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“The associations between physical fitness and measures of adiposity in Norwegian 15-year olds”

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Abstract

Introduction: Adiposity increases risk of developing several chronic diseases, including coronary heart disease – the leading cause of death worldwide. While these diseases usually manifest in adulthood, development of metabolic risk factors may start already in childhood. An inverse relation between fitness and adiposity has been observed in other young populations, but has not been thoroughly investigated in Norwegian youth.

Aim: The overall purpose of this study was to evaluate the associations between physical fitness and measures of adiposity in Norwegian 15-year olds.

Methods: A total of 986 15-year olds (477 girls) were included in the analysis, recruited from schools located from all over Norway. The fitness tests included in this part of the study were aerobic capacity (VO_{2max}) and handgrip strength. The measures of adiposity consisted of BMI, waist circumference and sum of 4 skinfolds. Multiple linear regression was used to find the associations between the variables.

Results: The adjusted models in the analyses show that both aerobic fitness (VO_{2max}) and handgrip strength are inversely associated to all the measures of adiposity in this study. Physical fitness explains more of the variation in adiposity (R^2) among young males, as compared to females.

Conclusion: Physical fitness associate inversely to adiposity measures, which is adding value to the importance of fitness for health. This could inform future interventions to target physical fitness in order to prevent early onset of coronary heart disease.

Keywords: Fitness, $VO_{2\ max}$, Children, Adolescents, Adiposity, Obesity

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A two-year long master program has come to an end. It has been a great experience participating in program based on collaborations between European universities. I have been fortunate to go to Rome, Odense and Oslo to learn how physical activity affects people's health, besides meeting and learning from scientific leaders in different parts of this field. The European Master in Health and Physical Activity program truly has increased my knowledge and ability to affect people's physical activity behaviour in later career options.

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Preface

In 2005, the Norwegian Directorate of Health initiated, in collaboration with the Norwegian School of Sport Science, a surveillance program of physical activity and physical fitness among Norwegian 9- and 15-year olds (S. Anderssen, Helsedirektoratet, & Norges, 2008). The data collection was carried out in 2005-2006. The study included a total of 2299 children and adolescents from all over Norway, which approximates to 80% of the invited. For the schools located in Oslo the participation rate was approximately 55%, and the researchers thought the overall selection were representative of typical Norwegian children and adolescents for the age group (S. Anderssen et al., 2008). The population included in that cross-sectional study was randomly drawn from schools by Statistics Norway. A total of 68 schools were invited to participate in the study, and 62 of them did.

This thesis use data that originate from the study by Anderssen et al. (2008). Therefore, gratitude is attributed to the people that were involved with the study. This appreciation goes to the researchers, the participating children and adolescents and additional collaborators.

This thesis involves data related to the two fitness variables; aerobic capacity (VO_{2max}) and handgrip strength, and the associations they have with the adiposity measures; BMI, waist circumference and sum of 4 skin folds. Solely the group of 15-year olds are used from the main dataset.

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1.0 Introduction

Greater physical fitness has proven to be beneficial for health for children and adolescents, especially considering metabolic health, but factors like academic achievement and cognitive performance is also important (S. Anderssen, Helsedirektoratet, & Norges, 2008; Jonatan et al., 2007; Marques, Santos, Hillman, & Sardinha, 2018; Ruiz-Ariza, Grao-Cruces, de Loureiro, & Martínez-López, 2017).

Considering metabolic health, it may be that the factors that are contributing to cardiometabolic diseases start to develop in early childhood and develop with time into adulthood (Ferreira, Twisk, van Mechelen, Kemper, & Stehouwer, 2005). Evidence even suggest that factors related to metabolic health in adults can be traced back to childhood and as early as the age of five (Koskinen et al., 2017). This phenomenon may be explained by several independent pathways. Ferreira et al. (2005) did a prospective study from adolescents (13 years) to adulthood (36 years) and found a relationship between lower aerobic capacity and increased metabolic risk factors. They also found that abdominal adiposity was independently contributing to increased risk, which is found in several studies mentioned in a systematic review (Ferreira et al., 2005; Kelishadi, Mirmoghtadaee, Najafi, & Keikha, 2015). Adiposity is in general known to be independently associated with increased risk for ill clustered metabolic health (Umer et al., 2017) and may therefore lead to higher prevalence of cardiovascular diseases over time.

The benefit of finding different correlates that influence metabolic risk factors from childhood is in gaining knowledge on how to improve people’s health. And further being able to treat those who need it the most. For this particular subject it may include promotion of physical activity, since a large percentage of children and adolescents spends excessive time being sedentary (Dalene, 2018; Sundgot-Borgen, 2013). In the society today the prevalence of overweight and obese children and adolescents are evidently high and increasing through the world. And it seems that the overweight and obese execute less moderate to vigorous physical activity compared to their normal weight peers (Kuzik et al., 2017; World Health Organization, 2020).

Physical activity and cardiorespiratory fitness may work solely and independently to lower metabolic risk score (Ekelund et al., 2007). Therefore, it may be that individuals with less favourable genetics for physical fitness may have a greater need of doing a lot of physical activity for health and wellbeing, as their fitness levels do not contribute (Bouchard & Rankinen, 2001). Regardless of the genetic makeup and the influence it serves, it seems that the sedentary and the least active children and adolescents has the greatest potential to increase aerobic capacity fitness. Because when they start to exercise they have the highest increases in aerobic fitness (Kristensen et al., 2010).

Physical fitness variables in children and adolescents relates inversely to risk factors like elevated blood pressure, central adiposity and total adiposity, which is associated with metabolic disease (S. A. Anderssen et al., 2007; Magalhães, Melo, Santos, Ornelas, & Sardinha, 2016; Umer et al., 2017) Therefore, studying fitness and weight in children and adolescents may give further knowledge on how it influence metabolic health. This also involves muscular fitness, as isometric muscle strength additionally appears to be associated with lower levels of metabolic risk factors (Grøntved et al., 2015). The pathways to maintain and prevent metabolic risk factors is therefore clearly more than one. This highlights that different aspects regarding metabolic health should be studied, in order to gain the best knowledge of preventing children and adolescents from having an early onset of metabolic diseases.

The main target of this thesis is increasing the knowledge on how physical fitness associate with metabolic risk factors such as abdominal adiposity, BMI and skinfold fatness in 15-year olds. The evidence linking poor cardiovascular fitness to increased levels of abdominal adiposity is found in several studies. And higher levels of cardiovascular fitness are associated with a healthier body composition (Lee & Arslanian, 2007; Ortega et al., 2010). Whether these associations remains similar among Norwegian 15-year olds are unknown.

1.1 Aim and hypotheses

The aim of this study is to investigate how physical fitness associate to measures of adiposity within this Norwegian sample of 15-year-old boys and girls. In this study, physical fitness consists of cardiorespiratory fitness (VO_{2max}) and handgrip strength. And BMI, waist circumference and skinfold measurements are used as measures of adiposity.

Hypotheses 1: Aerobic fitness will have an inverse association with the weight variables BMI, waist circumference and skin fold measurements.

Hypotheses 2: Hand grip strength will have an inverse association with the weight variables BMI, waist circumference and skin fold measurements.

Null Hypotheses 1: Aerobic fitness does not associate with the weight variables BMI, waist circumference and skin fold measurements.

Null Hypotheses 2: Hand grip strength does not associate with the weight variables BMI, waist circumference and skin fold measurements.

2.0 Theory

2.1 Physical Fitness

Fitness consist of characteristics within an individual that is due to genetics or physical activity behaviour. The characteristics explain the ability to execute physical activity, where health related fitness may explain the ability an individual has to do daily physical activity tasks within a reserve capacity (S. Anderssen et al., 2008). Having a higher reserve capacity may make the daily tasks easier and more comfortable to execute. The greatest contributor to the development of physical fitness is physical activity and exercise. The ability of the body to respond to it are however largely due to genetics (S. Anderssen et al., 2008). The main attributes of fitness are aerobic capacity, muscle strength, mobility, motor skills, and balance. This study will focus solely on handgrip strength and aerobic fitness (VO_{2max}) to find associations to the included weight variables.

2.2 Aerobic capacity

Health related fitness is evidently linked to aerobic capacity in adults, adolescents and children (Ortega et al., 2010; Ross & Katzmarzyk, 2003; Wong et al., 2004). The aerobic capacity or cardiorespiratory fitness is usually expressed as the maximum oxygen uptake, which means the highest rate oxygen can be utilized and taken up by the body during maximal effort physical activity (Bassett, 2000). Oxygen delivery is found to be the limiting factor for the maximum oxygen uptake, thus is the cardiorespiratory system the most important factor, and the skeletal muscles not as dependent because it can utilize all the oxygen (Bassett, 2000). The cardiorespiratory system consists of different central factors. Stroke volume combined with maximum heart rate are the best predictors of the maximum oxygen uptake. However, factors like oxygen carrying capacity and pulmonary factors are also important, but is only limiting under special conditions, for example when top athletes put on maximal exertion (Bassett, 2000). Furthermore, peripheral factors located in the muscle is also contributing in the equation of oxygen uptake when a person is physically active, they consist of diffusion gradients, mitochondrial enzyme levels and density of capillaries in the skeletal muscles (Joyner & Coyle, 2008).

The aerobic capacity correlates not only with performances in endurance sport but also with health variables, and is extensively used in health research. The best well documented fitness variable in relation to health is aerobic capacity (S. Anderssen et al., 2008). Several studies has found aerobic fitness to be inversely associated with abdominal adiposity (Bertoli et al., 2003; Ortega et al., 2010; Ross & Katzmarzyk, 2003; Wong et al., 2004), which may be the greatest marker of risk related to metabolic disease compared to other variables (Kuk et al., 2006). The metabolic risk factors may also develop already in childhood and follow into adulthood (Koskinen et al., 2017; Reilly et al., 2003). For older people, there is also evidence suggesting that a higher aerobic fitness relates to lower incidence of stroke and mortality (Hussain et al., 2018).

The health benefits of a higher level of aerobic capacity also accounts to children and adolescents, as an inverse relationship between the level of aerobic capacity and metabolic risk profile has been observed (Ortega, Ruiz, Castillo, & Sjöström, 2007). The benefits of aerobic fitness are even found when normal and overweight adolescents are compared, since the normal weight comparably did show superior aerobic fitness (Ortega et al., 2007). Therefore, not only weight reduction but increasing the aerobic capacity may benefit the cardio metabolic health.

