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"The effect of a one-year school based physical activity intervention on BMI, waist circumference and overall physical activity level among adolescents in Viken county, Norway".

A cluster randomized controlled trial

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Abstract

Background: Studies shows that physical activity (PA) level declines from childhood into adolescent, while the prevalence of overweight and obesity increases. PA-interventions in schools have had different success in regard to change this negative spiral.

Objective: Examine the effect of a one-year-school based PA intervention on BMI, waist circumference and overall PA levels amongst adolescent in 9th grade in Viken county, Norway.

Method: The sample in this thesis, is a subgroup from the School in Motion (ScIM) project. A total of 22 schools were invited to participate, out of these 11 agreed to join. All the 9th-grade students in the 11 schools were invited to participate in the study, out of 1149 students, 886 accepted. By lottery, the schools were divided into three intervention arms: Intervention model M1, intervention model M2 and control group. Data collection was conducted from the fall 2017 to summer of 2018. PA and time spent sedentary (SED) were objectively registered over seven consecutive days. Height, weight and waist circumference were measured by a test team from ScIM.

Results: Girls in the intervention groups had a significant increase in WC when compared with controls, with 0.8 cm and 0.9 cm increase in M1 and M2 respectively. Girls and boys in M1 had a significant higher mean difference in change in PA level and time in moderate-to-vigorous PA (MVPA) during school hours. However, there were no significant differences in full day PA, SED or time spent in MVPA for either boys or girls in M1 when compared to controls. Girls and boys in M2 had a significant lower activity level compared to controls, during school hours.

Conclusion: No intervention effect on BMI intervention M1 nor M2. However, an increase in WC was significant for girls in both intervention groups when compared to control group. Intervention M1 had a positive effect on PA level during school hours.

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Acronyms and abbreviations

BMI	Body mass index
BMR	Basal metabolic rate
CPM	Counts per minute
CRF	Cardiorespiratory fitness
EE	Energy expenditure
MET	Metabolic equivalent of task
MPA	Moderate physical activity
MVPA	Moderate- to vigorous physical activity
PA	Physical activity
PAEE	Physical activity energy expenditure
RMR	Resting metabolic rate
SED	Sedentary time
SMR	Sleeping metabolic rate
TEE	Total energy expenditure
TEF	Thermic effect of food
VPA	Vigorous physical activity
WHO	World Health Organization

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1. Introduction

Regular physical activity (PA) amongst youth and adolescent is necessary for normal growth and development of motor skills, agility, flexibility, muscle strength and cardiorespiratory endurance (Nordic Nutrition Recommendations, 2012). The physiological and physical health benefits of PA are well documented in adults, and there are growing evidence that PA is equally as beneficial in children (Janssen & LeBlanc, 2010; Sherar & Cumming, 2017). Children and adolescent in Norway are recommended to be physical active at least 60 minutes of moderate- to vigorous intensity each day (The Norwegian Directorate of Health, 2014). However, these recommendations seem to be difficult to obtain moving towards adolescent (Steene-Johannessen et al., 2019).

Generally, societies have become more mechanical and digitized, so people are not required to be physical active in a way that the previous generations experienced. From using elevators, remote controls, computers and transportation by various vehicles, all contributes to reduced time spent in PA (Lagerros & Rössner, 2013). The ordinary daily life tasks have become easier to perform, requiring less physical effort. Further, technology has afforded children and adolescent with more opportunities to conduct in sedentary behavior through playing video games, browsing the internet and watching TV (Ahn & Fedewa, 2011; Orsso et al., 2019). Other potential barriers that can influence the PA level amongst children and adolescent is poor motivation, reduced time spent in PA during school hours and limited access to playing spaces (Orsso et al., 2019).

There seem to be a general trend that from childhood into adolescent the PA level is reduced and the prevalence of overweight and obesity increases (Cooper et al., 2015; Dumith et al., 2011; Konstabel et al., 2014; Ruiz et al., 2011). This makes adolescents an important group to target in the regards of increasing PA level and reduce the number of adolescents with a high BMI (BMI >25 kg/m2). Furthermore, studies examining the effect of increased PA on BMI usually includes children and studies including adolescents is warranted.

1.1 Main aim

This thesis will investigate the effect of a one-year-school based physical activity intervention on BMI, waist circumference and overall physical activity level amongst adolescent in 9th grade in Viken county, Norway.

1.1.1 Research question

The following research question is formulated:

- What is the effect of a one-year-school based physical activity intervention on BMI, waist circumference and overall physical activity level amongst adolescent in 9th grade in Viken county, Norway?

2. Theory

2.1 Physical activity

Physical activity (PA) is defined as any bodily movement produced by skeletal muscles that results in energy expenditure (Caspersen et al., 1985). PA is a complex behavior and can be classified qualitatively into categories of sedentary behavior, work, leisure activities, locomotion, and exercise (Butte et al., 2012). Further, PA could be divided into three dimensions 1) *Frequency* relates to the number of PA events during a specific period, 2) *Duration* refers to the amount of time spent in a specific activity, 3) *Intensity* refers to the difficulty of an activity, and is usually classified as light, moderate or vigorous (Butte et al., 2012; Hildebrand & Ekelund, 2017; Thomas, Nelson & Silverman, 2011, p. 311). Intensity can be defined in absolute terms as metabolic equivalent of task (MET), and in relative terms as in maximal heart rate (HR) (Hildebrand & Ekelund, 2017). The term moderate-to-vigorous (MVPA) is also commonly used (Aparicio-Ugarriza et al., 2015). These three dimensions of PA are essential because their assessment provide the ability to calculate energy expenditure (EE) associated with PA (Warren et al., 2010).

Total energy expenditure (TEE) is usually divided into basal metabolic rate (BMR), resting metabolic rate (RMR), sleeping metabolic rate (SMR), thermic effect of food (TEF), and physical activity energy expenditure (PAEE) (Butte et al., 2012). PAEE is determined by body movement and body size, a large body requires more energy to move than a small body (Westerterp, 2013). PAEE typically accounts for 15-30% of TEE and is the most variable component of TEE (Warren et al., 2010). For individuals with a very high activity level, PAEE may constitute 60-70% of TEE.

For healthy normal-weight adult individuals at rest, the body oxygen consumption is approximately 3.5 ml/kg per minute, which is equal to about 1 kilocalorie (kcal)/kg/h as 1 l of O_2 has an energy cost of approximately five kcal (Warren et al., 2010). Further, this is said to be 1 metabolic equivalent (1 MET). Activities can be expressed as multiples of 1 MET, and for healthy adults activities in the range of sedentary behavior: $\leq$1.5 MET, low intensity: 1.8-2.9 MET, moderate intensity: 3.0-5.9 MET and vigorous intensity: >6.0 MET (Hildebrand et al., 2017; Warren et al., 2010). However, for children and adolescent the conventional MET values are not applicable (Butte et al., 2012). The BMR per unit body mass is higher in children than adults, and it declines gradually as children grow and mature, due to sex-specific developmental changes in organ weights, organ-specific metabolic rates, muscle mass, and differential in adiposity (Butte et al., 2018).

2.2 Physical activity measurement

Accurate measurement of PA is fundamental to detect the dose-response relationship between PA and health, monitoring trends in PA and evaluate the effect of interventions aiming to increase the PA levels (Chinapaw et al., 2010; Hildebrand et al., 2017; Shephard, 2003). Further, PA is a complex behavior which can change considerably from one day to another, in addition to be exposed to seasonal variations, therefore valid and reliable measurements are important. In table 1.1 an overview of selected PA measurement methods is presented.

