34 years were overweight or obese according to the Finriski 2012 study (Männistö *et al.* 2015), and in the NFBC 1986 subgroup study sample 17.7% of conscripts' mothers were overweight or obese and 82.3% were under- or normal weight during pregnancy. By comparing these findings with the ones of the Finriski 2012 study regarding women between the ages of 25 and 34 years, it is possible to demonstrate the increase in the proportion of overweight/obese women of fertile age. However the possibility of age differences while comparing overweight and obesity among women in the Finriski 2012 and the NFBC 1986 may occur. A decrease in the proportion of under- or normal weight women can also be observed, supporting the findings of an increase in BMI in adult populations (Kelly *et al.* 2008).

Maternal pre-pregnancy BMI has previously been shown to be associated with the offspring's cardiometabolic risk factors (Hochner *et al.* 2012) and obesity (Laitinen *et al.* 2012, Poston 2012), and the current study detected similar observations. Maternal obesity in pregnancy has also been shown to be associated with a higher risk for caesarean section, offspring congenital malformation, macrosomia and stillbirth compared with lean women (Poston 2012). We found that the offspring of overweight and obese mothers were heavier and had greater WC than the offspring of under- or normal-weight mothers. We also observed an association between higher maternal pre-pregnancy BMI and lower aerobic and muscular fitness in male offspring at the age of 19–20 years. However, according to the mediation analysis, the direct effects of maternal pre-pregnancy BMI and GWG on offspring's Cooper test results was non-significant, and therefore it could be concluded that the effect is in large extent mediated by offspring's own BMI.



### **6.2.2 Maternal gestational weight gain and offspring health outcomes**

An association has been observed between excessive GWG and overweight offspring (Drake & Reynolds 2010, Margerison Zilko *et al.* 2010, Paliy *et al.* 2014, Poston 2012). The U.S. Institute of Medicine (Institute of Medicine and National Research Council Committee to Reexamine IOM Pregnancy Weight Guidelines, US 2009) recommends only adequate weight gain during pregnancy, for the prevention of the short- and long-standing health consequences of the offspring. Excessive GWG has been linked with increased birth weight (Margerison Zilko *et al.* 2010), and especially elevated FM in infants (Hull *et al.* 2011, Carlsen *et al.* 2014). Excessive GWG has also been associated with heightened obesity risk in childhood (Oken *et al.* 2007, Crozier *et al.* 2010) and young adulthood (Mamun *et al.* 2009). The association between maternal pre-pregnancy BMI and offspring BMI could be explained by genetic predisposition and shared environment, but also the developmental overnutrition hypothesis (Drake & Reynolds 2010, Poston 2012). In the course of pregnancy an obese woman's fetus is exposed to increased nutrient supply, which increases the risk for large for gestational age (LGA) and fetal macrosomia (Poston 2012). High maternal glucose, free fatty acid and amino acid concentrations may cause constant changes in appetite control, neuroendocrine functioning and energy metabolism in the fetus (Drake & Reynolds 2010).

In the present study, the offspring of normal, overweight and obese mothers with excessive GWG had higher weight and WC at the age of 19 years, which is in line with previous literature. Interestingly, excessive GWG was associated with poorer aerobic and muscular fitness of the offspring, excluding offspring of underweight mothers. To the best of our knowledge, the association between maternal GWG and offspring aerobic fitness has not previously been investigated.

The current study did not observe any association between pre-pregnancy BMI, GWG or maternal smoking and offspring muscle fitness. The Finnish Military uses the MFI as an objective indicator of muscle fitness, and its components give an estimation of the endurance, strength and explosive strength (Santtila *et al.* 2006). Muscle fitness is to a large extent influenced by a person's own strength training and body weight, so it is unsurprising that we observed no effect of gestational factors on the muscle fitness of the offspring.