2.3 Neuromuscular fitness

Another important part of fitness is the neuromuscular, which is additionally associated with cardiovascular disease risk factors (Ortega et al., 2007). The association with bone health is also evident (Ortega et al., 2007). The researchers emphasize that the strongest effects on health and fitness is physical activity executed with high intensity, which relates to the necessary stimuli needed to develop neuromuscular strength (Ortega et al., 2007). Furthermore, neuromuscular fitness is found to be inversely and independently associated with all cause death in older men, even when confounding variables like aerobic fitness is taken into account (Ruiz et al., 2008). For children and adolescents, neuromuscular fitness is clearly associated with lower metabolic risk factors, relating to lower levels of total and central adiposity (J. Smith et al., 2014). The neuromuscular fitness in childhood may even be of importance regarding the fitness you bring into adulthood, as longitudinal studies have shown neuromuscular fitness in childhood to predict the neuromuscular fitness and related central health variables in adulthood (García-Hermoso, Ramírez-Campillo, & Izquierdo, 2019).

An important measure of neuromuscular fitness is the hand grip strength. The hand grip strength has been used as a tool in several epidemiological studies (Roberts et al., 2011). The results gained in research shows that handgrip strength may be inversely and independently associated with cardiovascular disease risk in adults (Rein, Saely, Vonbank, Zanolin, & Drexel, 2016; Silventoinen, Magnusson, Tynelius, Batty, & Rasmussen, 2009). For children and adolescents a similar pattern exists, as stronger handgrip is associated with a more beneficial metabolic risk profile (Ramírez-Vélez, Tordecilla-Sanders, Correa-Bautista, Peterson, & Garcia-Hermoso, 2016).

2.4 Physical activity and health

Physical activity is defined as any bodily movement leading to increased energy expenditure. It is characterized by four terms. Frequency, which means how often. Intensity, which is explaining how vigorous it is. Time, which relates to the duration of physical activity, and lastly the type of activity; which is explained by what kind of bodily movements (Rhodes, Janssen, Bredin, Warburton, & Bauman, 2017). The World Health Organization has developed guidelines on how much physical activity people should perform (World Health, 2010). For children and youth, the guidelines state that 60 minutes of moderate to vigorous intensity of physical activity should be accumulated daily. Further they emphasize, that the activity should be mostly aerobic, and that parts of the activity during the week should be vigorous enough to build muscle and bone strength (World Health, 2010). The guidelines are based on evidence from research that evidently shows the benefits on health. The World Health Organization states that physical activity contributes to the development of muscles, joints, bones, heart and lungs. It gains neuromuscular awareness that leads to better coordination and movement control in activities. And importantly, it helps in weight regulation, facilitating a healthy body weight (World Health, 2010).

Countless of older people suffer chronic diseases and premature death. Physical activity has shown to be a preventive factor of both (Warburton, Nicol, & Bredin, 2006). It is found a graded relationship between the volume of physical activity and different health measures (Warburton et al., 2006). The greatest benefits are however found to be for the individuals that are the least fit, as they have a good and immediate response to the increasing amount of physical activity (Warburton et al., 2006). Further has being regularly active shown to be a preventor of 25 chronic diseases. This includes conditions like cardiovascular disease, stroke, hypertension, colon cancer, breast cancer, type 2 diabetes and osteoporosis (Rhodes et al., 2017). The pathways of how physical activity works as a preventor of chronic diseases is however not fully known. Some of the important factors are nevertheless related to weight variables. Since physical activity may increase weight control, reduce adiposity and in general give a healthier body composition (Warburton et al., 2006). This is similarly, and simultaneously with reducing adiposity, further is other factors related to metabolic risk also independently improved by physical activity. This is factors that include blood lipids, insulin sensitivity and glucose homeostasis, factors which may lead to better flow in the cardiovascular system and may keep coagulation and disease at distance (Warburton et al., 2006).

The intensity and frequency of physical activity is an important factor for health benefits, this is for example found to be determining the occurring incidents of type 2 diabetes (Warburton et al., 2006). The greatest graded benefits are however found for the individuals that goes from a sedentary state, to a state of doing some physical activity, but it should be noted that higher doses of physical activity further increases benefits (A. Smith, Crippa, Woodcock, & Brage, 2016).

For children, evidence suggest vigorous physical activity to be superior stimuli for health measures compared to light and moderate physical activity. This may be related to the development of a healthy aerobic fitness (Santos, Marques, Minderico, Ekelund, & Sardinha, 2018). Therefore, vigorous or high intensity physical activity is considered to have a superior influence on metabolic risk profile in children and adolescents. This is acknowledged by a huge observational study, as the amount of time spent in different intensities appeared to determine the variation in cardiometabolic risk factors for the children involved in the study (Tarp et al., 2018). This is also seen in children with high levels of adiposity and low aerobic fitness, as more vigorous physical activity was found to prevent development of metabolic risk factors (Ortega et al., 2010).

Vigorous physical activity is however not only beneficial for children and adolescent. Even people above 60 years of age has a significant lower mortality if they execute vigorous and or moderate physical activity regularly. The benefits even seems to increase with the doses (Hupin et al., 2015). Overweight and obese adults in the normal age population can also improve cardiometabolic risk factors, if they increase the aerobic capacity with vigorous exercise (Batacan, Duncan, Dalbo, Tucker, & Fenning, 2017). Furthermore, prospective studies from adolescence to adulthood has shown that more moderate to vigorous physical activity leads to lower metabolic risk factors (Ried-Larsen, Grøntved, Kristensen, Froberg, & Andersen, 2015). Clearly, the benefits of vigorous physical activity accounts to all age groups.

2.5 Adiposity

Adiposity is another word used for being severely overweight and obese (Stöppler, 2020). Overweight and obesity is defined as abnormal or excessive fat accumulation that presents a health risk (World Health Organization, 2020). Adiposity may be defined by the accumulated fat placed in the hip and abdominal region. The World Health Organization (2020) states that the issue of overweight and adiposity has grown to epidemic proportions, as four million deaths relates to adiposity each year. The prevalence of overweight and obesity has increased in children and adolescents from 4% to 18 % globally from 1975 to 2016 (World Health Organization, 2020). It was considered to be a problem in rich countries in the past but it is now becoming an increasing issue in low and middle income countries as well (World Health Organization, 2020). One of the major problems of overweight and obesity is the likelihood of developing metabolic syndrome, which is defined by having a clustering of risk factors (Wilson, D'agostino, Parise, Sullivan, & Meigs, 2005) Among them is elevated waist circumference, elevated blood pressure, low HDL cholesterol lipids, high triglycerides lipids and hyperglycemia (S. M. Grundy, Brewer, Cleeman, Smith, & Lenfant, 2004). Adults who have developed a type of metabolic syndrome have an increased risk of developing type 2 diabetes and different types of cardiovascular disease (Wilson et al., 2005).

2.6 BMI

World Health Organization states that the risk of getting coronary heart disease, ischemic stroke, and type 2 diabetes is increasing steadily with a higher Body Mass Index (BMI). The measure is based on an equation; weight related to height: kg/m^2. WHO states that the risk of getting other chronic diseases also increases with higher BMI, including different cancer types like breast, prostate, colon and kidney (World Health Organization, 2020).

BMI is a valuable measure of the prevalence of adiposity in populations involving children and adolescents (Doak et al., 2013). However, it should be used with caution, due to the influence of height. Since height might make skewness, as it does not work exactly the same for tall, short or average height people (Doak et al., 2013). Measurements like waist circumference and skin fold measurements may be used as a supplement (Doak et al., 2013). This is probably why a measure like waist circumference to height also is used in studies (Brambilla, Bedogni, Heo, & Pietrobelli, 2013). Furthermore, it should be noted that BMI does not disentangle between fat and fat-free mass tissue. Therefore, a high proportion of muscle mass will increase the measure of BMI independent of fat-mass.

2.7 Waist circumference

Waist circumference is a measure of the length around the waist and works as an indicator of fat placed at the waist – also known as abdominal adiposity. Abdominal adiposity is regarded as one of the main risk factors to developing metabolic diseases and other chronic conditions (M. S. Grundy et al., 2005; Kuk et al., 2006; Okosun, Liao, Rotimi, Prewitt, & Cooper, 2000). Waist circumference is among other things used as a metric in the diagnosis of the metabolic syndrome (M. S. Grundy et al., 2005). It is also found to be inversely correlated with cardio respiratory fitness (Dyrstad, Edvardsen, Hansen, & Anderssen, 2017), which furthermore highlights the importance of fitness in protection of the chronic conditions.

2.8 Skin fold measurements

Skin fold measurements works as a supplement to the measurement of total fatness when BMI and waist circumference alone is not perfect. This is due to the different places skin fold measurements can be done, giving a finer picture of the body fat distribution (Durnin, Rahaman, & Durnin, 2003). For studies involving children and adolescents it is important to have measurements that can track the development of fatness and its distribution over time (Lohman, 1989), and skin fold measurements may be appropriate in this regard.

2.9 Metabolic risk and disease

Diseases linked to metabolic risk are hypertension, type 2 diabetes, atherosclerosis and stroke, all examples of or strongly linked to the development of coronary heart disease.

World health organization states that the leading killer globally is coronary heart disease and that a third of coronary heart disease are attributable to excessive adiposity (World Health Organization, 2020). Adiposity is the biggest contributor to both metabolic risk and the related diseases. Abdominal adiposity alone is one of the factors considered when diagnosing an individual with metabolic syndrome, which is based on an equation of the different risk factors (M. S. Grundy et al., 2005).

Metabolic risk and fitness are closely related not just for adults but also for children (Dencker et al., 2012; Ekelund et al., 2007; Sasayama, Ochi, Adachi, & Sasayama, 2015). Sasayama et al. (2015) found metabolic risk to be inversely related to both aerobic fitness and BMI measures, whereas lower BMI and higher aerobic fitness gave lower metabolic risk. The findings also suggested that the children with a higher BMI had a lower metabolic risk if they at the same time had a stronger aerobic fitness, which in turn suggest that aerobic fitness is a powerful tool in a protective perspective in childhood. The link between metabolic risk and weight is clearly evident also in children (Antonios, Helen, & Savvas, 2012; Nyberg, Ekelund, Yucel-Lindberg, Modeér, & Marcus, 2011; Sasayama et al., 2015).

3.0 Methods

3.1 Population

The original study included a selection of 9-year olds and 15-year olds. Solely the selection of 15-year olds are used in this study. To find the participants it was made a clustered selection where schools where the main source. Statistics Norway did the selection of schools. They made sure that geographic and population density where considered. Schools with less than 10 pupils in the relevant grades were excluded by practical means. Also “special” schools were excluded. Together they may have accounted for 4% of eligible children and youth.

Some of the participants in this study were drawn based on that they took part in an earlier study in Oslo, as European youth heart study had a part of their study in Oslo in 1999-2000. It was an examination of 800 randomly selected 9 and 15-year old children and youth. The examination looked at physical activity, determinants for being physically active, aerobic capacity and simple health measures. All the primary schools in Oslo were stratified in different categories socio economically based on the average salary in the different parts of the city. The schools were then organized alphabetically, and every student given a number. Then random numbers were selected, and the schools of the pupils were asked whether they would participate or not. This made sure that the selection was drawn on an individual level and that each school in Oslo had a probability of being selected based on the proportionality of the number of students they had. The whole age group at the school were included at the selected schools.