2.2.1 Physical activity measurement methods

There are numerous instruments to use when measuring PA which vary by particular needs, feasibility and accuracy (Chen & Bassett, 2005). We could categorize them into 1) criterion methods, 2) subjective methods and 3) objective methods (Vanhees et al., 2005).

Criterion methods is the most precise methods for measuring energy expenditure from PA and is often used to validate other methods (Vanhees et al., 2005). Doubly labeled water (DLW), indirect calorimetry and direct observation are examples of criterion methods. Disadvantages to these methods are the financial cost, the invasiveness and limitation to mainly laboratory situations (Vanhees et al., 2005).

DLW is considered as the gold standard for measuring free-living energy expenditure in animals and humans (Buchowski, 2014). Total energy expenditure (TEE) is divided by resting energy expenditure (REE) (PA level = TEE / REE) to compare PA levels within and between subjects (Westerterp, 2017). DLW provides an accurate measure of TEE, but no information on PA patterns in terms of frequency, duration and intensity (Guy Plasqui & Westerterp, 2007).

Indirect colometry provides one of the most accurate, sensitive and noninvasive measurements of energy expenditure (EE) in an individual (Gupta et al., 2017). Due to high cost associated with the isotopes and sample analysis, the use of DLW and indirect colometry is limited in many clinical and research settings, and mostly used in laboratory settings (Aparicio-Ugarriza et al., 2015; Vanhees et al., 2005).

The principle of the direct observation method is to collect and evaluate information from the subjects being studied in his or her usual environment, without altering that environment and it is one of the earliest methods to assess PA (Holmes, 2013; Vanhees et al., 2005). Direct observation is an effective method when the goal is to evaluate an ongoing behavior process, situation or event, and when there are physical outcomes that easily can be detected. However, it is a very time-consuming method, and it is therefore not convenient for large-scale studies (Vanhees et al., 2005). Direct observation can be overt or covert, so either the subjects and individuals are aware of the purpose of the study, or they're not.

Subjective methods is one of the most frequently used methods for measuring PA, and includes questionnaires, proxy-reports, interviews and diaries (Vanhees et al., 2005). These methods are able to assess type of PA, sport and vigorous activities, but not able to give accurate estimate regarding PAEE or PA intensity (Hildebrand & Ekelund, 2017). Subjective methods are principally self-reports and could be influenced by the opinion and perception of the participant, researcher, or both (Hildebrand & Ekelund, 2017). The validity of measures may also be affected in children and adolescent who feel compelled to respond in a socially acceptable manner (Sherar & Cumming, 2017). Self-report methods for recalling intensity, frequency and duration bouts of PA are problematic, especially in children (Sherar & Cumming, 2017). Children are usually less time conscious than adults, and their activity pattern more sporadic, making it hard to document in regard to time and intensity (Hildebrand & Ekelund, 2017; Sherar & Cumming, 2017). Overestimation of time spent in PA is therefore not uncommon in children and adolescents (Sallis & Saelens, 2000).

Objective methods include methods that register either a physiological or biomechanical measurement for estimating energy expenditure or PA levels (Hildebrand & Ekelund, 2017). These methods include heart rate monitor, pedometer and accelerometer (Vanhees et al., 2005). Objective methods are susceptible to measurement errors but are not influenced by opinions and perceptions (Hildebrand & Ekelund, 2017).

Several factors need to be considered when choosing a method for assessing PA, such as validity, reliability, accuracy, and responsiveness (Hildebrand & Ekelund 2017). Other important factors are PA component of interest, study objectives, characteristic of the target population, and feasibility in terms of cost and logistics (Butte et al., 2012; Hildebrand & Ekelund 2017).

2.2.2 Questionnaire

Physical activity questionnaires (PAQs) are effective and feasible when assessing PA levels in large-scale studies (Helmerhorst et al., 2012; Shephard, 2003). However, there are some limitations regarding reliability and validity, despite extensive use over 40 years (Shephard, 2003). Measurement error and bias due to misreporting, either because of cognitive limitations related to recall or comprehension, or deliberate, is to be taken into account when using PAQs (Helmerhorst et al., 2012; Vanhees et al., 2005). For elderly people, degeneration can make self-report of PA particularly difficult, as for younger people because of cognitive immaturity. To avoid such misreporting the questionnaires used to assess information about PA should be clearly structured to guide the participants, with closed questions in a logical order (Warren et al., 2010). Questions must be specific and explain the intent of the question clearly to the respondent. The International Physical Activity Questionnaire – Short Form (IPAQ-SF) is cost-effective and one of the recommended methods to assess PA (P. H. Lee et al., 2011). Several PAQs use the reported frequency and duration of activities to calculate PAEE by ascribing MET values (Warren et al., 2010). Despite that, most PAQs seem to be unable to do this with accuracy. On the other hand, PAQs are often able to give estimates of time spent in activities of various levels and intensity, and to rank individuals according to intensity levels of reported activity (Helmerhorst et al., 2012; Warren et al., 2010).

2.2.3 Accelerometer

To explore the relationship between PA, health, growth and development in children, the ability to generate accurate and detailed PA data is essential (Stone et al., 2009). Accelerometer is a small and wearable PA monitor, that is very useful in the accurate and detailed measurement of free-living PA (Chen & Bassett, 2005). It is frequently used to assess PA in children, and it is one of the most effective ways to produce objective information on frequency, duration and intensity on children's habitual PA (Rowlands, 2007). For the measurement of PA, accelerometry is assumed to be the most objective technique for recording body movement (Hallal et al., 2013). It is a durable and relatively inexpensive measuring tool, that have been proven reliable.

Accelerometers measures body movement in terms of acceleration, which can be used to estimate the intensity of PA over time (Chen & Bassett, 2005). Accelerometers are easy to use, one simply just have to wear it, on the hip, wrist or ankle, for a specific time. Participants are instructed to wear the accelerometer at all times, expect for when attending activities in water (Evenson & Terry, 2009). The accelerometers can measure acceleration in one to three orthogonal plans; v*ertical, mediolateral, and anteroposterior* (Rowlands, 2007).The signal from an accelerometer is integrated over a given time interval, known as epoch, then summed and stored. In children it is recommended that epoch durations are 10 seconds or less, when evaluating PA. Accelerometers eliminate literacy difficulties, recall- and social desirability bias (Evenson & Terry, 2009), but cannot provide information about what type of activity is being recorded or estimate carrying loads (Aparicio-Ugarriza et al., 2015).

Table 1.1*: Overview of selected measurement methods for physical activity (Aparicio-Ugarriza et al., 2015; Buchowski, 2014; Gupta et al., 2017; Hildebrand & Ekelund, 2017; Holmes, 2013; Plasqui & Westerterp, 2007; Sallis & Saelens, 2000; Sherar & Cumming, 2017; Vanhees et al., 2005)*