### **6.2.3 Maternal smoking and offspring health outcomes**

The prevalence of maternal smoking in the Nordic countries has declined over the last 20 years, except in Finland where the prevalence of maternal smoking remains 10–15% (Ekblad *et al.* 2014). In a cross-sectional study performed in 15 European countries, 35.3% of women reported smoking before pregnancy and 4.2%–18.9% of pregnant women continued to smoke during pregnancy (Smedberg *et al.* 2014). In the current study sample the prevalence of maternal smoking was 12%, which can be compared to the prevalence of maternal smoking in recent years. This was the first study to detect the inverse association between maternal smoking during pregnancy and the aerobic fitness of male offspring at the age of 19 years, although confounding factors were taken into account. Maternal smoking causes harm to the unborn child and it may have long-lasting consequences on the offspring's health, seen also as decreased aerobic fitness. Maternal smoking rates remain high despite the increased awareness of the disadvantageous effects of maternal smoking during pregnancy.

Previous studies in the Northern Finland Birth Cohort (NFBC 1966) have observed a dose-dependent association between maternal smoking and reduced birth weight (Rantakallio 1978b), which other studies have confirmed (Power & Jefferis 2002, Chen & Morris 2007, Raatikainen *et al.* 2007, Mund *et al.* 2013). Children born small have an increased risk for catch-up growth and insulin resistance and obesity later in life (Barker *et al.* 2009). In a review article by Oken *et al.* (2008) it was seen that everyday maternal smoking during pregnancy increases the risk for the offspring being overweight at the ages of 3–33 years. Obesity and higher fat mass may be one reason for lower aerobic fitness among offspring exposed to maternal smoking in utero. Overweight in 15–16-year-olds has been inversely associated with aerobic performance and increased fat mass predicts weak physical fitness (Kyrolainen *et al.* 2010). Confirming existing knowledge, this study reported an inverse association between maternal smoking and offspring obesity. However, novel finding was the inverse and dose-dependent association between maternal smoking and aerobic fitness of the offspring at the age of 19.

In the NFBC 1966 cohort, associations have been detected between maternal smoking and offspring morbidity and mortality in childhood (Rantakallio 1978a) and respiratory diseases in adolescence (Rantakallio 1983), when compared with the offspring of non-smokers. Maternal smoking during pregnancy has various

effects on the health of the offspring, such as elevated risk for congenital heart defects, altered psychological and neurological behavior, and respiratory and gastrointestinal infections (Harding & Maritz 2012, Mund *et al.* 2013).

Animal tests have showed that maternal smoking during pregnancy may alter the structure of the offspring's lungs and therefore reduce the normal capacity for gas exchange. This may, in turn, reduce the offspring's exercise capacity (Harding & Maritz 2012). The influence of maternal smoking on the development of the offspring's pulmonary system and lung function (Chen & Morris 2007, Harding & Maritz 2012) has been also considered. Some studies have discussed the effects of nicotine and carbon monoxide on the unborn child due to maternal smoking. Nicotine passes through the placenta completely, and fetal concentrations have been estimated to exceed maternal levels (Chen & Morris 2007). Nicotine acts peripherally and centrally by reducing appetite and body weight in humans and animals (Oken *et al.* 2008). Maternal smoking may also have some effects on the offspring's biochemical system, hormones and neural development (Chen & Morris 2007, Oken *et al.* 2008, Mund *et al.* 2013). Smoking, both active and passive, has been shown to be associated with glucose intolerance and insulin resistance. It has been speculated that insulin sensitivity in smokers impaired insulin sensitivity is caused by nicotine, carbon monoxide or other substances in tobacco. Long-term smoking may lead to vascular changes and therefore reduced blood flow in the skeletal muscles, resulting in a decrease in insulin-mediated glucose uptake. (Facchini *et al.* 1992) The underlying mechanisms of the inverse association between maternal smoking during pregnancy and offspring aerobic fitness remain uncharacterized, and could be considered for future research.

In addition to the possible underlying physiological mechanisms of this finding, there are social factors that promote an inactive lifestyle and therefore may also impact on the aerobic performance of the offspring. Some studies have concluded that offspring whose parents smoke during the offspring's adolescence also have unhealthier lifestyles such as a poorer diet and perform less PA (Crawley & While 1996, Burke *et al.* 1998). Maternal smoking at the time of offspring's adolescence has been shown to be associated with the risk for adolescent (O'Callaghan *et al.* 2006) and adulthood (Paul *et al.* 2008) smoking in the offspring. In the present study, even after adjustment for maternal education level, paternal smoking status, passive and own smoking during youth, the offspring's own PA in youth, the association between maternal smoking during pregnancy and offspring aerobic fitness remained significant.