The pupils that were 9-year olds in the 1999-2000 study in Oslo were invited to participate in this study additionally, at the age of 15. Schools in this study as whole where however not only from Oslo, but from all over Norway. 68 schools were invited to participate, where six of them did not participate, due to different reasons. Three of them did not participate due to occurring logistic problems for the researchers. The participating 15-year olds was in total 74% of all the invited, considering all schools attending all over Norway. In Oslo however, the rate was lower with 55% of the invited participating.

3.2 Procedure

The schools were contacted beforehand to gather a contact person for the collection of the data. The contact person made sure to give the needed information to the pupils and their parents. Including the surveys and written consents.

In agreements with the schools, the test-team travelled to the different schools and did the tests in locations the schools had made available. The collection of data lasted from Mars 2005 until October 2006. Approximately 10-15 pupils were tested each day. The tests were divided into different stations: blood sample, breakfast, blood pressure and anthropometrics, measurements of muscular fitness and measurements of aerobic capacity.

All the participants were posted to do all the tests, which were including physical activity, fitness, fasting blood test, blood pressure, weight variables and determinants for physical activity.

3.3 Anthropometrics

These anthropometric measures were included: Body Mass Index (BMI), waist circumference, and skin fold measurements. The youth’s weight was measured to the closest 0.1 kg with a Seca Digital weight. Height were measured to the closes 1 mm with a measuring tape mounted vertically to a wall. They were guided to stand with arms down, the weight balanced on both feet and to breath normally. Waist circumference was measured with tape in cm, at the height of the navel with arms hanging downwards, breathing normally and weight placed on both feet. The body-fat composition was estimated based on skin fold measurements on four different places: the bicep muscle (biceps brachi), tricep muscle (tricep brachi), 1-2 cm downward from the scapular (subscapular) and the iliac crest (suprailiac surae). The tool used for this was Harpender caliper, it was always taken two measurements for each position, if it was a deviation above 2 mm a third measurement was taken. The test person was of the same gender as the participants on the skinfold measurements. All the anthropometric test was taken with the participant standing in underwear, and without shoes. Biologic development was considered using Tanners scale (Tanner, 1962).

3.4 Physical fitness

The aerobic capacity was measured with a bike-test with a progressively increasing load until exhaustion. The protocol is identical to the one used in EYHS (Riddoch et al., 2005). The bike (Monark 839 E) was electronically calibrated every day before the first test. The bike was calibrated mechanically after being transported. The Oxygen uptake was registered with a transportable Meta Max 3X oxygen analyser (Cortex Biophysics GmbH, Leipzig, Germany). Before the test started each morning it was done a two-point gas and volume calibration of the analyser. Further was the barometric pressure in the analyser calibrated to values from the meteorological institute.

The handgrip strength was measured clamping on a dynamometer with the dominant hand (Baseline ®)(Council of Europe Committee of Experts on Sports, 1993).

3.4.1 Test procedures

Before the test of aerobic capacity, the children got to try the mouthpiece (Hans Rudolph Inc, USA) accustomed for children. Which was connected with a triple V-turbin (Hans Rudolph Inc, USA). A heartrate belt (Polar OY, Finland) was placed at lower part of the breastbone. The height of the seat at the bike was adjusted to individual height to make sure they had a light flexion in the knee when the pedal was at the lowest and the foot was horizontal. The pupil was then told about the test and how it would be performed. For the girls the watt load in the start of the test was 40, and for boys 50. Through the test the watt increased every 3 minutes with the amount of the start load. At the same time, they were told to keep 60-70 repeats per minute. The Oxygen uptake, respiratory exchange ratio (RER), ventilation and heart frequency were registered in the last minutes of the test. The average of the highest measures of a 30 seconds period was used as the registration of the maximal oxygen uptake.

For the test to be approved, the test leader had to experience that the child was exhausted by a subjective measure. This was evaluated by sweat, breathing and failing to keep the told pedal frequency when the test leader gave enthusiastic encouragements. At the same time maximal heart rate was registered above 185 RPM. Also, registration of flattening of the maximal oxygen uptake and RER > 0.99 was done.

The procedure of handgrip strength was as follow; clamping the dynamometer gradually and continuously at max effort for at least two seconds. This was done with the dominant hand, standing upwards with the arm straight down but slightly out from the body. The best out of two attempts was used.

3.5 Statistical analyses

SPSS statistics (Version 22, IBM) was used to analyse the data. Multiple linear regression was used to estimate the associations. The dependent variables were the adiposity and weight related variables BMI, waist circumference and skinfold measurements. One to four independent variables were used in the different models in order to find associations that were both unadjusted and adjusted. For the total sample both “unadjusted” β and “adjusted” β were adjusted for gender. The “adjusted” β in the total sample was additionally adjusted for weight and sexual maturation (Tanner scale) when analysing handgrip strength (kg), and for height and sexual maturation when analysing VO_{2max} (ml/kg/min). Additionally, the dataset was divided by gender into a female group and a male group. Both genders were tested unadjusted and therefore only handgrip strength and VO_{2max} was used as the independent variables in the analysis. The adjusted measures for both genders were additionally adjusted for weight and sexual maturation regarding handgrip strength, and height and sexual maturation regarding VO_{2max}. The adjusted measured used are probably important to the results as they are likely to affect the associations in a natural manner, and the focus will therefore be on the adjusted results. Significance level was set at 0.05.

A sensitivity analysis was performed excluding five outliers in the weight variables that were found when checking the dataset for normality. All the tests were performed with the excluded individuals, this did however not affect the dataset in any significant measure. The presented results are therefore including all original participants. The data of the fitness variables handgrip strength and VO_{2max} were found to be approximately normally distributed.

3.6 Ethics

The examination is performed in relation to the visions in the Helsinki declaration and approved of the local ethics committee and Norwegian Centre for Research Data. The visions of the Helsinki declaration are based on protecting human subjects in medical research (National Library of, 2013). The ethical principles of the declaration intend to protect, and make sure the health and wellbeing of the participants is more important than the research itself (National Library of, 2013). Therefore, the research can only be led by professionals who makes sure that the participants rights, wellbeing, health and privacy is protected. This accounts to before, during and after the study is finalised (National Library of, 2013).

Written consent was therefore gathered before this study started, both the participating adolescents and their parents signed and agreed to the rights and terms of the study. Which involves the important part of the Helsinki declaration of informed consent, meaning that the participants authorize that they have been given needed information about the study that may be important to them (National Library of, 2013).

(Appendix 1, 2 and 3).

4.0 Results

4.1 Description of the sample

Basics characteristics of the sample are displayed in table 1. The average of the sample was 15.6 years, and the boys had higher body weight and were taller compared to the girls. BMI and waist circumference had mean values of 21.0 kg/m^2 and 74.2 cm respectively, with no gender differences in these variables. Sum of 4 skinfolds shows differences between genders as expected and a mean of 48.8 mm. The sample had an average of maximum oxygen uptake of 46.6 (ml/kg/min) and a handgrip strength of 36.0 (kg), where expected gender differences are observed. The boys had a higher mean of VO_{2max} and handgrip strength compared to the girls.

Table 1. Basic characteristics of the included sample

Variables	**Total (n = 986)** **Mean (SD)**	**Male (n = 509)** **Mean (SD)**	**Female (n = 477)** **Mean (SD)**
Age (years)	15.6 (0.4)	15.6 (0.4)	15.5 (0.4)
Weight (kg)	61.5 (11.2)	64.6 (12.1)	58.3 (8.9)
Height (cm)	171.0 (8.3)	175.8 (7.2)	165.9 (6.2)
BMI (kg/m^2)	21.0 (3.2)	20.8 (3.4)	21.2 (2.9)
Sum of 4 skinfolds (mm)	48.8 (25.1)	38.1 (22.4)	60.2 (22,6)
Waist-circumference (cm)	74.2 (8.2)	75.0 (8.9)	73.4 (7.3)
VO_{2max} (ml/kg/min)	46.6 (9.1)	51.9 (7.9)	40.7 (6.0)
Handgrip strength (kg)	36.0 (8.4)	41.1 (7.9)	30.4 (4.5)

4.2 Physical fitness and BMI

The associations of VO_{2max} and handgrip strength with BMI are shown in table 2. There is a significant negative relationship between VO_{2max} and BMI when adjusted for gender (-0.28; 95 % CI: -0.30 to -0.26; $p < 0.001$), meaning that BMI reduces by an average of 0.3 for every ml/kg/min increase in this sample. Similarly, there is a negative relationship between handgrip strength and BMI – but only when body weight is added to the regression model. The regression coefficient for handgrip strength when adjusted for gender, weight and sexual maturation is (-0.06; 95 % CI: -0.08 to -0.05; $p < 0.001$). These trends are persistent when analyzing in subgroups of gender, where we can observe through the adjusted R^2 that more of the variation in BMI is explained by the fitness variables among males, compared to females.

Table 2. Associations between physical fitness and BMI.

Variables	**Unadjusted β (95% CI)**	**P-value**	**R^2**	**Adjusted β[1] (95% CI)**	**P-value**	**R^2**
Total sample						
VO_{2max} (ml/kg/min)	-.28 (-.30 to -.26)	.000	.40	-.28 (-.30 to -.26)	.000	.44
Handgrip (kg)	.15 (.12 to.18)	.000	.10	-.06 (-.08 to -.05)	.000	.81
Females						
VO_{2max} (ml/kg/min)	-.25 (.29 to -.21)	.000	.28	-.23 (-.26 to -.19)	.000	.36
Handgrip (kg)	.20 (.14 to .25)	.000	.01	-.07 (-.11 to-.04)	.000	.76
Males						
VO_{2max} (ml/kg/min)	-.30 (-.33 to -.27)	.000	.47	-.30 (-.33 to-.28)	.000	.49
Handgrip (kg)	.14 (.10 to .18)	.000	.10	.05 (-.07 to -.03)	.000	.84

[1]VO_{2max} Adjusted for height and sexual maturation, handgrip strength adjusted for weight and sexual maturation. Total sample additionally adjusted for gender on β and β[1].

4.3 Physical fitness and waist circumference

The associations of VO_{2max} and handgrip strength with waist circumference are shown in table 3. There is a significant negative relationship between VO_{2max} and waist circumference when adjusted for gender, height and sexual maturation (-0.67; 95 % CI: -0.73 to -0.61; $p < 0.001$), explaining that waist circumference reduces by an average of 0.67 for every ml/kg/min increase in this sample. Handgrip strength and Waist circumference shows the same negative relationship, but only when body weight is added to the regression model. The regression coefficient for handgrip strength when adjusted for gender, weight and sexual maturation is -0.22 (95 % CI: -0.27 to -0.17; $p < 0.001$). The trends are similar on both genders. Additionally, for waist circumference the variation is explained more by the fitness variables for males compared to females, observed through the adjusted R^2.