Measuring method	Strengths	Limitations
Criterion methods		
Doubly labeled water Measurement of CO_2 production after ingestion of two stable isotope. Gives an estimate of TEE and PAEE.	▪ Accurate ▪ Noninvasive ▪ Suitable for all populations ▪ Validates other measurement methods	▪ Expensive ▪ Not suitable for large selections ▪ Demanding analyzes ▪ Provide no information about specific activities, intensity, duration or frequency
Indirect calorimetry Provides an estimate on PAEE by measuring O_2 consumption in relation to production of CO_2	▪ Accurate measurement on short term energy expenditure ▪ Validates other measurement methods	▪ Expensive ▪ Not suitable for large selections ▪ Demanding for participants ▪ Does not capture natural activity pattern
Direct observation Registers the participants PA level by observation	▪ Can measure all dimensions of PA ▪	▪ Expensive ▪ Time-consuming ▪ Not suitable for large selections
Subjective methods		
Questionnaires Participants evaluates and register time spent in PA, in a given questionnaire	▪ Inexpensive ▪ Noninvasive ▪ Easy to administrate ▪ Easy to implement ▪ Suitable for large selections	▪ Not accurate measurement of PA ▪ Recall bias ▪ Social bias ▪ Over-/underestimation ▪ Misinterpretation of questions ▪ Difficult to estimate energy expenditure
Objective methods		
Heart rate monitor Measures heart rate (beats per minute) and can estimate physical activity energy expenditure	▪ Relatively inexpensive ▪ Quick and easy data collection ▪ Suitable for large selections ▪ Quite accurate at group level	▪ Allergic reactions may occur ▪ Increased heart rate may be due to other factors than PA, e.g. stress ▪ Less accurate at individual level
Accelerometer Small electronic meter that records all movement it is exposed to and all activity beyond normal human movement is filtered away	▪ Noninvasive ▪ Suitable for all ages ▪ Suitable for large selections ▪ Large capacity for data storage ▪ Provides information on activity intensity, duration and frequency	▪ Relatively expensive ▪ Does not capture all activities e.g. swimming, cycling ▪ Not waterproof ▪ Entails large amounts of data and demanding analysis work
Pedometer Counts the number of steps and/or distance traveled	▪ Inexpensive ▪ Noninvasive ▪ Suitable for large selections	▪ Calibration is time-consuming ▪ Does not measure intensity, duration or frequency ▪ Difficult to calculate energy expenditure

2.3 Physical activity guidelines

The first PA guidelines for children and adolescents were developed in 1998 and published by the UK Health Education Authority (Janssen, 2007). These guidelines recommended a minimum of 60 minutes of MPA daily. Before 1998 the PA guidelines for children and adolescent were consistent with the PA guidelines for adults, which typically recommended about 20-30 min of accumulated PA on most or all days of the week. The guidelines developed for children and adolescent over the years have been very consistent with those published in 1998 in terms of the volume of PA recommended.

The Norwegian PA guidelines are in line with the global health recommendations proposed by the World Health Organization (WHO) (Norwegian Directorate of Health, 2014; World Health Organization, 2018). The present PA recommendations from the Norwegian health authorities for adolescents, is to conduct 60 minutes of MVPA daily (Norwegian Directorate of Health, 2014). The activity should be varied, versatile and of moderate to high intensity. To optimize the health gains, a minimum of three days a week should include high-intensity activities, as well as an intention to increase muscle strength. Equally important as increasing PA level, is reducing the sedentary time (SED) as much as possible.

2.3.1 Proportion of children and adolescents who meets the guidelines

Several international and national studies have examined the proportion of children and adolescent who meet the recommendations of 60 min/day of MVPA. The International children's accelerometry database (ICAD) used accelerometer to examine time spent in PA and SED amongst 27 637 children and adolescent, age 3- 18½ years from ten countries (Norway, Denmark, UK, Estonia, Belgium, Switzerland, Portugal, Brazil, Australia and USA (Cooper et al., 2015). Results show that overall amongst the countries, a low percentage of participants met the guidelines. Only 9.0% of boys and 1.9% of girls aged 5-17 achieve 60 min/day in MVPA (Cooper et al., 2015). Norwegian boys had the highest percentage, with respectively 13%. Further, Norwegian boys aged 9-10 years recorded the highest values of meeting or exceeding 60 min of MVPA on 60.5% of measured days. Similar values were recorded by boys from Estonia and Australia.

In a recent systematic survey that examined the variations in objectively measured PA and SED in 47497 children and adolescent across Europe, results show that 29% of the children and adolescent spent a minimum of 60 minutes in MVPA daily (Steene-Johannessen et al., 2020). Country- and region-specific differences in PA and SED time were observed, and the lower PA levels and prevalence estimates were found in Southern European countries. The boys spent more time in PA and had less SED, in all age-categories (Steene-Johannessen et al., 2020). Around age 6 to 7 the onset of age-related lowering or leveling-off PA and increase in SED seem to become apparent. The study concluded that two third of European children and adolescent are not sufficiently active, and that there are age, gender, country and region-specific differences in PA (Steene-Johannessen et al., 2020).The impact of age is well shown in a study conducted in Sweden in 2020 (Nyberg, Kjellenberg, Fröberg & Lindroos, 2020) where the results indicate that PA levels decrease with increasing age. In both girls and boys, the PA level has been reduced from 32% to 20% and 54% to 31%, respectively, from age 11-12 to 17-18.

Similar findings in age differences can be found in UngKan3 “The Norwegian national mapping of physical activity, sedentary time and physical fitness among children and adolescent”,, where 87% of girls and 94% of boys at the age of 6 meet the recommendations for PA, against 40% and 51% of 15-year-olds, respectively (Steene-Johannessen et al., 2019). The 6-years old are 53% more active than the 15-years old (Steene-Johannessen et al., 2019). Back in 2011, results from UngKan2 showed that amongst the 15-year old girls, 43.2% met the PA recommendations, as well as 58.1% of the boys (Kolle et al., 2012). This indicates that boys and girls had a slightly higher activity level in 2011 when compared results from 2019, the biggest decrease in PA is seen amongst the boys (Kolle et al., 2012; Steene-Johannessen et al., 2019).

2.3.2 Health benefits of physical activity

Individuals engaged in regular PA reduces the risk of coronary heart disease, type 2 diabetes mellitus, hypertension, osteoporosis, plus some cancers (Hallal et al., 2006). Although these diseases manifest in adulthood, it is understood that their development starts in childhood and adolescent. PA during adolescent reduces the incident of chronic disease in adulthood, and adolescent who are physical active are more likely to obtain the PA levels during adulthood (Hallal et al., 2006). Participating in as little as two or three hours of MVPA per week is associated with health benefits, and observational studies suggest that higher doses of PA is beneficial for greater health benefits (Janssen & LeBlanc, 2010). However, most studies on the subject in children are cross-sectional, and it's therefore not possible to infer cause and effect relations (Shear & Cumming, 2017).

The European Youth Hearth Study (EYHS) examined the relationship between the metabolic syndrome and objectively measured PA and whether fitness modified this relationship, in a group of Danish children (589 participants, mean age 9.6 years) (Brage et al., 2004). The metabolic syndrome is characterized by hyperinsulinemia, low glucose tolerance, hyperlipidemia, hypertension, and obesity (Brage et al., 2004). A metabolic syndrome risk score from the following six measurement were computed: *Insulin, glucose, HDL cholesterol, triglycerides, the sum of four skinfolds, and blood pressure*. Results showed that PA are inversely associated with metabolic risk. Other studies have also proven the benefits of PA in relation to metabolic-risk factors in children (Ekelund et al., 2006).

In a meta-analysis of 20 trials reviewing the effectiveness of school-based PA interventions concluded that it is possible to improve cardiorespiratory fitness (CRF) in children and adolescent by increasing PA during school hours (Pozuelo-Carrascosa et al., 2018). CRF is a direct measure of aerobic functional capacity and children's CRF has been associated with both a cardiometabolic risk profile and general health during childhood, and further with cardiovascular disease risk later in life (Pozuelo-Carrascosa et al., 2018). MPA and VPA had a stronger effect on improvement of CRF compared with MVPA. The meta-analysis suggests that school-based PA programs are effective for improving CRF in children, particularly girls, even though the magnitude of the effect is small. Results from the meta-analysis also show that both MPA and VPA interventions significantly increase CRF, but the effective size was slightly greater for VPA programs (Pozuelo-Carrascosa et al., 2018).