## **6.3 Associations between lifestyle factors and body composition changes during military service**

Obesity has been shown to result from a complex process that includes poor lifestyle choices such as physical inactivity, smoking, alcohol consumption and unhealthy diet, as well as complex familial and psychosocial factors. High energy intake coupled with low energy consumption results in a positive energy balance, leading to excess energy being stored as fat tissue. (Fogelholm & Kaukua 2014) Associations between individual lifestyle factors like PA, diet, alcohol and smoking and body weight and body composition are difficult to evaluate because of the combined effects of various factors. This can also be challenging in the intervention setting. Moreover, it can also be difficult to separate the effects of genetic factors from those of lifestyle factors on body composition.

### **6.3.1 Obesity**

Increasing body weight of military conscripts has been an area of research in recent years for example in several countries, including Finland (Santtila *et al.* 2006), Norway (Dyrstad *et al.* 2005) and the U.S. (Sharp *et al.* 2002). A decline in aerobic and muscular fitness has also been observed (Dyrstad *et al.* 2005, Santtila *et al.* 2006). In the present study, the prevalences of overweight and obesity at the beginning of military service were 25% and 9%, respectively. At follow-up the prevalence of overweight had fallen to 24% and obesity to 5%, among those conscripts who completed their military service. The proportion of candidates who were excused from military service was not available, however there were no significant differences between the BMI classes among those who discontinued their military service (Mikkola *et al.* 2009). At the time when our Sodankylä Jaeger Brigade study was performed (2005–2006) the military pre-medical examination did not consider conscripts' obesity as a strict obstacle to the military service. Based on the health examination and instructions (Finnish Defence Forces 2012) doctors categorize the conscripts before military service into eligibility classes (A, B, C and E). Class A conscripts can be considered to have good health and performance. Class B conscripts have a disease or disability which might affect their military service, and might have a slight effect on their performance. Based on the current instructions (Finnish Defence Forces 2012), conscripts with BMI >30 and poor fitness, are categorized as Class E. Class E

denotes a conscript who has a disease or disability that can be considered to be an obstacle to performing military service, but which will likely resolve. Class C is used for young men with BMI >35, with attendant poor fitness and performance, and in whom weight loss will not succeed. Conscripts categorized as Class C are being liberated from military service during peacetime. (Finnish Defence Forces 2012)

At baseline, 31% of our Sodankylä Jaeger Brigade study population was overweight or obese, and therefore it can be concluded that the sample was representative for examining obesity. In addition, health and fitness benefits of military service were observed among the overweight and obese subjects.

### **6.3.2 Physical activity and physical fitness**

There are currently only limited data that evaluate baseline lifestyle factors simultaneously as predictors of changes in body composition and fitness during military service. A study performed in Croatian military service conscripts found that a low level of PA at the beginning of service was associated with the greatest improvements in aerobic and muscular fitness during a 5-week training program (Sporis *et al.* 2014). In a previous study in the Sodankylä Jaeger Brigade 2005–2006 cohort, PA before military service was associated with body composition changes, particularly among overweight and obese conscripts (Mikkola *et al.* 2009). In a finding consistent with the previous literature, we observed that PA before military service was inversely associated with improvements in the muscular and aerobic fitness: The greatest improvement in aerobic fitness and muscular fitness was observed among subjects who had previously been physically inactive. Similar findings were obtained in the setting of military service in Norway, where conscripts with lower  $VO_{2max}$  at the baseline showed the greatest improvements in  $VO_{2max}$  (Dyrstad *et al.* 2006).

According to the WHO 2010 statistics 20–29.9% of adult men perform insufficient PA (World Health Organization 2014b). In the in Sodankylä Jaeger Brigade cohort 58.9% of the conscripts reported being physically active and 15.8% being inactive at the start of military service. The self-reported PA levels correlated with the measured aerobic and muscular fitness at baseline. The data from the NFBC1986 subpopulation revealed that of those who were physically active or very active at the age of 16 years were also to a large extent active at the beginning of their military service. Therefore, in this current study the exercise habits in adolescence seem to have been transferred into young adulthood.