Table 3. Associations between physical fitness and waist circumference.

Variables	**Unadjusted β (95% CI)**	**P-value**	**R^2**	**Adjusted β[1] (95% CI)**	**P-value**	**R^2**
Total sample						
VO_{2max} (ml/kg/min)	-.69 (-.75 to -.63)	.000	.38	-.67 (-.73 to -.61)	.000	.39
Handgrip (kg)	.30 (.22 to .38)	.000	.07	-.22 (-.27 to -.17)	.000	.74
Females						
VO_{2max} (ml/kg/min)	-.53 (-.63 to -.43)	.000	.21	-.47 (-.57 to -.37)	.000	.24
Handgrip (kg)	.36 (.23 to .50)	.000	.05	-.25 (-.35 to -.15)	.000	.65
Males						
VO_{2max} (ml/kg/min)	-.77 (-.84 to -.70)	.000	.47	-.76 (-.84 to -.69)	.000	.48
Handgrip (kg)	.28 (.18 to .38)	.000	.59	-.22 (-.27 to -.16)	.000	.79

[1]VO_{2max} Adjusted for height and sexual maturation, handgrip strength adjusted for weight and sexual maturation. Total sample additionally adjusted for gender on β and β[1].

4.4 Physical fitness and sum of 4 skinfolds

The associations of VO_{2max} and handgrip strength with Sum of 4 skinfolds are shown in table 4. There is a significant negative relationship between VO_{2max} and Sum of 4 skinfolds when adjusted for gender, height and sexual maturation (-2.19; 95 % CI: -2.34 to -2.04; $p < 0.001$), meaning that Sum of 4 skinfolds reduces by an average of 2.2 for every ml/kg/min increase in this sample. Similarly, there is a negative relationship between handgrip strength and Sum of 4 skinfolds – but only when body weight is added to the regression model. The regression coefficient for handgrip strength when adjusted for gender, weight and sexual maturation is (-1.11; 95 % CI: -1.27 to -0.95; $p < 0.001$). These trends are persistent when analyzing in subgroups of gender, where we can observe the same patterns.

Table 4. Associations between physical fitness and sum of 4 skinfolds.

Variables	Unadjusted β (95% CI)	P-value	R^2	Adjusted β[1] (95% CI)	P-value	R^2
Total sample						
VO_{2max} (ml/kg/min)	-2.14 (-2.29 to -1.99)	.000	.56	-2.19 (-2.34 to -2.04)	.000	.57
Handgrip (kg)	.29 (.07 to .52)	.011	.19	-1.11 (-1.27 to -.95)	.000	.69
Females						
VO_{2max} (ml/kg/min)	-2.32 (-2.60 to -2.04)	.000	.39	-2.21 (-2.50 to -1.93)	.000	.41
Handgrip (kg)	.76 (.30 to 1.22)	.001	.02	-1.21 (-1.55 to -.87)	.000	.59
Males						
VO_{2max} (ml/kg/min)	-2.05 (-2,22 to -.187)	.000	.52	-2.14 (-2.31 to -1.96)	.000	.55
Handgrip (kg)	.15 (-.11 to .41)	.268	.000	-1.00 (-1.18 to -.83)	.000	.68

[1]VO_{2max} Adjusted for height and sexual maturation, handgrip strength adjusted for weight and sexual maturation. Total sample additionally adjusted for gender on β and β[1].

5.0 Discussion

5.1 Main findings

In the present study, both VO_{2max} and handgrip strength is found to associate with lower levels of BMI, waist circumference and sum of 4 skinfolds in the Norwegian 15-year olds. The adjusted R^2 shows that the variation in the three adiposity measures is better explained by fitness for males compared to females.

For VO_{2max} the pattern is clear, all variables tested are negatively associated with the weight variables BMI, waist circumference and Sum of 4 skinfolds. This entails that a higher VO_{2max} is associated with lower levels of BMI, waist circumference and sum of 4 skinfolds. This is when the measure of VO_{2max} is related to weight (ml/kg/min) and adjusted for potential confounders such as height and sexual maturation.

When adjusted for weight and sexual maturation handgrip strength also show a significant negative relationship with all measures of adiposity, meaning that stronger handgrip strength is associated with lower levels of BMI, waist circumference and sum of 4 skinfolds.

This is an observational study, which means that the gathered data can only be used to compare variables and find associations. Therefore, the results found in this study cannot be used as evidence that increasing VO_{2max} and or improving the muscular fitness through training intervention will at the same time decrease BMI, waist circumference and the sum of 4 skinfolds. This may however be plausible and will therefore be considered later in the discussion.

5.2 Selection

The 15-year olds in this study can be anticipated to be representative of all 15-year olds in the country as the selected schools were from all over the Norway. For Norwegian 15-year olds, going to school is mandatory. However, the rate of participating pupils based on the invited was lower in Oslo (55%) compared to the total sample (74%), which may suggest that the data and the results in this study could be less representative for the 15-year olds living in Oslo (approximately 20% of the total sample) as compared to Norway as a whole. However, this is not probable, due to the nature and context of the study. The associations between weight and fitness is probably similar in this study sample and for other 15 year olds in the Norwegian population, since the dataset already consists of a wide spectrum in both the fitness and weight variables. Internationally the data gathered in this study are most likely comparable to other Nordic countries and may be comparable to other western societies.

5.3 Aerobic capacity

Aerobic capacity is in several studies proven to be a determinant factor for health-related variables such as metabolic risk (Ross & Katzmarzyk, 2003; Ruiz et al., 2016; Wong et al., 2004). For children and adolescents, researchers have even contemplated a cut point for a too low aerobic capacity, set at VO_{2max} below 42 (ml/kg/min) for males and 35 (ml/kg/min) for females (Ruiz et al., 2016). This is due to the fact that coronary heart disease is a leading cause of global mortality, and that the precursors of the disease may develop already in childhood (Berenson et al., 1998). Given that the precursors of disease start as early as childhood, the findings in this study may contribute to further explain the role of aerobic fitness on metabolic risk in adolescents, since VO_{2max} and the weight variables showed an inverse association to adiposity – and thereby metabolic risk. The association between VO_{2max} and waist circumference highlights this, as waist circumference correlates strongly to abdominal fat, which is one of the strongest predictors of metabolic risk (Wong et al., 2004). This relationship might even work both ways, as waist circumference levels has been found to predict VO_{2max} in the study by Dyrstad et al. (2017). In the study, cut points in waist circumference reflected differences in VO_{2max} in both adult men and women (Dyrstad et al., 2017). For children and adolescents, several studies emphasize the importance of having a developed aerobic fitness to ensure a good metabolic risk profile (Adegboye et al., 2011; Ruiz et al., 2016; Tomkinson, 2011). Aerobic fitness is regardless of this not used regularly in health screening (Tomkinson, 2011). This may be since aerobic fitness is dependent on factors within individuals that not only relates to physical activity, but also genes (Schutte, Nederend, Hudziak, Bartels, & de Geus, 2016). And implementing physical activity for the individuals that need it may not be that easy, regarding the need for behavior change. Further, to implement aerobic capacity in health screening would probably be expensive, given the personnel, equipment and work needed. But using aerobic fitness in health screening in the future should not be ruled out, as exercise for obese adolescents has proven to be beneficial for health (Silva et al., 2015). Health screening may therefore find and put the right individuals on beneficial exercise programs.

In the study by Adegboye et al. (2011) the suggested VO_{2max} cut point level for adolescents having metabolic risk were 46 (ml/kg/min) for males and 33 (ml/kg/min) for females. In the meta-analysis by Ruiz et al. (2016) the suggested values were lower than 42 (ml/kg/min) for males and lower than 35 (ml/kg/min) for females. The age of the participants in the studies was 8-19 years of age. In comparison, the mean VO_{2max} in this study was 52 (ml/kg/min) among the males and 41(ml/kg/min) among the females. Therefore, the mean of 15-year old’s in this study sample were not at risk for having a too low aerobic capacity considering metabolic health. However, individuals with a too low VO_{2max} based on the suggested cut points by Adegboye et al. (2011) and Ruiz et al. (2016), could likely benefit from an exercise intervention to improve metabolic health.

Aerobic capacity does not only associate with metabolic health. A study from England in 11-12-year old’s found through questionnaire and physical tests that aerobic capacity also was the factor that had the strongest influence on physical and psychological wellbeing, and social and peer support (Azevedo, Watson, Haighton, & Adams, 2015). In another study, associations of aerobic fitness and health variables did show that children and adolescents having parents with less education also were the ones with lower aerobic capacity (Finger, Mensink, Banzer, Lampert, & Tylleskar, 2014). The influence of aerobic capacity and importance it has for health is evident. Therefore, exercise interventions might be beneficial in several ways for children and adolescents.

5.4 Neuromuscular fitness

The meta-analysis by Smith et al. (2014) shows that muscular fitness has an inverse association with total and central adiposity for children and adolescents. Additionally, cardiovascular disease and metabolic risk factors associated inversely with muscular fitness (J. Smith et al., 2014). Therefore, the results in the presents study align as handgrip strength show negative inverse associations to BMI, waist circumference and sum of 4 skinfolds. This is however only when it is adjusted for weight. Similar results to this are found in another study regarding hand grip strength involving children and adolescents (Ramírez-Vélez et al., 2016). Even prospective studies from childhood to adulthood has found associations between muscular fitness and metabolic risk factors

(García-Hermoso et al., 2019). The use of handgrip strength as a measure of muscular fitness is common in epidemiological studies. Additionally where metabolic benefits is found (Ramírez-Vélez et al., 2016; Rein et al., 2016; Roberts et al., 2011).

The present study is an observational one, therefore, cause and effect cannot be drawn from the results. However, the possible explanations to why individuals with stronger handgrip also show a better metabolic health profile when adjusted to weight may be explained by doses of physical activity. That's possibly why Grøntved et al. (2015) suggest that muscle strengthening activities may be of benefit for youth's metabolic health. And it is probable that the intensity needed to benefit muscle strength also benefits other parts of fitness that correlates to health. This may even explain why Grøntved et al. (2015) found muscle fitness to be beneficial for metabolic health independent of aerobic capacity.

In this study handgrip strength was however only negatively associated with the weight variables when adjusted for weight. It was positively associated for both male and female unadjusted, therefore, the heavier individuals in the sample had a stronger handgrip. This is in line with the results from "The HELENA" study, who found hand grip strength and upper body muscular strength to be superior in adolescents with a higher level of adiposity (Moliner-Urdiales et al., 2011). Increasing strength on the basis of overweight is however not optimal, when knowing overweight increases the likelihood of attaining several chronic diseases (Rhodes et al., 2017).