2.4 Overweight and obesity

2.4.1 Definition of overweight and obesity

The pathogenesis of obesity is complex and not completely understood (Schwartz et al., 2017). The term obesity refers to an excess of fat and is defined as an accumulation of adipose tissue that is of sufficient magnitude to impair health (Kumar, Abbas & Ester, 2014; Kumar & Kelly, 2017). Adiposity is the amount of body fat, presented as mass or as percentage of total body mass, whilst obesity is a state above normal adiposity at a level where health problems are likely to occur (Bar-Or & Baranowski, 1994). Excess fat accumulates when there is an energy imbalance; energy intake exceeds total energy expenditure (Kumar et al., 2014).

The Norwegian Directorate of Health defines overweight and obesity by BMI, which is calculated by dividing the weight (kg) by the square of height (m^2): BMI = kg /m^2 (Norwegian Directorate of Health, 2010). The Norwegian Directorate of Health defines normal weight as BMI < 25 kg/m^2, overweight BMI >25 kg/m^2, Obese BMI >30 kg/m^2 and severe obesity BMI >35 kg/m^2 (Norwegian Directorate of Health, 2010).

The classifications of overweight and obesity is different in children and adolescent, compared to adults. Skeletal- and muscle mass is reduced in children before puberty, and girls develop earlier than boys. Therefore, gender and age-adjusted limits for overweight and obesity are recommended in children 2 to 18 years of age (Norwegian Directorate of Health, 2010). Cole et al. 2000 established an international standard for this age group, aimed to help provide internationally comparable prevalence rates of overweight and obesity in children and adolescents (Cole et al., 2000). There is a variety of definitions of child obesity internationally, which makes it difficult to quantify or to compare the prevalence (Cole et al., 2000).

Before the onset of puberty, muscle mass and fat-free mass (FFM) increases slowly and steady with body growth (Orsso et al., 2019). Puberty is a dynamic period marked by rapid growth, associated with a number of hormonal and metabolic, changes in body size, shape and composition (Brufani et al., 2009; Rogol et al., 2002). Throughout adolescence 50% of adult body weight is gained. Especially in girls, the BMI values depend on pubertal degree of maturation (Bini et al., 2000). Studies have shown that BMI values were significantly higher in post-menarche girls compared to pre-menarche girls similar in age (Bini et al., 2000). Therefore, when BMI is evaluated in adolescent, this influence should be taken into account (Bini et al., 2000; O'Dea & Abraham, 1995).

2.5 Measurement of overweight and obesity

Body composition methods are useful for the screening of excess body fat and its related metabolic complications (Rodríguez, Pietrobelli, Wang & Moreno, 2011). Reliable and practical methods to measure body composition are therefore important in epidemiological-, clinical- and population studies for monitoring overweight, obesity and its consequences (Rodríguez et al., 2011). There are numerous of methods for measuring body composition, and these are often categorized as *field methods* or *laboratory methods* (Norgan, 2005). An overview of selected measuring methods is presented in table 2.1.

Examples of *field methods* are bioimpedance analysis (BIA) and anthropometric measurements such as BMI, skinfold thickness and waist circumference (WC). Skinfold thickness and BIA are the most commonly used field techniques for measuring body composition, and BMI is widely used to measure the level of fatness (Norgan, 2005; Sherar & Cumming, 2017). The skinfold technique measures subcutaneous fat, and the measurements are made at sites such as the biceps, triceps, subscapular and suprailiac (Kuriyan, 2018). Age- and gender specific equations are used to arrive at values of body density. BIA is a frequently used method that is inexpensive, easy to operate and portable (Ellis, 2000; Kuriyan, 2018). The method can also provide quick and easy estimates of fat free mass and total body water in both healthy populations and in obese individuals (Kuriyan, 2018).

Anthropometric measurements are non-invasive which helps identifying individuals at risk, monitoring the efficacy of a nutrition intervention, providing information about the fat stored in the body and the muscle mass, and to assess nutritional status (Kuriyan, 2018). The anthropometric measurement methods are simple to use, inexpensive and don´t require high levels of technical skills (Kuriyan, 2018). They are widely used in large epidemiological studies and in clinical situations.

Examples of *laboratory methods* is Dual-energy X-ray absorptiometry (DEXA), underwater weighing (UWW) and Magnetic Resonance Imaging (MRI). DEXA is a relatively new whole body and regional body composition technique that is used more frequently in medicine and biology (Norgan, 2005; Sherar & Cumming, 2017). Body fat, muscle mass and total body bone mineral is measured using two X-ray energies

(Kuriyan, 2018; Norgan, 2005). The UWW method is a valid method for measuring accurate body volume and body density, however, there might be individual variations related to gender, age and ethnicity (Kuriyan, 2018). This method is time-consuming and it requires the individuals to go completely under water, which may cause discomfort (Ellis, 2000; Kuriyan, 2018). MRI is designed to measure body fat and skeletal muscle *in vivo*, which makes it useful in regional measures of body composition in regards to muscle mass and abdominal adipose tissue deposits (Norgan, 2005).

2.5.1 Body mass index

Techniques that directly measures body fat is often unavailable and costly, therefor BMI has emerged as the acceptable clinical standard measure of overweight and obesity for children (Kumar & Kelly, 2017). The association between BMI and total fat is strong, but due to individual's variation in growth rates and maturity levels in youth, like height and muscle mass, the use of BMI might not be the most accurate measuring tool (Krebs et al., 2007; S. Lee et al., 2006). Strength and limitations should therefore be considered when used in clinical and research settings (Kumar & Kelly, 2017). BMI is a simple and noninvasive surrogate measure of body fat, relatively easy to use and cheap (Chung, 2015; Daniels, 2009). Categorization on BMI percentiles may not be precise in defining risk of comorbid condition, and there are limitations regarding differentiating between body fat and lean (fat free) mass.

2.5.2 Waist circumference

Waist circumference (WC) is a anthropometric measure used to assess abdominal obesity, and it is the most frequently used measurement method for this purpose (Kumar & Kelly, 2017; Magalhães et al., 2014). Studies have proven positive correlation with BMI, total fat and upper body fat percentage. WC provides relevant information about fat distribution in the body, and therefore may give information on future risk for developing certain lifestyle diseases (Norwegian Directorate of Health, 2010). WC is easy to administrate, low cost, relatively accurate, and hence favored in large-scale public health project (Fredriksen et al., 2018, s. 6). Limit values for overweight and obesity in children based on WC haven't been defined nationally or internationally, although age- and gender adjusted reference tables have been published in several countries (Norwegian Directorate of Health, 2010).

Table 2.1*: Overview of selected measurement methods for body composition* (Chung, 2015; Daniels, 2009; Ellis, 2000; Kumar & Kelly, 2017; Kuriyan, 2018; S. Lee et al., 2006; Magalhães et al., 2014; Norgan, 2005)