However, a decline in PA from childhood to adulthood has been observed in a study performed among Finnish youth (Telama & Yang 2000) and a study performed among Finnish reservists reported that 26% of the 30-year old men performed a level of PA sufficient for maintaining and improving health-related fitness (Fogelholm *et al.* 2006).

### **6.3.3 Diet**

Regular military service has shown to positively affect the anthropometrics and body composition of conscripts. The diet of conscripts at the beginning and during military service has been studied in the Armoured Brigade in Southern Finland and the Kainuu Brigade in Northern Finland in 2007–2009 (Bingham *et al.* 2009, Bingham *et al.* 2010, Jallinoja *et al.* 2011, Bingham *et al.* 2012a). A significant reduction in the consumption of fat-containing food items, such as french fries and hamburgers have been observed during military service, accompanied by a beneficial increase in the consumption of cereal products, fruit and vegetables (Bingham *et al.* 2012a).

The National Institute for Health and Welfare together with The Finnish defence forces (Uutela *et al.* 2015) performed an intervention (VARU) during 2006–2008 in the Armoured and Kainuu Brigades designed to increase conscripts' knowledge of healthy eating habits and to improve their diet. The improvements in diet (increase in fibre-rich foods and vegetables) and serving (promotion of the healthy food items) were performed in collaboration with the garrison's refectories and the soldiers' home cafeterias. The intervention group showed a more pronounced reduction than the control group in WC, FM and body fat % and a greater increase in muscle mass (Uutela *et al.* 2015).

In the current study the subjects' diet was evaluated using a modified healthy and unhealthy diet index. The same questionnaire and index has been used previously on the NFBC 1966 cohort (Laitinen *et al.* 2004, Jääskeläinen *et al.* 2015). The applied unhealthy eating index included frequent consumption of doughnuts, hamburgers, pizzas, snacks, sugar-sweetened beverages, chocolate and candies. The need for a more accurate evaluation of the effects of unhealthy food on the body composition of young men was highlighted by previous knowledge of the high consumption of sweets and junk food during conscripts' spare time while performing military service in the First Signal Company, Oulu in the year 1997 (Tähtinen *et al.* 2002).

#### **6.3.4 Smoking**

The prevalence of current smoking among Finnish military conscripts has varied between 30.0% and 46.5% during the period from 1995 to 2009 (Tähtinen 2006, Jallinoja *et al.* 2008, Bingham *et al.* 2010, Hamari *et al.* 2010,). The prevalence of smoking in the current study population was consistent with previous literature, at 45.2%.

A decrease in smoking among 15 and 16-year-olds has been observed during the 21st century in Finland (Raitasalo *et al.* 2012). The Finnish Adolescent Health and Lifestyle Survey 2015 reported the prevalence of daily tobacco smoking as 22.3% among 18-year old boys (Kinnunen *et al.* 2015).

In the current study it was observed that smoking was associated with higher body fat%, as well as poorer muscular fitness. Previous studies conducted at the start of military service, have found that smoking is associated with higher weight (Hamari *et al.* 2010, Macera *et al.* 2011) and poorer aerobic fitness (Dyrstad *et al.* 2005, Hamari *et al.* 2010, Macera *et al.* 2011) findings which our study confirms. By contrast, some studies have reported smokers being leaner than non-smokers (Miedinger *et al.* 2006, Sherrill-Mittleman *et al.* 2009).

Smoking has various disadvantageous health consequences for young adults. Similarly to our findings, a previous study in conscripts at the start of military service observed that regular smokers consumed more unhealthy food items than to non-smokers (Bingham *et al.* 2010). Furthermore, smokers consumed more alcohol than non-smokers and Hamari *et al.* (2010) observed that conscripts who smoked regularly had more respiratory symptoms such as chronic cough and sputum production.