5.5 Weight variables and health

Weights variables are evidently important factors considering metabolic diseases, and both central and general adiposity seems to be causal factors. Central adiposity however seems to be an even stronger predictor of the typical and severe metabolic diseases (Dale et al., 2017). Therefore, waist circumference may be the best predictor of future metabolic diseases in the adolescents participating in the present study. The results in this study highlight both stronger VO_{2max} and handgrip strength to associate with lower levels of waist circumference. This is in line with other studies, Wong et al. (2004) found, that aerobic fitness was associated with lower abdominal fatness independent of BMI, performed with a treadmill test that were correlating very well to VO_{2max}. Further, regarding muscular fitness the meta-analysis by Smith et al. (2014) clearly states that muscular fitness associates with both central and total adiposity. The same is found in the European Youth Heart Study by Grøntved et al. (2015). So evidently general fatness and central and abdominal fatness is associated with fitness. And general and central fatness is clearly becoming an increasing problem in the world, also for children (McCarthy, 2006; World Health Organization, 2020). This is why including waist circumference in general health screening is suggested by McCarthy (2006), as increasing levels of fatness is increasing the occurrences of chronic conditions in children and thereby increasing the likelihood of developing illness in adulthood (McCarthy, 2006).

In one study the ability and relevance of the tools; BMI, waist circumference and waist to height ratio were tested to classify metabolic risk in youth (Luís et al., 2016). They found that the tools had a low precision in detecting metabolic risk for whole samples of studies. However, for the obese and overweight individuals in the sample, the prediction of metabolic risk did work exceedingly better compared to the normal weight individuals. Which may be natural considering that overweight and obese in general are at higher metabolic risk (Dale et al., 2017). For BMI a percentile has been proposed to work as an identification of abdominal adiposity and metabolic risk for children and adolescents. The percentile they have found to be predicting is 95th (Harrington, Staiano, Broyles, Gupta, & Katzmarzyk, 2012). Sometimes BMI may however not be adequate in detecting fat mass, which is why some studies classify individuals as normal weight obese. This is when the BMI number is within the limit of being classified as normal weight even though they have a high body fat percentage (Olafsdottir, Torfadottir, Arngrimsson, & Buchowski, 2016). Therefore, the use of skin fold measurements might be a sufficient measurement tool in some samples involving children and adolescents (Susi Kriemler et al., 2010). This is further supported by the associations in this study, as the skin fold measurements shows the same patterns as BMI and waist circumference. However, BMI is clearly an adequate measure of fatness in overweight and obese adolescents, since it is found that reducing it also reduces metabolic risk factors (Gläßer, Zellner, & Kromeyer-Hauschild, 2011; Kolsgaard et al., 2011). Furthermore, higher BMI scores has shown to associate with higher prevalence of metabolic syndrome in children and adolescents (Sen, Kandemir, Alikasifoglu, Gonc, & Ozon, 2008). It is even found in a prospective study that already at the age of eight the BMI measure can predict development of type two diabetes for adults (Koskinen et al., 2017). Therefore, the results from the this study where fitness is negatively associated with BMI, highlights BMI as an indicator of possible metabolic risk.

5.6 Physical activity and exercise

Exercise interventions for obese and or overweight children and adolescents may be an important part of the possible dealing with the issue of excessive fatness in youth. In a study, an intervention was performed to investigate the difference between high and low intensity aerobic exercise. And the results did show that both training intensities did improve metabolic risk factors (Silva et al., 2015), which is promising, considering that low intensity aerobic exercise might be considered more comfortable to perform. Similar results regarding exercise intensity is found and included in the meta-analysis by Parikh & Stratton (2011), the intervention studies they included in their analysis did show that moderate and vigorous physical activity interventions were lowering the adiposity levels and increasing the aerobic fitness in the samples. However, vigorous intensity was found to be significantly greater than moderate intensity (Parikh & Stratton, 2011). This is also in line with other studies as both aerobic capacity and muscular fitness in children and adolescents is found to be more developed with short bouts of high intensity (Benson, Torode, & Fiatarone Singh, 2007; Bond, Weston, Williams, & Barker, 2017). This highlights that exercise interventions for children and adolescent’s health, can and maybe should be executed with short bouts of high intensity to gain the best possible health benefits.

The benefits of physical activity and exercise are numerous, one of them are insulin sensitivity. Therefore, the results by Labayen et al. (2011) showing that insulin sensitivity in childhood is associated with central and general adiposity gain later in adolescence is interesting. This further highlights the need for physical activity interventions, especially since the insulin sensitivity also was negatively associated for non-overweight children, regardless of baseline adiposity measures (Labayen et al., 2011).

In order to find appropriate training methods for obese adolescents it has been investigated whether land-based or water-based training work best for health measures. This is in order to handle the obesity problem in the best possible manner. The results of the study indicate that water-based training decreased fat mass slightly more than land based training, the overall result indicate however that both training methods are valuable and therefore a multidisciplinary approach to training is suggested (Lopera et al., 2016) .

In observational studies similar to the present study, the amount of vigorous physical activity is also found to be a predictor of adiposity (Parikh & Stratton, 2011). Moderate intensity physical activity were comparably not a significant predictor of adiposity in the studies that were included in the meta-analysis (Parikh & Stratton, 2011). Vigorous physical activity therefore may be a superior stimulus in protecting against adiposity.

The review by Wewege et al. (2018) who focused on exercise interventions found aerobic exercise to be positive for metabolic risk factors for adolescents with metabolic syndrome, involving those who had not yet developed type 2 diabetes. As in the present study it was investigated waist circumference, which was significantly reduced by the aerobic exercise (Wewege, Thom, Rye, & Parmenter, 2018). Therefore, not only observed fitness levels as in the present study is valuable to health, but also levels of physical activity. Increasing physical activity may therefore work as a metabolic risk preventor for individuals with low fitness. And increasing the physical activity levels will also likely increase fitness levels.

The living environment may be an important asset in the prevention strategies, as urban living environment is found to be associated with less physically active children and children with lower physical fitness scores (S. Kriemler et al., 2008). The metabolic risk factors were also alarming in the considered children (S. Kriemler et al., 2008). The environment people live in may need a change towards being more developed for physical activity, as millions of people around the world are living in cities and this may be a factor that contributes to those people's health and wellbeing.

Independent of the prevalence of obese and overweight children and adolescents in the world, the individual response to physical activity and exercise and the possible prevention it may present may be individually different, as the aerobic fitness is affected differently by exercise due to genetics (Bouchard & Rankinen, 2001). This may be more recognized in individuals who are going from a sedentary state to an active state, where the response to exercise is found to be diverse and highly different (Bouchard & Rankinen, 2001). The diversity and different response may be due to heritability of VO_{2max} in children and adolescents. This has been investigated using twins and siblings as research subjects, as they found that the variance of VO_{2max} was more than half determined by genetic factors in the years going from childhood to early adulthood (Schutte et al., 2016).

6.0 Conclusion

The current study shows inverse associations between physical fitness and weight variables among Norwegian 15-year olds. Both fitness variables (aerobic capacity (VO_{2max}) and handgrip strength) were inversely associated to the weight variables BMI, waist circumference and sum of 4 skinfolds. Given that this is an observational study the causation cannot be detected. It is however likely that physical activity plays a role in the development of physical fitness, even considering different genetics. As the proportion of adiposity levels in children and adolescents has rapidly increased the last several decades, implementation of physical activity may be an important tool in enhancing physical fitness and preventing development of metabolic risk factors.

References

Adegboye, A. R., Anderssen, S. A., Froberg, K., Sardinha, L. B., Heitmann, B. L., Steene-Johannessen, J., . . . Andersen, L. B. (2011). Recommended aerobic fitness level for metabolic health in children and adolescents: a study of diagnostic accuracy. In (pp. 722): BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine.

Anderssen, S., Helsedirektoratet, & Norges, i. (2008). *Fysisk aktivitet blant barn og unge i Norge : en kartlegging av aktivitetsnivå og fysisk form hos 9- og 15-åringer*. Oslo: Helsedirektoratet i samarbeid med Norges idrettshøgskole.

Anderssen, S. A., Cooper, A., Riddoch, C., Sardinha, L., Harro, M., Brage, S., & Andersen, L. (2007). Low cardiorespiratory fitness is a strong predictor for clustering of cardiovascular disease risk factors in children independent of country, age and sex. *Eur. J. Cardiovasc. Prev. Rehabil., 14*(4), 526-531.

Antonios, D. C., Helen, T. D., & Savvas, P. T. (2012). Cardiorespiratory Fitness, Metabolic Risk, and Inflammation in Children. *International Journal of Pediatrics, 2012*. doi:10.1155/2012/270515

Azevedo, B. L., Watson, B. D., Haighton, B. C., & Adams, B. J. (2015). Health-related Quality Of Life In School Children: Association With Aerobic Fitness, Physical Activity And Bmi: 1626 May 28, 1: 45 PM - 2: 00 PM. *Medicine & Science in Sports & Exercise, 47*(5S Suppl 1), 433-433. doi:10.1249/01.mss.0000477613.38690.31

Bassett, R. D. (2000). Limiting factors for maximum oxygen uptake and determinants of endurance performance. *Medicine & Science in Sports & Exercise, 32*(1), 70-70.

Batacan, R. B., Duncan, M. J., Dalbo, V. J., Tucker, P. S., & Fenning, A. S. (2017). Effects of high-intensity interval training on cardiometabolic health: a systematic review and meta-analysis of intervention studies. In (pp. 494): BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine.

Benson, A. C., Torode, M. E., & Fiatarone Singh, M. A. (2007). A rationale and method for high-intensity progressive resistance training with children and adolescents. *Contemporary clinical trials, 28*(4), 442. doi:10.1016/j.cct.2006.11.004

Berenson, G. S., Srinivasan, S. R., Bao, W., Newman, W. P., Tracy, R. E., & Wattigney, W. A. (1998). Association between Multiple Cardiovascular Risk Factors and Atherosclerosis in Children and Young Adults. *The New England journal of medicine, 338*(23), 1650-1656. doi:10.1056/NEJM199806043382302

Bertoli, A., Di Daniele, N., Ceccobelli, M., Ficara, A., Girasoli, C., & De Lorenzo, A. (2003). Lipid profile, BMI, body fat distribution, and aerobic fitness in men with metabolic syndrome. *Acta diabetologica, 40 Suppl 1*, S130.

Bond, B., Weston, K., Williams, C., & Barker, A. (2017). Perspectives on high-intensity interval exercise for health promotion in children and adolescents. *Open Access Journal of Sports Medicine, 8,* 243-265.

Bouchard, C., & Rankinen, T. (2001). Individual differences in response to regular physical activity. *Medicine and Science in Sports and Exercise, 33*(6 Suppl), S446-S451.