Measuring method	Strengths	Limitations
Laboratory measurements		
Dual-energy X-ray absorptiometry Direct measurement of body fat, muscle and total body bone mineral. The gold standard.	• Relatively quick • Reliable • Non-invasive • Accurate measurements of total or regional body composition • Suitable for children and adolescents	• Expensive • Difficulties distinguishing between soft tissue and bone in all regions of the body • The scanner may not accommodate large individuals • Not suitable for large selections
Underwater weighing Estimates total body volume and calculates body composition	• Reliable • Accurate • Measures bone mineral density	• Expensive • Influenced by age, sex and ethnicity • Not suitable for children • Not suitable for large selections • Requires carefully trained testers
Magnetic resonance imaging *In vivo* measurements of different fat depots and fat infiltrations in organs	• Precise • No exposure to X-rays • Measures regional/visceral fat	• Expensive • Requires carefully trained testers
Field methods		
Waist circumference Measured with measuring tape under the ribs and over the hip comb, after light exhalation	• Inexpensive • Quick and easy • Noninvasive • Good predictor of abdominal obesity	• Does not have international limit values for disease risk • Can be difficult to get accurate measurements of very obese participants
Body mass index Indicator of overweight and obesity, by dividing the weight (kg) by the square of height (m2): BMI = kg /m2	• Inexpensive • Quick and easy • Noninvasive • Suitable for large selections • Possible to compare results across countries	• Does not differentiate between muscle mass- and fat. • Provides no information on fat distribution
Skinfold thickness Measures skin fold thickness using Harpenden caliper. Usually measured in triceps, subscapular and suprailiac, which correlates with total body fat	• Inexpensive • Suitable for large selections • Direct measurement of subcutaneous fat • Quite accurate	• Requires carefully trained testers • Challenging to measure slim and obese people
Bioimpedance analysis Estimates bodyfat and/or fat-free mass by analyzing the conductivity of electrical impulses through the participant's total body water	• Inexpensive • Quick • Noninvasive • Easy to learn • Portable	• May be affected by hydration status, nutrient intake, exercise, menstrual cycle and environmental temperature

2.6 Prevalence of overweight and obesity

Childhood obesity has increased significantly around the world (Ekelund et al., 2006; NCD Risk Factor Collaboration, 2017; Ng et al., 2014). WHO claims that most of the world's population live in countries where overweight and obesity kills more people than underweight (World Health Organization, 2020). Analysis from 2416-population-based studies on BMI in children and adolescents, shows that the prevalence of overweight and obesity have increased globally and in most regions from 1975 to 2016 (NCD Risk Factor Collaboration, 2017). The prevalence of obesity increased from 0.9% in 1975 to 7.8% in 2016 amongst the boys, and the number of boys classified as obese increased from 6 million to 75 million. Similar trends were seen in girls, with an increase from 0.7% to 5.6%, and from 5 million in 1975 to 50 million in 2016 (NCD Risk Factor Collaboration, 2017).

The prevalence of overweight and obesity in Norway seem to be increasing from childhood into adolescents (Steene-Johannessen et al., 2019). Results from UngKan3 classified 10.3% of the 6-years old girls and 9.2% of the boys as overweight, and 1.7% and 2.8% as obese (Steene-Johannessen et al., 2019). Higher numbers were seen amongst the 15-years old girls and boys, where 13.9% of the girls and 15.6% of the boys where classified as overweight, and 4.0% and 1.4% as obese. When comparing changes in weight status amongst 9- and 15- years old in UngKan1 (2005-2006) and UngKan2 (2011) there were no significant changes in prevalence of overweight and obesity (Kolle et al., 2012).

Results from Ung-HUNT 1 (1995-97) to Ung-HUNT 3 (2006-08) shows that the proportion of young people with overweight and obesity continues to increase (HUNT Research Center, 2011). The average weight for both girls and boys were higher in Ung-HUNT 3 than Ung- HUNT 1. The increase was greater amongst the boys, and especially the proportion of boys with obesity. A total of 20% of the girls, and 22% of the boys in lower secondary school, and 25% of the girls and 27% of the boys in upper secondary school were classified as overweight or obese in Ung- HUNT 3 (HUNT Research Center, 2011).

2.6.1 Health consequences of overweight and obesity

In general, overweight and obesity is associated with different negative psychological- and physical outcomes. Overweight during childhood increases the chances of developing cardiovascular disease, insulin resistance and type 2 diabetes, atherosclerosis, dyslipidemia and other health conditions later in life (Ekelund et al., 2006; Goran et al., 2003; Hands & Parker, 2008; Kumar & Kelly, 2017; Panda, 2019). Obesity in childhood is associated with comorbidities affecting almost every system in the body; musculoskeletal systems, gastrointestinal, pulmonary, cardiovascular and endocrine (Kumar & Kelly, 2017). Metabolic syndrome in children is a rising health problem, especially in developed countries, but the prevalence is also increasing in developing countries (Panda, 2019). Abdominal obesity, dyslipidemia, high blood pressure, and problems with how the body uses insulin and blood sugar, are all metabolic-risk factors related to overweight (Ekelund et al., 2006; Panda, 2019). Further, early onset of sexual maturation in girls, with accelerated linear growth and advanced skeletal maturation may be associated with obesity. The prevalence of developing hyperandrogenism and polycystic ovary syndrome (PCOS) is higher in obese adolescent girls (Panda, 2019).

2.7 Relationship between physical activity and overweight/obesity

Several studies show that the average level of PA is lower in children and adolescent who are overweight and obese (Bourdeaudhuij et al., 2013; Cooper et al., 2015; Kolle et al., 2012; Møller et al., 2014). Results from UngKan2 showed significant differences in PA level between normal weight and overweight in 9- years old boys, where those with normal weight had a 18.7% higher PA level than the boys categorized as overweight and obese (Kolle et al., 2012). Findings from ICAD showed that weight status was not impacted by PA in the youngest age group, but from age seven onwards, overweight and obese participants were less active then their normal weight counterparts (Cooper et al., 2015). Further, the ENERGY project concluded that more time in MVPA and less SED is associated with healthier weight status among 10- to 12-year-old girls (Bourdeaudhuij et al., 2013). For boys, time spent in MVPA seem to be most important for weight status, and SED appears to be less relevant (Bourdeaudhuij et al., 2013).

Results from previous studies show that higher levels of time spent in MVPA were associated with better cardiometabolic risk factors, regardless of amount of time spent SED (Ekelund et al., 2012). MVPA and SED were not associated with WC at follow-up, but a higher WC at baseline was associated with higher amounts of SED at follow-up. Other studies on PA, SED, BMI or BMI z-score found favorable results, but results regarding nutrition behavior were inconclusive (Verjans-Janssen et al., 2018).

The HELENA study examined whether the current PA recommendations for adolescents (60 minutes/day in MVPA) are associated with lower risk of excess of body fat in European adolescents (sample of 2094, aged 12.5-17.5) (Martinez-Gomez et al., 2010). Findings suggest that the recommendations are associated with reduced risk of overweight and obesity, and time spent in VPA might have additional effect in preventing obesity (Martinez-Gomez et al., 2010). Adolescents who did not meet the PA recommendations increased the risk of having overweight and obesity (OR=1.24, 95% CI=1.01, 1.534) and overfat and obesity (OR=1.76, 95% CI= 1.33, 2.42). Further, adolescents who did not meet the recommendations of at least 15 minutes/day in VPA increased the risk of being overweight or obese. Results from the International Study of Childhood Obesity (ISCOLE) on children age 9-11 years, found that attending at least 55 min/day of MVPA were associated with lower obesity, which supports the findings in the HELENA study (Katzmarzyk et al., 2015; Martinez-Gomez et al., 2010). Further, greater time spent in MVPA and VPA were both associated with lower odds of obesity independent of SED (Katzmarzyk et al., 2015).

School-based intervention have had different results regarding affecting BMI, WC and PA level (Grydeland et al., 2013; Grydeland et al., 2014; Kriemler et al., 2010; Martínez-Vizcaíno et al., 2020; Møller et al., 2014). The MOVI-KIDS study examined the effect of increased PA during school hours on adiposity, fitness and blood pressure (BP) in children age 4-7 years (Martínez-Vizcaíno et al., 2020). Results showed no significant changes in FM%, WC or BMI in the intervention group (Martínez-Vizcaíno et al., 2020). However, improvements in CRF were seen in girls, and improvement in velocity, agility and muscular strength was found in both girls and boys.