#### **6.3.5 Alcohol consumption and binge drinking**

Bingham *et al.* (2009) reported that conscripts who drank beer 2–7 days/week consumed higher amounts of unhealthy food items, as well as the least healthy food items (Bingham *et al.* 2009). This is consistent with our findings. In our study we detected that the group who self-reported binge drinking at least once a week had the most unfavorable lifestyle habits: as well as consuming the most alcohol, they consumed the most junk food and the least healthy food items. The positive association in young adults between binge drinking and consumption of fried food has also been observed in Ireland (Mohamed & Ajmal 2015). Snacking

has also been related to increased alcohol intake in men (Ovaskainen *et al.* 2010), which the findings of this current study confirm.

As a novel finding, the binge drinking was associated with higher body fat% and body weight, as well as with an unhealthier lifestyle and reduced aerobic and muscular fitness at the beginning of military service. The group who reported binge drinking at baseline at least once a week benefited the most from the military service period: A reduction in body weight and body fat % and evident improvement in muscular and aerobic fitness were observed in this group and their alcohol intake fell by a median 19.6 grams/week. They also began to consume more healthy food items and fewer unhealthy food items. These results highlight the importance of baseline lifestyle factors as predictors for successful changes in body composition and anthropometrical measurements during military service.

In Finland in 2010 heavy episodic drinking was reported in  $\geq 30\%$  people aged 15 – 19 years (World Health Organization 2014), an alarming figure because the excessive consumption of alcohol has been related to negative health and social consequences. In the present study population the prevalence of binge drinking at least once a week was 29.8%, and the alcohol consumption was significantly greater than in comparable groups. The median alcohol consumption was 198.1 grams/week (interquartile range: 158.9, 350.7), which equates to approximately 16 units of alcohol per week. Based on the present guidelines the alcohol consumption risk limits for adults can be applied to young adults as well, and the detected amount of alcohol consumption among the group with binge drinking at least once a week exceeded the moderate risk limit in men, which is 14 units per week (Treatment of alcohol abuse: Current Care Guidelines 2015). Heavy drinking and binge drinking has been linked with alcohol-related harms, such as social and health related consequences, accidents and injuries (Little *et al.* 2012).

High alcohol intake has been linked with higher weight, as the associations between current and lifetime alcohol consumption and overall and central obesity have been observed among adults (Lourenco *et al.* 2012). French *et al.* (2010) discovered that the amount of consumed alcohol has an effect on the BMI in men. Our results are consistent with the existing literature, but as a novel finding we discovered a positive association between the frequency of alcohol consumption and binge drinking and higher weight and body fat % in a population of healthy, young men. The positive association of binge drinking/heavy drinking with high



BMI (Wannamethee *et al.* 2005, Alcacera *et al.* 2008,), higher risk for obesity (Arif & Rohrer 2005) and high percentual body fat and WC (Wannamethee *et al.* 2005) have been observed.

## **6.4 Strengths and limitations of the study**

### **6.4.1 Strengths**

Almost 80% of Finnish men perform compulsory military service, with only approximately 10% exempt due to medical reasons based on the medical examinations. Therefore, our study population of military conscripts provided a representative sample of healthy young men. Men with the most severe physical and psychiatric disabilities are exempt from military service, and about 7% of eligible men choose to perform non-military service (Mattila *et al.* 2007).

In the year 2004 the mean weight of Finnish conscripts was 75.2 kg (Santtila *et al.* 2006), which is similar to that of the current study population. The mean Cooper test result in this study was 2,474 m, consistent with the 2,434 m recorded for all Finnish conscripts in 2006 (Santtila *et al.* 2006). Our study measured PA both subjectively with questionnaires, and objectively with physical fitness tests which is a design strength confirming robust and reliable results. The fitness tests were conducted in a standardized study setting, and in accordance with the Finnish Defence Forces examination protocol, which uses the Cooper test (Cooper 1968) to test aerobic fitness and the MFI (Santtila *et al.* 2006) to test muscular fitness. The Cooper test supplied an evaluation of the  $VO_{2max}$  (Cooper 1968), as it was not possible for us to perform treadmill testing in this large population study.

The PA of the NFBC 1986 subpopulation as evaluated at the age of 15–16 years, correlated with physical fitness at the beginning of military service.