Brambilla, P., Bedogni, G., Heo, M., & Pietrobelli, A. (2013). Waist circumference-to-height ratio predicts adiposity better than body mass index in children and adolescents. *International Journal of Obesity, 37*(7), 943. doi:10.1038/ijo.2013.32 ;published online 12 March 2013 Keywords: children; body composition; body fat; body mass index; trunk fat; waist circumference

10.1038/ijo.2013.32

Council of Europe Committee of Experts on Sports, R. (1993). *Eurofit : handbook for the Eurofit tests of physical fitness* (2nd ed. ed.). Strasbourg: Council of Europe, Committee for the Development of Sport.

Dale, E. C., Fatemifar, M. G., Palmer, E. L. T., White, R. J., Prieto-Merino, W. D., Zabaneh, J. D., . . . Casas, P. J. (2017). Causal Associations of Adiposity and Body Fat Distribution With Coronary Heart Disease, Stroke Subtypes, and Type 2 Diabetes Mellitus: A Mendelian Randomization Analysis. *Circulation, 135*(24), 2373-2388. doi:10.1161/CIRCULATIONAHA.116.026560

Dalene, K. E. (2018). Physical activity in Norwegian children and adolescents: With a special focus on physical activity trends, health implications, correlates and determinants of physical activity. In.

Dencker, M., Thorsson, O., Karlsson, M., Lindén, C., Wollmer, P., & Andersen, L. (2012). Aerobic fitness related to cardiovascular risk factors in young children. *European Journal of Pediatrics, 171*(4), 705-710. doi:10.1007/s00431-011-1617-0

Doak, C. M., Hoffman, D. J., Norris, S. A., Campos Ponce, M., Polman, K., & Griffiths, P. L. (2013). Is body mass index an appropriate proxy for body fat in children? *Global Food Security, 2*(2), 65-71. doi:10.1016/j.gfs.2013.02.003

Durnin, J. V. G. A., Rahaman, M. M., & Durnin, J. V. G. A. (2003). The assessment of the amount of fat in the human body from measurements of skinfold thickness. 1967. *The British journal of nutrition, 89*(1), 147-155.

Dyrstad, S. M., Edvardsen, E., Hansen, B. H., & Anderssen, S. A. (2017). Waist circumference thresholds and cardiorespiratory fitness. doi:https://doi.org/10.1016/j.jshs.2017.03.011

Ekelund, U., Anderssen, S., Froberg, K., Sardinha, L., Andersen, L., & Brage, S. (2007). Independent associations of physical activity and cardiorespiratory fitness with metabolic risk factors in children: the European youth heart study. *Clinical and Experimental Diabetes and Metabolism, 50*(9), 1832-1840. doi:10.1007/s00125-007-0762-5

Ferreira, I., Twisk, J. W. R., van Mechelen, W., Kemper, H. C. G., & Stehouwer, C. D. A. (2005). Development of Fatness, Fitness, and Lifestyle From Adolescence to the Age of 36 Years: Determinants of the Metabolic Syndrome in Young Adults: The Amsterdam Growth and Health Longitudinal Study. *Archives of Internal Medicine, 165*(1), 42-48. doi:10.1001/archinte.165.1.42

Finger, J. D., Mensink, G. B. M., Banzer, W., Lampert, T., & Tylleskar, T. (2014). Physical activity, aerobic fitness and parental socio-economic position among adolescents: the German Health Interview and Examination Survey for Children and Adolescents 2003-2006 (KiGGS). *The International Journal of Behavioral Nutrition and Physical Activity, 11*(1). doi:10.1186/1479-5868-11-43

García-Hermoso, A., Ramírez-Campillo, R., & Izquierdo, M. (2019). Is Muscular Fitness Associated with Future Health Benefits in Children and Adolescents? A Systematic Review and Meta-Analysis of Longitudinal Studies. *Sports Medicine, 49*(7), 1079-1094. doi:10.1007/s40279-019-01098-6

Gläßer, N., Zellner, K., & Kromeyer-Hauschild, K. (2011). Validity of body mass index and waist circumference to detect excess fat mass in children aged 7-14 years. *European Journal of Clinical Nutrition, 65*(2), 151-159. doi:10.1038/ejcn.2010.245

Grundy, M. S., Cleeman, I. J., Daniels, R. S., Donato, A. K., Eckel, H. R., Franklin, A. B., . . . Costa, A. F. (2005). Diagnosis and Management of the Metabolic

Syndrome: An American Heart Association/National Heart, Lung, and Blood Institute Scientific Statement Executive Summary. *Circulation, 112*(17), e285-e290. doi:10.1161/CIRCULATIONAHA.105.169405

Grundy, S. M., Brewer, H. B., Cleeman, J. I., Smith, S. C., & Lenfant, C. (2004). Definition of metabolic syndrome: Report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. *109*(3), 433-438. doi:10.1161/01.CIR.0000111245.75752.C6

Grøntved, A., Ried-Larsen, M., Møller, N. C., Kristensen, P. L., Froberg, K., Brage, S., & Andersen, L. B. (2015). Muscle strength in youth and cardiovascular risk in young adulthood (the European Youth Heart Study). In (pp. 90): BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine.

Harrington, D. M., Staiano, A. E., Broyles, S. T., Gupta, A. K., & Katzmarzyk, P. T. (2012). BMI percentiles for the identification of abdominal obesity and metabolic risk in children and adolescents: evidence in support of the CDC 95th percentile. *European Journal of Clinical Nutrition, 67*(2), 218. doi:10.1038/ejcn.2012.203; published online 12 December 2012 Keywords: body mass index; visceral adipose tissue; children; adolescents; Centers for Disease Control and Prevention; body fat

10.1038/ejcn.2012.203

Hupin, D., Roche, F., Gremeaux, V., Chatard, J.-C., Oriol, M., Gaspoz, J.-M., . . . Edouard, P. (2015). Even a low-dose of moderate-to-vigorous physical activity reduces mortality by 22% in adults aged ≥60 years: a systematic review and meta-analysis. In: BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine.

Hussain, N., Gersh, B. J., Gonzalez Carta, K., Sydó, N., Lopez-Jimenez, F., Kopecky, S. L., . . . Allison, T. G. (2018). Impact of Cardiorespiratory Fitness on Frequency of Atrial Fibrillation, Stroke, and All-Cause Mortality. *The American Journal of Cardiology, 121*(1), 41-49. doi:10.1016/j.amjcard.2017.09.021

Jonatan, R. R., Francisco, B. O., Nico, S. R., Inga, V., Anita, H.-W., Leila, O., & Michael, S. (2007). High Cardiovascular Fitness Is Associated with Low Metabolic Risk Score in Children: The European Youth Heart Study. *Pediatric Research, 61*(3), 350. doi:10.1203/pdr.0b013e318030d1bd

Joyner, M. J., & Coyle, E. F. (2008). Endurance exercise performance: the physiology of champions. In (Vol. 586, pp. 35-44). Oxford, UK.

Kelishadi, R., Mirmoghtadaee, P., Najafi, H., & Keikha, M. (2015). Systematic review on the association of abdominal obesity in children and adolescents with cardio-metabolic risk factors. *Journal of Research in Medical Sciences, 20*(3), 294-307.

Kolsgaard, M. L. P., Joner, G., Brunborg, C., Anderssen, S. A., Tonstad, S., Andersen, L. F., & Kolsgaard, M. L. P. (2011). Reduction in BMI z-score and improvement in cardiometabolic risk factors in obese children and adolescents. The Oslo Adiposity Intervention Study - a hospital/public health nurse combined treatment. *BMC Pediatrics, 11*, 47-47. doi:10.1186/1471-2431-11-47

Koskinen, J., Magnussen, C. G., Sinaiko, A., Woo, J., Urbina, E., Jacobs, D. R., Jr., . . . Juonala, M. (2017). Childhood Age and Associations Between Childhood Metabolic Syndrome and Adult Risk for Metabolic Syndrome, Type 2 Diabetes Mellitus and Carotid Intima Media Thickness: The International Childhood Cardiovascular Cohort Consortium. *J Am Heart Assoc, 6*(8). doi:10.1161/jaha.117.005632

Kriemler, S., Manser-Wenger, S., Zahner, L., Braun-Fahrländer, C., Schindler, C., & Puder, J. (2008). Reduced cardiorespiratory fitness, low physical activity and an urban environment are independently associated with increased cardiovascular risk in children. *Clinical and Experimental Diabetes and Metabolism, 51*(8), 1408-1415. doi:10.1007/s00125-008-1067-z

Kriemler, S., Puder, J., Zahner, L., Roth, R., Meyer, U., & Bedogni, G. (2010). Estimation of percentage body fat in 6- to 13-year-old children by skinfold thickness, body mass index and waist circumference. *Br J Nutr, 104*(10), 1565-1572. doi:10.1017/S0007114510002357

Kristensen, P., Moeller, N., Korsholm, L., Kolle, E., Wedderkopp, N., Froberg, K., & Andersen, L. (2010). The association between aerobic fitness and physical activity in children and adolescents: the European youth heart study. *European Journal of Applied Physiology, 110*(2), 267-275. doi:10.1007/s00421-010-1491-x

Kuk, J. L., Katzmarzyk, P. T., Nichaman, M. Z., Church, T. S., Blair, S. N., & Ross, R. (2006). Visceral Fat Is an Independent Predictor of All-cause Mortality in Men. *Visceral Fat Is an Independent Predictor of All-cause Mortality in Men, 14*(2), 336-341. doi:10.1038/oby.2006.43

Kuzik, N., Carson, V., Andersen, L., Sardinha, L., Grøntved, A., Hansen, B., & Ekelund, U. (2017). Physical Activity and Sedentary Time Associations with Metabolic Health Across Weight Statuses in Children and Adolescents. *Obesity, 25*(10), 1762-1769. doi:10.1002/oby.21952

Labayen, I., Ruiz, J., Ortega, F., Harro, J., Merenäkk, L., Oja, L., . . . Sjostrom, M. (2011). Insulin sensitivity at childhood predicts changes in total and central adiposity over a 6-year period. *International Journal of Obesity, 35*(10), 1284-1288. doi:10.1038/ijo.2011.98

Lee, S., & Arslanian, S. (2007). Cardiorespiratory fitness and abdominal adiposity in youth. *European Journal of Clinical Nutrition, 61*(4), 561-565. doi:10.1038/sj.ejcn.1602541

Lohman, T. G. (1989). Assessment of Body Composition in Children. *Pediatric Exercise Science, 1*(1), 19-30. doi:10.1123/pes.1.1.19

Lopera, C., Da Silva, D., Bianchini, J., Locateli, J., Moreira, A., Dada, R., . . . Nardo, N. (2016). Effect of water- versus land-based exercise training as a component of a multidisciplinary intervention program for overweight and obese adolescents. *Physiol. Behav., 165*, 365-373. doi:10.1016/j.physbeh.2016.08.019

Luís, B. S., Diana, A. S., Analiza, M. S., Anders, G., Lars, B. A., & Ulf, E. (2016). A Comparison between BMI, Waist Circumference, and Waist-To-Height Ratio for Identifying Cardio-Metabolic Risk in Children and Adolescents. *PloS one, 11*(2), e0149351. doi:10.1371/journal.pone.0149351

Magalhães, J., Melo, X., Santos, D., Ornelas, R., & Sardinha, L. (2016). Changes in Cardiorespiratory Fitness in Children and Adolescents Predicts Adulthood Body Composition Phenotypes: 858 Board #174 June 1, 3: 30 PM - 5: 00 PM. *Medicine & Science in Sports & Exercise, 48*(5S Suppl 1), 240-240. doi:10.1249/01.mss.0000485721.63398.77

Marques, A., Santos, D. A., Hillman, C. H., & Sardinha, L. B. (2018). How does academic achievement relate to cardiorespiratory fitness, self-reported physical activity and objectively reported physical activity: a systematic review in children and adolescents aged 6–18 years. In (pp. 1039): BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine.