Another study, however, did find a significant effect on BMI (p=0.02) and BMI-for-age Z-score (p=0.003) for girls, after a 20-month school-based intervention, but not on WC or weight status (Grydeland, Bjelland, et al., 2014). Further, the HEIA study showed an intervention effect on overall PA (p= 0.05), with an small effect between intervention and control of 50 cpm in favor of the intervention group (95% CI- 0.4, 100)(Grydeland et al., 2013). The effect appeared to be more profound among girls, and among participants in the low-activity group, compared to boys and the participants in the high-activity group. PA among the participants with normal weight were more positively affected by the intervention, then among the overweight participants (Grydeland et al., 2013). In a study by Kriemler (Kriemler et al., 2010) found that the intervention had a significant positive effect on time spent in MVPA during school hours and full day, for the intervention group. Total PA level during school hours were also higher in the intervention group than in the control group. However, no significant change in full day PA level (Kriemler et al., 2010). The intervention managed to favorably affect estimates of body composition in the intervention groups compared to control.

Table 3.1*: Overview of studies that examined the relationship between PA and BMI*

Author and country	Study-design, study	Age and sample (n)	Measurement method PA	Anthropometric measurement	Results
Bourdeaudhuij et al., 2013 Hungary, Belgium, Netherlands, Greece, Switzerland	Cross-sectional study ENERGY project	10-12 766	ActiGraph GT1M, GTX3 Actitrainer	BMI *Coles index*	More time in MVPA significant associated with lower BMI and WC amongst girls and boys
Cooper et al., 2015 Australia, Belgium, Brazil, Denmark, Estonia, Norway, Portugal, Switzerland, UK, USA	Cross-sectional study ICAD	2.8-18.4 27 637	ActiGraph GT1M	Height Weight BMI *Colex index*	Overweight and obesity is associated with lower levels of PA in the oldest age groups, for both boys and girls.
Grydeland et al. 2013 Norway	Cluster RCT HEIA-study	11 700	Accelerometer		Effect on overall PA in favor of the intervention group
Grydeland et al., 2014 Norway	Cluster RCT HEIA-study	11 700		Height Weight WC BMI	Beneficial effect for BMI (p=0.02) and BMIz (p=00.03) in girls only. No intervention effect for WC and wight status (p > 0.05)
Katzmarzyk et al., 2015 Australia, Brazil, Canada, China, Colombia, Finland, India, Kenya, Portugal, South-Africa, UK, USA	Cross-sectional study ISCOLE	9-11 6 539	ActiGraph GTX3+	BMI z-score WHO	Higher levels of PA negatively associated with overweight and obesity, independent of SED
Kolle et al., 2012 Norway	Cross-sectional study UngKan2	6, 9 and 15 3538	Accelerometer GT1M + ActiGraph GT3x	Height Weight WC BMI	Significantly more normal weight 6- and 9-year old met the recommendations for PA. PA level decreases with age.
Kriemler et al., 2010 Switzerland	Cluster RCT KISS	6 and 11	Accelerometer	Skinfold WC BMI	Significant results in skinfolds (P=0.003) in favor of intervention group. Beneficial intervention effect on BMI.
Martinez-Gomez et al., 2010 Greece, Germany, Belgium, France, Hungary, Italy, Sweden, Austria, Spain	Cross-sectional study HELENA	12.5-17.5 2094	ActiGraph GT1M	Skinfolds BMI - *Coles index*	Current PA recommendations was associated with lower risk of overweight and obesity
Martínes-Vizcaíno et al., Spain	Crossover randomized cluster trial MOVI-KIDS	4-7 1434	Accelerometer GT3X	Heigh Weight WC BMI - *Cole index*	Significant improvement in cardiorespiratory fitness in girls, and muscular strength and velocity/agility in both girls and boys.
Møller et al., 2014 Denmark	Quasi experimental research program The CHAMPS-study DK	4-7	Accelerometer GT3C ActiGraph	Height Body mass WC BMI	No significant difference in full day PA level. Children in sport school significantly more active during school hours.

3. Methods

ScIM was a multicenter, school-based, three-arm cluster randomized controlled trial (cluster-RCT) recruiting ninth graders from lower secondary schools. The ScIM consist of two different intervention models and one control group, which explains the three-arm design. The study was conducted by four collaborating study partners with a geographical spread across Norway (Norwegian School of Sport Sciences, Western Norway University of Applied Sciences, University of Agder, and University of Stavanger). The included schools were from municipalities in a geographical area around the four test centers. Population density was taken into account when selecting the schools, more schools in high population density were included. Private schools, special schools, schools with fewer than 25 students in 9th grade and schools that participated in another project with the same outcome was excluded. In addition, schools that already worked systematically with physical activity or had expanded physical activity as an integral part of the school day, were excluded as well. The sample for this thesis is a subgroup from ScIM recruited from Viken county, and only what is relevant for this thesis will be described further.

3.1 Population

A total of 22 schools were invited to participate in ScIM in Viken county. Of these, 11 of the schools agreed to participate in the study, while 11 schools declined. By lottery (randomization), schools were divided into three intervention arms. The distribution was made by a neutral third party. When the project started, there were 3 schools in intervention model M1, 4 schools in intervention model M2 and 4 schools in the control group. All the 9th grade students at the included schools were invited to participate in the study. Out of 1149 students, 886 returned signed consent. Which gives the study a participation rate of 77%. After twelve weeks of the project, one M2 school withdrew from the project (the students have data at test 1, and these are included in the analyzes in this thesis).