Living circumstances in military service are fairly standardized, regarding diet, PA and sleep. This arrangement offers a valuable research opportunity. In other settings it would be very difficult to conduct a similar study to evaluate changes in anthropometrics, body composition and fitness with a 6–12-month follow-up. The anthropometric, body composition and biochemical measurements were performed by trained personnel. Biochemical measurements were analysed with the same method and laboratory.

### **6.4.2 Limitations**

Although diet and exercise were generally standardized in the military setting of our study, the conscripts had the option to purchase snacks from the canteen, thereby increasing their daily energy intake and possibly affecting their weight. No dietary intervention was included in the study design. The military diet is designed based on the national nutrition recommendations, and comprises energy of 3400–3800 kcal/day (Bingham *et al.* 2009).

Participation in military service is optional for females in Finland, and 15 female military service conscripts attended the Sodankylä Jaeger Brigade in 2005. They were all invited to the study, but due to their low numbers, were excluded from the statistical analyses. The findings of the present study are limited to healthy young men and cannot therefore be generalized to other age groups. Due to the study design there was no control group, however conscripts served as their own controls.

The 8-week basic training period includes a minimum of 4 hours sports-related PA and 12- hours of military-related physical training per week (Santtila *et al.* 2008). After the basic training period the amount and type of physical training varies between companies. This study could be limited by the fact that body composition and physical fitness measurements were neither performed immediately after the 8-week of basic training period nor at the midpoint of the 6, 9 or 12 months of military service. The amount of exercise and intensity of PA during military service were not directly and objectively measured. However, the objectively measured aerobic and fitness parameters enhance the results despite the limitations.

According to Thomson *et al.* (2007) BIA provides accurate estimates of body composition changes resulting from weight loss (Thomson *et al.* 2007). Using BIA may slightly underestimate the fat mass of normal weight participants, and slightly overestimate it among overweight and obese participants when compared to DEXA (Shafer *et al.* 2009). Nevertheless, these errors have only minor biological significance (Bedogni *et al.* 2002, Shafer *et al.* 2009). In epidemiological studies, the evaluation of the diet is challenging, and in this study the diet was evaluated with the food frequency questionnaire. However, it does not provide a detailed evaluation of the consumed food.

## **7 Summary of the findings and conclusions**

The main findings of Studies I-III were:

Study I:

The prevalence of MetS decreased from 6.1% to 3.6% during military service, and the reduction was present among overweight and obese conscripts. None of the normal weight conscripts had MetS at the beginning of military service. The change in the MetS Z-score was mainly explained by the reduction in WC and weight loss, but also by an improvement in muscular fitness.

Study II:

Maternal smoking during pregnancy was associated with poorer aerobic fitness in the offspring at the age of 19. The association of maternal pre-pregnancy BMI and GWG with the offspring's aerobic fitness was mediated via the offspring's own BMI.

Study III:

Lifestyle factors including diet, smoking, alcohol consumption and binge drinking are associated with conscripts' body composition and fitness test results at the beginning of military service. The prevalence of at least weekly binge drinking was a high 29.8%, and the military service was especially beneficial for this group, which showed the greatest reduction in weight, body fat % and alcohol consumption. This group also demonstrated a particular improvement in aerobic and muscular fitness and increased consumption of healthy food items.

### **7.1 Conclusions and research implications**

This study included a representative amount of overweight and obese participants, almost one third of the study population. Additionally, the study population also included obese participants with no MetS. An interesting question is how the obese participants with and without MetS differ from each other concerning biochemical, body composition and fitness measurements. In future it would be of high interest to examine the conscripts at the age of 30 years to evaluate the same

group longitudinally, and evaluate the possible impact of the lifestyle factors and military as well.

Maternal smoking and poorer aerobic fitness of the male offspring in young adulthood were related, although the relationship's underlying mechanism remains to be characterized. Maternal smoking has been associated with the overweight offspring at the age of 3–33 years (Oken *et al.* 2008). Overweight in the 15–16-year-olds has been inversely associated with aerobic performance and increased fat mass is predictive of weak physical fitness (Kyröläinen *et al.* 2010). Therefore overweight and higher fat mass may be one reason for lower aerobic fitness among offspring exposed to maternal smoking in utero. Or does the maternal smoking have an influence on the pulmonary development of the unborn child and thereby impair the lung function later in life? Children of smokers have been shown to be less physically active (Burke *et al.* 1998), therefore the social impact of maternal smoking may be an additional explanation.