McCarthy, H. D. (2006). Body fat measurements in children as predictors for the metabolic syndrome: focus on waist circumference. *Proc. Nutr. Soc., 65*(4), 385-392. doi:10.1017/S0029665106005143

Moliner-Urdiales, D., Ruiz, J. R., Vicente-Rodriguez, G., Ortega, F. B., Rey-Lopez, J. P., Espana-Romero, V., . . . Moreno, L. A. (2011). Associations of muscular and cardiorespiratory fitness with total and central body fat in adolescents: The

HELENA Study. *British Journal of Sports Medicine, 45*(2), 101. doi:10.1136/bjsm.2009.062430

National Library of, M. (2013). World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA, 310*(20), 2191-2194. doi:10.1001/jama.2013.281053

Nyberg, G., Ekelund, U., Yucel-Lindberg, T., Modeér, T., & Marcus, C. (2011). Differences in metabolic risk factors between normal weight and overweight children. *International Journal of Pediatric Obesity, 6*(3-4), 244-252. doi:10.3109/17477166.2011.575226

Okosun, I. S., Liao, Y., Rotimi, C. N., Prewitt, T. E., & Cooper, R. S. (2000). Abdominal Adiposity and Clustering of Multiple Metabolic Syndrome in White, Black and Hispanic Americans. *Annals of Epidemiology, 10*(5), 263-270. doi:10.1016/S1047-2797(00)00045-4

Olafsdottir, A. S., Torfadottir, J. E., Arngrimsson, S. A., & Buchowski, M. (2016). Health Behavior and Metabolic Risk Factors Associated with Normal Weight Obesity in Adolescents. *PloS one, 11*(8). doi:10.1371/journal.pone.0161451

Ortega, F. B., Ruiz, J. R., Castillo, M. J., & Sjöström, M. (2007). Physical fitness in childhood and adolescence: a powerful marker of health. *International Journal of Obesity, 32*(1), 1. doi:10.1038/sj.ijo.0803774

Ortega, F. B., Ruiz, J. R., Hurtig-Wennlöf, A., Vicente-Rodríguez, G., Rizzo, N. S., Castillo, M. J., & Sjöström, M. (2010). Cardiovascular fitness modifies the associations between physical activity and abdominal adiposity in children and adolescents: the European Youth Heart Study. In (pp. 256): BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine.

Parikh, T., & Stratton, G. (2011). Influence of Intensity of Physical Activity on Adiposity and Cardiorespiratory Fitness in 5–18 Year Olds. *Sports Medicine, 41*(6), 477-488. doi:10.2165/11588750-000000000-00000

Ramírez-Vélez, R., Tordecilla-Sanders, A., Correa-Bautista, J. E., Peterson, M. D., & Garcia-Hermoso, A. (2016). Handgrip Strength and Ideal Cardiovascular Health among Colombian Children and Adolescents. *The Journal of Pediatrics, 179*, 82-89.e81. doi:10.1016/j.jpeds.2016.08.099

Reilly, J. J., Methven, E., McDowell, Z. C., Hacking, B., Alexander, D., Stewart, L., & Kelnar, C. J. H. (2003). Health consequences of obesity. In (pp. 748): BMJ Publishing Group Ltd and Royal College of Paediatrics and Child Health.

Rein, P., Saely, C., Vonbank, A., Zanolin, D., & Drexel, H. (2016). HAND GRIP STRENGTH SIGNIFICANTLY PREDICTS CARDIOVASCULAR EVENT RISK IN PATIENTS WITH TYPE 2 DIABETES. *Journal of the American College of Cardiology, 67*(13), 2029-2029. doi:10.1016/S0735-1097(16)32030-7

Rhodes, R. E., Janssen, I., Bredin, S. S. D., Warburton, D. E. R., & Bauman, A. (2017). Physical activity: Health impact, prevalence, correlates and interventions. *Psychology & Health, 32*(8), 942-975. doi:10.1080/08870446.2017.1325486

Riddoch, C., Edwards, D., Page, A., Froberg, A., Anderssen, S. A., Wederkopp, N., . . . center, V. U. U. m. (2005). The European Youth Heart Study-Cardiovascular disease risk factors in children: rationale, aims, study design, and validation of methods. *Journal of Physical Activity & Health, 2*, 115-129.

Ried-Larsen, M., Grøntved, A., Kristensen, P. L., Froberg, K., & Andersen, L. B. (2015). Moderate-and-vigorous physical activity from adolescence to adulthood and subclinical atherosclerosis in adulthood: prospective observations from the European Youth Heart Study. In (pp. 107): BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine.

Roberts, H. C., Denison, H. J., Martin, H. J., Patel, H. P., Syddall, H., Cooper, C., & Sayer, A. A. (2011). A review of the measurement of grip strength in clinical and epidemiological studies: towards a standardised approach. *Age Ageing, 40*(4), 423-429. doi:10.1093/ageing/afr051

Ross, R., & Katzmarzyk, P. T. (2003). Cardiorespiratory fitness is associated with diminished total and abdominal obesity independent of body mass index. *International Journal of Obesity, 27*(2), 204. doi:10.1038/sj.ijo.802222

Ruiz-Ariza, A., Grao-Cruces, A., de Loureiro, N. E. M., & Martínez-López, E. J. (2017). Influence of physical fitness on cognitive and academic performance in adolescents: A systematic review from 2005-2015. In (Vol. 10, pp. 108-133).

Ruiz, J. R., Cavero-Redondo, I., Ortega, F. B., Welk, G. J., Andersen, L. B., & Martinez-Vizcaino, V. (2016). Cardiorespiratory fitness cut points to avoid cardiovascular disease risk in children and adolescents; what level of fitness should raise a red flag? A systematic review and meta-analysis. In: BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine.

Ruiz, J. R., Sui, X., Lobelo, F., Morrow, J. R., Jackson, A. W., Sjöström, M., & Blair, S. N. (2008). Association between muscular strength and mortality in men: prospective cohort study. In: British Medical Journal Publishing Group.

Santos, D. A., Marques, A., Minderico, C. S., Ekelund, U., & Sardinha, L. B. (2018). A cross-sectional and prospective analyse of reallocating sedentary time to physical activity on children's cardiorespiratory fitness. *Journal of Sports Sciences, 36*(15), 1720. doi:10.1080/02640414.2017.1411176

Sasayama, K., Ochi, E., Adachi, M., & Sasayama, K. (2015). Importance of both fatness and aerobic fitness on metabolic syndrome risk in Japanese children. *PloS one, 10*(5), e0127400-e0127400. doi:10.1371/journal.pone.0127400

Schutte, N. M., Nederend, I., Hudziak, J. J., Bartels, M., & de Geus, E. J. (2016). Twin-sibling study and meta-analysis on the heritability of maximal oxygen consumption. *Physiol Genomics, 48*(3), 210-219. doi:10.1152/physiolgenomics.00117.2015

Sen, Y., Kandemir, N., Alikasifoglu, A., Gonc, N., & Ozon, A. (2008). Prevalence and risk factors of metabolic syndrome in obese children and adolescents: the role of the severity of obesity. *European Journal of Pediatrics, 167*(10), 1183-1189. doi:10.1007/s00431-007-0658-x

Silva, H., Andersen, L., Lofrano-Prado, M. C., Barros, M., Freitas, I. F., Hill, J., & Do Prado, W. (2015). Improvements on Cardiovascular Diseases Risk Factors in Obese Adolescents: A Randomized Exercise Intervention Study. *J. Phys. Act. Health, 12*(4), 553-560. doi:10.1123/jpah.2013-0199

Silventoinen, K., Magnusson, P., Tynelius, P., Batty, G., & Rasmussen, F. (2009). Association of body size and muscle strength with incidence of coronary heart disease and cerebrovascular diseases: a population-based cohort study of one million Swedish men. *Int. J. Epidemiol., 38*(1), 110-118. doi:10.1093/ije/dyn231

Smith, A., Crippa, A., Woodcock, J., & Brage, S. (2016). Physical activity and incident type 2 diabetes mellitus: a systematic review and dose-response meta-analysis of prospective cohort studies. *Diabetologia, 59*(12), 2527-2545. doi:10.1007/s00125-016-4079-0

Smith, J., Eather, N., Morgan, P., Plotnikoff, R., Faigenbaum, A., & Lubans, D. (2014). The Health Benefits of Muscular Fitness for Children and Adolescents: A Systematic Review and Meta-Analysis. *Sports Medicine, 44*(9), 1209-1223. doi:10.1007/s40279-014-0196-4

Stöppler, M. C. (2020). Medical Definition of Adiposity. Retrieved from https://www.medicinenet.com/script/main/art.asp?articlekey=196295

Sundgot-Borgen, C. (2013). Physical activity level and sedentary time in Norwegian adolescents. In.

Tanner, J. M. (1962). *Growth at adolescence : with a general consideration of the effects of hereditary and environmental factors upon growth and maturation from birth to maturity* (2nd ed. ed.). Oxford: Blackwell.

Tarp, J., Child, A., White, T., Westgate, K., Bugge, A., Grøntved, A., . . . Brage, S. (2018). Physical activity intensity, bout-duration, and cardiometabolic risk markers in children and adolescents. doi:https://doi.org/10.1038/s41366-018-0152-8

Tomkinson, G. (2011). Aerobic fitness thresholds for cardio metabolic health in children and adolescents. In (pp. 686): BMJ Publishing Group Ltd and British Association of Sport and Exercise Medicine.