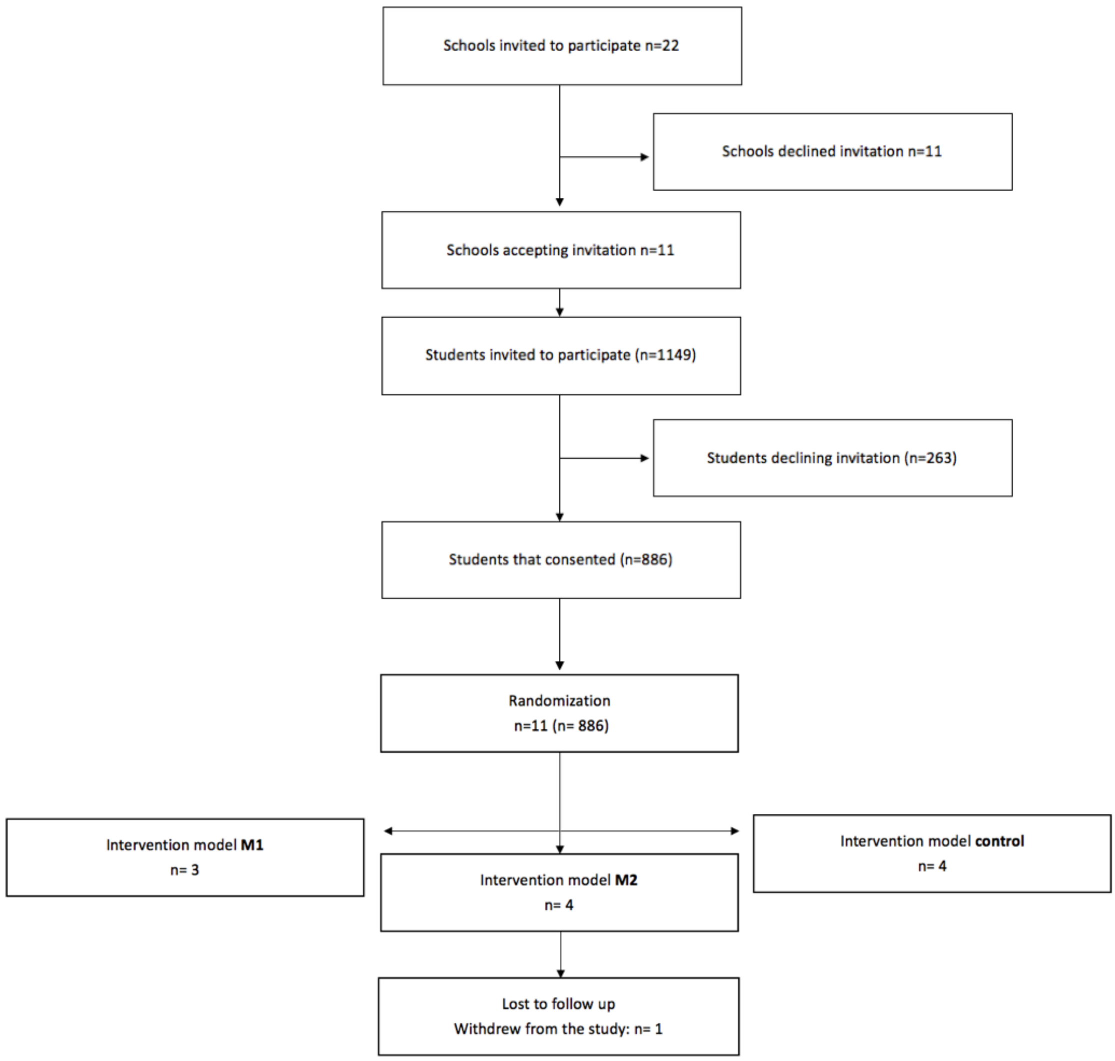

Figure 1.1: Flow chart with overview of schools and students that participated in School in Motion (ScIM) from Viken County. N= number of schools, and the numbers in parentheses are the number of students.

3.2 Intervention models

The ScIM interventions were designed to provide the adolescents with the opportunity to engage in 120 min of PA per week in addition to the two or three (approx. 120 min) scheduled mandatory physical education (PE) lessons per week. The intervention components were established as a part of the mandatory curriculum for all students in ninth grade. The interventions were delivered from September 2017 to June 2018.

The ScIM interventions was underpinned by a socio-ecologic understanding that recognizes the complex interplay between the many personal and environmental influences on behavior (McLeroy et al., 1988). The two intervention models were different, whereas the first model (PA learning, M1) mainly were based on the results of interventions in primary school, whilst the second model (DWBH, M2), is a more innovative model that considers the project as a social intervention as much as a PA intervention. For the intervention models, it was set aside funds for one hour of extra PA or PE per week, by the Directorate of Education and Training, which were based on the number of pupils at the school. In addition, the schools were to redeploy up to 5% of the remaining number of hours to PA (approximately one hour).

3.2.1 Intervention model 1 (M1): Physical active learning

This model consisted of three different components: Exercise, PA learning and PA. The aim was to increase PA levels among students while improving their academic performance.

- Physical Education: *One extra physical education class per week. All activity was carried out in accordance with the current curriculum. This class was led by the school's physical education teacher.*
- Physical active learning: *Physical activity was included in school subjects (e.g. mathematics and Norwegian) and used as a learning activity to achieve learning objectives in the relevant subject. It should be done 30 minutes per week.*
- Physical activity: *Scheduled time for physical activity that was not linked to subjects. It should be done 30 minutes per week and was led by the teachers.*

Teachers in the M1 intervention group were encouraged to motivate adolescents, and provide a variety of activities that should be enjoyable for everyone and give them a sense of mastery and thereby stimulate positive feelings and attitudes towards PA. We adopted a self-determination perspective, and intervention schoolteachers were provided with an online 'tool-kit' of different activities. These activities were based on feedback from teachers and students, and already existing pedagogical material.

3.2.2 Intervention model 2 (M2): Don’t worry- Be happy

Model 2 consisted of an extra hour of compulsory PE lesson per week and one extra compulsory hour per week for locomotor activity. The classes should have their own designations that were not associated with PE or PA. Examples of such designations were the “don’t worry- class (the extra PE hour), and the “be happy-class” (PA hour), but the intervention schools were free to use other designations. The “be happy- class” was to be organized in groups across classes. In the start of the intervention, the students (in collaboration with the teachers) found an activity context they considered meaningful to them (e.g. dance/choreography, traditional sports, outdoor activities, drama group, yoga, tour group). An activity context should be defined as a group of young people who should develop and exchange interests and values with peers through a clarified form of activity during school hours (and possibly outside of school hours). The various groups should develop goals, annual plans and period plans for the activity. The social dimension of “friendship through physical activity” should be central to the work. The “don’t worry - class” should take place in class (like other physical education lessons), but the hours should be related to “Be happy hours”. During these hours, the youth should work individually or in smaller groups with the teacher as support.

The M2 intervention models was anchored to an integrative relational developmental systems (RDS) approach to human development, theories on Positive Youth Development (PYD) and the concept of Positive Movement Experiences (PME) (McLeroy et al., 1988). By letting the adolescents choose their own activity, they were meant to do an activity that was meaningful for them and they were supposed to do the activities together with friends. According to the theories on PYD all youth have strengths. Therefore, in the M2 intervention group the adolescents were responsible for conducting the intervention, they had to form activity groups, constitute aims for the activities the group should do, develop a management structure, a strategy for impending conflicts and routines for registration of attendance.

3.2.3 Control group

The schools in the control group continued current practice including the usual amount of mandatory PE that was part of the curriculum.

3.2.4 Delivery

Each week teachers in the intervention schools documented the extent to which the intervention dose was delivered as intended, as well as the intensity and the duration of the activity. Logging was carried out using electronic registration and the registration was followed up weekly by ScIM's project coordinators at the various test centers.

3.3 Measurements

The measurements variables related to this master thesis is described below. The tests were conducted at each school, and it was conducted by experienced test teams from the test center the school belonged to. The test teams at the various test centers consisted mainly of PhD students, academic staff at the institutions, people with sports master's degree and bachelor's students at the institutions. Anthropometric measurements (height, weight and WC) were performed on all adolescents. On the test day, students were given an accelerometer, which records PA levels. The following physical health parameter was measured:

3.3.1 Anthropometry

Students weight was measured to the nearest 0.1 kg by a digital scale with external display (Seca 899, Hamburg, Germany). Height was measured to the nearest 1 mm using a portable stadiometer (Seca 123, Hamburg, Germany). WC was measured using a measuring tape (Seca 2010, Hamburg, Germany) to the nearest 1 mm. The participants stood with their arms hanging along the side, weight distributed on both legs as they were asked to breathe normally. The circumference was measured between upper hip and lower ribs after a normal exhalation. The average of two measurements was used. All the anthropometric measurements were made with the participants standing in light clothing (t-shirt and pants) and without shoes. From each person's weight, it was subtracted from 0.6 or 1.5 kg, to correct body weight for the use of little (e.g. t-shirt and pants) or some clothes (e.g. jeans and sweater).

Classification of participants as overweight or obese was based on age- and gender-specific BMI limit values developed by Cole and colleagues (Cole et al., 2000). The limits for overweight and obesity correspond to the limit values for overweight (BMI 25-30) and obesity (BMI>30) for adults (>18 years).

3.3.2 Physical activity

ActiGraph accelerometer (model GT3X+) was used to record student's PA levels (ActiGraph, LLC, Pensacola, Florida, USA). An accelerometer is one small electronic meter that records all movement it is exposed to and all activity beyond normal human movement is filtered away. The accelerometers used measure movement in three different plans. The ActiGraph accelerometer is extensively validated and reliability tested (Brage et al., 2003; Ekelund et al., 2001; Grydeland, Hansen, et al., 2014). Each participant was according to protocol supposed to carry the accelerometer in a belt around the waist for seven consecutive days.