In this study maternal smoking during pregnancy was positively associated with the body weight of the offspring in young adulthood. Previous studies have observed the positive association between maternal smoking and the offspring's fat mass. Therefore it would be interesting to examine whether the association between maternal smoking and adiposity in young adulthood remains significant in later life, despite the other confounding factors that may accumulate over time. In this study, maternal GWG was nearly associated with the Cooper test result of the offspring. Therefore, further studies with larger populations are needed to evaluate the effects of GWG on the aerobic fitness of the offspring.

## **7.2 Clinical and public health implications**

According to the Finnish School Health Survey 2015, 18–25% of boys attending high school and vocational school were overweight (National Institute for Health and Welfare 2015), and the prevalence of overweight among adolescents has tripled since the 1970s (Kautiainen 2011). At its earliest, CVD can be detected in young adulthood, and prevention strategies should be focused in particular on the high risk groups. Increases of weight and reductions in physical fitness have been recognized during recent years in conscripts, reflecting an increased impact from the public health point of view. Military service has been shown to be especially beneficial for those who are overweight and obese. The Finnish defence forces tightened the criteria for drafted servicemen in 2006, with the result that men with

BMI over 30 kg/m<sup>2</sup> could be excluded from military service more easily. Why should obese men be liberated from military service, even though the public and individual health benefit is more pronounced in this group?

It is not only military service that has a positive effect on the body composition and fitness of young men with suboptimal health behavior, but military service, seen as an intervention, affects alcohol consumption and dietary habits. As military service is compulsory for Finnish men, why not also utilize the period from a public health perspective? Alcohol consumption, particularly binge drinking is associated with poorer lifestyle habits and physical fitness. Health care professionals working with young adults should systematically ask about alcohol consumption and binge drinking to promote healthier lifestyle, particularly among those reporting excessive binge drinking. A relevant question is also, how to maintain the beneficial changes in health behavior gained by the young men during military service be extended into civilian life?

This study was performed among young men, and therefore these results should also be tested with women. How can the effect of military service on obese women be determined equally successfully? Were this possible, any beneficial effects on the cardiovascular and reproductive health of women in fertile age could also be assessed.

Maternal smoking during pregnancy has been shown to effect the health of the offspring in various ways and it may have an impact on later aerobic fitness. These findings add an important piece of information to the knowledge of the disadvantageous effects of maternal smoking during pregnancy. The prevalence of maternal smoking has declined in the Nordic countries during the past 20 years, except in Finland where the prevalence of maternal smoking remains 10–15% (Ekblad *et al.* 2014). Special attention should be paid in community clinics to pregnant mothers who are current smokers and they should be supplied with information on the harmful, potentially long-standing effects of their smoking on their offspring's aerobic fitness.



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## Original articles

- I Hagnäs MP, Cederberg H, Mikkola I, Ikäheimo T, Jokelainen J, Laakso M, Härkönen P, Peitso A, Rajala U & Keinänen-Kiukaanniemi S. (2012) Reduction in metabolic syndrome among obese young men is associated with exercise-induced body composition changes during military service. *Diabetes Res Clin Pract* 98:312-319.
- II Hagnäs MP, Cederberg H, Jokelainen J, Mikkola I, Rajala U & Keinänen-Kiukaanniemi S. (2015) Association of maternal smoking during pregnancy with aerobic fitness of offspring in young adulthood: a prospective cohort study. *BJOG*. DOI: 10.1111/1471-0528.13789.
- III Hagnäs MP, Jokelainen J, Cederberg-Tamminen H, Niemelä S, Härkönen P, Rajala U & Keinänen-Kiukaanniemi S. (2016) Alcohol consumption frequency and binge drinking as predictors of body composition changes during an exercise intervention among young men. Manuscript.

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