Umer, A., Kelley, G., Cottrell, L., Giacobbi, P., Innes, K., & Lilly, C. (2017). Childhood obesity and adult cardiovascular disease risk factors: a systematic review with meta-analysis. *BMC Public Health, 17*(1). doi:10.1186/s12889-017-4691-z

Warburton, D., Nicol, C. W., & Bredin, S. (2006). Health benefits of physical activity: the evidence. *Can. Med. Assoc. J., 174*(6), 801-809. doi:10.1503/cmaj.051351

Wewege, M. A., Thom, J. M., Rye, K.-A., & Parmenter, B. J. (2018). Aerobic, resistance or combined training: A systematic review and meta-analysis of exercise to reduce cardiovascular risk in adults with metabolic syndrome. *Atherosclerosis, 274*, 162-171. doi:10.1016/j.atherosclerosis.2018.05.002

Wilson, W. F. P., D'agostino, B. R., Parise, B. H., Sullivan, B. L., & Meigs, B. J. (2005). Metabolic Syndrome as a Precursor of Cardiovascular Disease and Type 2 Diabetes Mellitus. *Circulation, 112*(20), 3066-3072. doi:10.1161/CIRCULATIONAHA.105.539528

Wong, L. S., Katzmarzyk, T. P., Nichaman, Z. M., Church, S. T., Blair, N. S., & Ross, N. R. (2004). Cardiorespiratory Fitness is Associated with Lower Abdominal Fat Independent of Body Mass Index. *Medicine & Science in Sports & Exercise, 36*(2), 286-291. doi:10.1249/01.MSS.0000113665.40775.35

World Health, O. (2010). Global recommendations on physical activity for health. In. Geneva: World Health Organization.

World Health Organization. (2020). Obesity. Retrieved from https://www.who.int/health-topics/obesity#tab=tab_1

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Lars Bo Andersen
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Norges idrettshøgskole
Postboks 4014 Ullevål Stadion
0806 OSLO

Vår dato: 04.02.2005 Vår ref: 200500162 PB /RH Deres dato: Deres ref:

KVITTERING FRA PERSONVERNOMBUDET

Vi viser til melding om behandling av personopplysninger, mottatt 24.01.2005. All nødvendig informasjon om prosjektet forelå i sin helhet 03.02.2005. Meldingen gjelder prosjektet:

12166	Aktivitetsvaner og fysisk form blant barn og unge i Norge
Behandlingsansvarlig	Norges idrettshøgskole, ved institusjonens øverste leder
Daglig ansvarlig	Lars Bo Andersen

Norsk samfunnsvitenskapelig datatjeneste AS er utpekt som personvernombud av Norges idrettshøgskole, jf. personopplysningsforskriften S 7-12. Ordningen innebærer at meldeplikten til Datatilsynet er erstattet av meldeplikt til personvernombudet.

Personvernombudets vurdering

Etter gjennomgang av meldeskjema og dokumentasjon finner personvernombudet at behandlingen av personopplysningene vil være regulert av S 7-27 i personopplysningsforskriften. Dette betyr at behandlingen av personopplysningene vil være unntatt fra konsesjonsplikt etter personopplysningsloven S 33 første ledd, men underlagt meldeplikt etter personopplysningsloven S 31 første ledd, jf. personopplysningsforskriften S 7-20.

Unntak fra konsesjonsplikten etter S 7-27 gjelder bare dersom vilkårene i punktene a) — e) alle er oppfylt:

a) førstegangskontakt opprettes på grunnlag av offentlig tilgjengelige registre eller gjennom en faglig ansvarlig person ved virksomheten der respondenten er registrert,

b) respondenten, eller dennes verge dersom vedkommende er umyndig, har samtykket i alle deler av undersøkelsen,

c) prosjektet skal avsluttes på et tidspunkt som er fastsatt før prosjektet settes i gang,

d) det innsamlede materialet anonymiseres eller slettes ved prosjektavslutning,

e) prosjektet ikke gjør bruk av elektronisk sammenstilling av personregistre.

Personvernombudets vurdering forutsetter at prosjektet gjennomføres slik det er beskrevet i vedlegget.

UNIVERSITETET 1 OSLO

DET MEDISINSKE FAKULTET

Professor Dr.med Lars Bo Andersen
Norges idrettshøgskole

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Dato: 11.01.05
Deres ref.:
Vår ref.•. S-04305

Kost, aktivitetsvaner og helse blant barn og unge i Norge

Vi viser til brev datert 20.12.04 med vedlegg: revidert informasjonsskriv og samtykkeerklæring.

Komiteen takker for grundig og oversiktlig svar på merknader, og tar disse til etterretning.

Komiteen har ingen merknader til revidert informasjonsskriv og samtykkeerklæring.

Komiteen tilrår at prosjektet gjennomføres og forskningsbiobank opprettes.

Vi ønsker lykke til med prosjektet!

Med vennlig hilsen

Sigurd Nitter-Hauge (sign) Professor dr.med.
Leder

Tone Haug
Rådgiver
Sekretær

KJÆRE ELEV OG FORELDRE/FORESATTE

Fysisk aktivitet blant norske barn og unge

På oppdrag fra Sosial- og helsedirektoratet skal Norges idrettshøgskole i perioden 2005-2006 gjennomføre en kartlegging av kost og fysisk aktivitetsvaner, fysisk form og ulike helsevariabler på barn og unge. Et landsrepresentativt utvalg på 2000 barn og unge i aldersgruppen 9-10 år og 15-16 år skal delta i undersøkelsen.

Det finnes i dag ikke nok informasjon om fysisk aktivitet og fysisk form i befolkningen for å kunne beskrive utviklingstrender og forskjeller mellom befolkningsgrupper. Slike data er sentrale for å kunne målrette og evaluere arbeidet med å øke graden av fysisk aktivitet i befolkningen. Barn og unge er en prioritert målgruppe i det helsefremmende arbeidet. Denne undersøkelsen vil gi oss verdifull informasjon og kunnskap om barn og unges aktivitetsvaner.

Deler av denne undersøkelsen er en oppfølging av European Youth Heart Study som ble gjennomført i Oslo i skoleåret 1999-2000. De barna som var med den gang er invitert til å delta, og vi ønsker med dette å invitere også dere til å delta i denne undersøkelsen.

Deres barns skole har sagt ja til deltakelse i denne undersøkelsen, og alle tester skjer i full forståelse med skolens ledelse.

Registreringer i undersøkelsen

Alle testene vil skje i skolens lokaler i løpet av skoledagen. Det er planlagt at elevene skal gjennomføre flere tester, men de kan selvsagt velge om de vil avstå fra enkelte av disse.

Fysisk undersøkelse

Det vil være måling av høyde og vekt. Det vil gjøres hudfoldsmålinger på overarm, rygg, legg og hofte. Vi vil gjennomføre måling av hvileblodtrykk og analyse av fastende blodprøve for fett i blodet, samt insulin og blodsukker. Prøven tas av en erfaren bioingeniør. Blodprøven skal være fastende, og vi ber derfor om at eleven ikke spiser etter midnatt natten før testdagen. Elevene vil få frokost umiddelbart etter at blodprøven er tatt.

Kondisjonstest og aktivitetsregistrering

Vi vil gjennomføre en arbeidstest på ergometersykkel. Testen blir utført med en gradvis økende belastning, og med en varighet på 6-10 minutter. Testen stoppes når eleven ikke ønsker å fortsette. Aktivitetsregistrering gjøres ved hjelp av en liten aktivitetsmåler som elevene skal bære på hoften i 5 dager. Aktivitetsmåleren blir levert ut på skolen.

Muskelutholdenhet og motorisk kompetanse

Elevene skal dessuten gjennomføre enkle tester av styrke, bevegelighet og koordinasjon.

Spørreskjema

Elevene besvarer et spørreskjema vedrørende kost- og mosjonsvaner. Foresatte har rett til å se spørreskjemaet som skal besvares av elevene. Et kort spørreskjema vil også bli gitt foreldre/foresatte vedrørende deres fritids- og mosjonsvaner.

Generell informasjon

Deltagelsen i undersøkelsen er frivillig og deltagerne har rett til å trekke seg fra hele eller deler av forsøket uten å oppgi grunn, og uten at det får negative konsekvenser. Det er imidlertid vesentlig for utbyttet av undersøkelsen at så mange som mulig deltar. Dersom foreldre/foresatte ønsker å trekke biologiske prøver eller andre opplysninger fra studien kan dette gjøres ved å kontakte biobankansvarlig professor Lars Bo Andersen, på telefon

23 26 20 00. Foreldre/foresatte er velkomne til å være tilstede i løpet av testdagen dersom dere ønsker det.

Testene vil bli utført av personer med relevant utdannelse og erfaring. Deltagerne er forsikret gjennom Gjensidige NOR; forsikringsnr 0398160

Hvis testresultatet eller blodprøvene til noen av elevene viser avvikende medisinske verdier vil skolehelsetjenesten informeres. Informasjonen til barn/foreldre vil ved disse tilfellene komme fra skolehelsetjenesten. Testresultatene registreres i et dataregister men personopplysningene blir avidentifisert. Etter prosjektslutt, forventet omkring utgangen av år 2006, blir datamaterialet anonymisert. Prosjektet er tilrådd av Regional komité for medisinsk forskningsetikk og er meldt til Personvernombudet for forskning, Norsk samfunnsvitenskapelig datatjeneste AS.

Ansvarlig for gjennomføringen av studien er Seksjon for Idrettsmedisin ved Norges idrettshøgskole, Oslo. Prosjektleder er professor Lars Bo Andersen. Dersom dere ønsker ytterligere informasjon er dere velkomne til å kontakte forsker Jostein Steene-Johannessen eller forsker Elin Kolle på telefon 41 08 28 98.

Vennligst returner samtykkeformularet (side 3) i svarkonvolutten til klasseforstander.

Med vennlig hilsen

Lars Bo Andersen professor / prosjektleder

SAMTYKKESKJEMA

På deres skole vil testene foregå man 2. – ons 4. oktober 2006 Nærmere informasjon om dato og testene vil leveres senere.

☐ Ja, jeg bekrefter herved å ha mottatt informasjon om testene. Jeg/vi ønsker å delta og lar min/vår datter/sønn delta i studien.

Vennligst utfyll barnets opplysninger nedenfor:

(Skriv tydelig, helst med blokkbokstaver)

Fornavn: .. …………………………………………………………………………………….

Etternavn: ……………………………………………………………………………………..

Personnummer (11 siffer): ………………………………………………………………….

Jeg er informert om at deltagelsen er frivillig og at vår datter/sønn kan avstå fra enkelte deler av testene, eller trekke seg fra videre deltagelse uten å oppgi grunn. Jeg er også bekjent med at foresatte har rett til å trekke seg/trekke opplysninger om seg selv fra prosjektet.

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Foreldre/verges underskrift

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Elevens underskrift

Leveres klasseforstander i vedlagte konvolutt så snart som mulig.