3.4 Data collection

The data collection was conducted during the period January to April 2018. The intervention started up at week 38 in 2017 and lasted until June 2018. The schools were informed that they had to complete intervention for test 2 within spring 2018. The first schools started testing at T2 in week 19, while the last schools were tested just before the summer holiday in June. The completion rate is calculated from week 38 in 2017 to week 19 in 2018 (despite the fact that the length of implementation was longer for some schools). When calculating possible activity sessions, following periods were taken out: the autumn holidays (week 40 or 41), Christmas holidays (weeks 51 and 52), winter holidays (week 7 or 8) and the Easter holiday (week 13). Based on this, there is 29 weeks in which the schools had the opportunity to implement the intervention.

To investigate whether the intervention was effective, all students were tested before the intervention began (after the schools were randomized) and at the end of the intervention.

3.4.1 Data assessment

The accelerometers were initialized using the ActiLife software (ActiGraph LLC, Pensacola, FL, USA). At initialization, the start date was set to be one day after the students were handed the meter. Upon delivery, the belts were correctly fitted by one of the test team and the following instructions were given:

- The belt should always be positioned so that the accelerometer is located on the right hip

- The accelerometer should be used at all times, except at night when sleeping and at various water activities.
- The accelerometer should be used for seven consecutive days

After the registration period, the accelerometer was collected by contact persons at the various schools and picked up at the school by one of the ScIM's project staff. Data from the accelerometer were processed at The Norwegian School of Sport Sciences (NIH). Raw data was downloaded from the accelerometer and transformed into readable data using the ActiLife software. All raw data files were reduced by 10 second storage intervals (epochs). Missing periods of data (periods where it is assumed that the participants removed the accelerometer) were defined as consecutive periods of 20 minutes or more where the accelerometer recorded 0 counts. The activity data were analyzed in two different groups: 1) PA level throughout the day (6 am to 11 pm), and 2) PA level during the school day. Schedules from each school were used to define the school day exactly at the minute for each class. After data reduction, the following criteria were set for the activity records to be valid and thus included in the statistical analyzes:

PA level throughout the day:

- Each day had to consist of at least 8 hours of activity registrations
- Each student must have at least 2 days of approved activity registration

PA level during the school day or leisure:

- Each day must consist of at least 40% with valid activity registration in the relevant 12 time period
- Each student must have at least 2 days of approved activity registration

Data from the accelerometer is called counts and is an expression of how strong the accelerations from the meter is exposed to. The main PA variable is the average PA level (average counts/min = CPM), and additional variables are time spent in different intensity categories. The cut points used for the different intensities used in this master´s thesis is described below:

- Sedentary time: <100 counts/min
- Moderate-to-high intensity activity (MVPA): ≥2000 counts/min

The ActiGraph models used in ScIM are robust and not infested with technical faults. Purification of the activity meter database was carried out for unrealistically high and low values, duplicate files and defective meters.

3.5 Ethics

The project was reviewed by the Regional Committee for Medical and Health Research Ethics (REK) in Norway, who according to the Act on medical and health research (the Health Research Act 2008) concluded that the study did not require full review by REK. The study was approved by the Norwegian Centre for Research Data.

3.6 Statistical analysis

We included all students with valid baseline or follow-up measures for weight, BMI and WC. Data was assessed for normality and homogeneity of variance. We fitted linear mixed models to all continuous outcomes with repeated measurements. Each model contained fixed effects for intervention, time (baseline – follow-up) and intervention x time interaction. As the units of randomization were schools, we added random effects for school, class and subject ID to accommodate the clustering of participants within these units. Based on the linear mixed models, we estimated mean group values with 95% CI at baseline and follow-up. We estimated the between group difference in change from baseline to follow-up between the participants in the intervention arms and the control arm, with adjustment for gender. Descriptive data are presented as mean and SD unless other stated. Baseline differences between students in the three intervention arms were investigated using linear regression. A value of $p < 0.05$ was considered statistically significant. Statistically significant interaction between genders was evident in all models ($p < 0.001$ for interaction), consequently all analyses were stratified by gender. All statistical analyses were performed in STATA SE (15.1 (StataCorpStataCorp LP).

3.6.1 Power calculation

The main aim of the ScIM study was to evaluate the effect of increase PA and PE on student's PA levels. Therefore, the ScIM study was designed to detect a difference in total PA level of seven percent (49 CPM) between participants in the intervention models and the control group. We assumed a standard deviation (SD) of 150 CPM, a power of 90%, a significance level of 0.05, which lead to 492 participants in each group. To allow for 20% loss to follow-up we needed 590 participants in each group. Furthermore, we needed ten cluster per study group, and we aimed to recruit until we had at least ten cluster and 590 individuals in each study arm. The power calculation is only applicable for the main study. Specific power calculation for this thesis is not calculated.

4. Results

4.1 Descriptive data

Table 3.1 and 3.2 presents the students' anthropometrical data and PA level at baseline. Gender distribution was equal in the three groups. There were no significant differences in height, weight or WC amongst the girls in the intervention groups when compared with their control school counterparts. Among boys in M1 there was no significant difference in age, height, weight or WC when compared with boys in the control group. However, there was a significant difference in weight ($p \leq 0{,}004$) and WC ($P \leq 0{,}001$) between boys in M2 and control. There was no significant difference in BMI between intervention groups and control group, and the majority of adolescents participating in our study were normal weight (BMI <25 kg/m2) at baseline.

4.2 Body mass index

In table 3.3. and 3.4 the mean values and SD on BMI pre- and post-intervention is presented. The intervention had no significant effect on BMI when comparing intervention groups to control group, this applies to both the girls and boys.

4.3 Waist circumference

Table 3.3 and 3.4 presents the group differences between the intervention groups and controls, in addition to means values at baseline and follow up. For girls (table 3.3) there was a significant intervention effect on WC among both intervention groups when compared with controls. The mean difference in change when compared with controls was 0.8 cm (95% CI 0.002; 1.6), and 0.9 cm (95% CI 0.04; 1.7) for girls in M1 and M2 respectively. For boys (table 3.4) there was no significant intervention effect amongst the intervention groups and control group.

4.4 Physical activity level

There was significant effect of the intervention on the mean PA level during school hours (table 3.5 and 3.6). Girls (table 3.5) in M1 had a significant increase in the mean PA level during school hours which was 104 counts/min higher (95% CI 44.5; 164.3) when compared to girls in the control group. The girls in M1 had a reduction in SED, which was on average 11 minutes (95% CI -18.3; -5.0) lower per school hours compared to girls in the control group. Time spent in MVPA were increased by 6 minutes (95% CI 2.4; 9.4) for girls in M1 compared to control. For girls in M2 the mean PA level during school hours reduced with 137 counts/min (95% CI -200.7; -73.7) when compared with their control school counterparts. Girls in M2 had an increase in mean SED during school hours with 15 minutes compared to control (95% CI 8.6; 23.0). For time spent in MVPA girls in M2 had a reduction of 6 minutes compared to control (95% CI -10.1; -2.4). There was no significant difference in full day PA, SED or time spent in MVPA among M1 compared to control (table 3.5). Girls in M2 had an average increase of 17 minutes in SED compared to control (95% CI 4.0; 30.7), and an average reduction of 8 minutes for time spent in MVPA compared to girls in control group (95% CI -15.7; -4.8).

For boys (table 3.6) there is significant difference in total PA during school hours between M1 and control as well as M2 and control. Boys in M1 increased on average with 87 counts/min (95% CI 15,0; 159,0), and M2 reduced their total PA with an average of 138 counts/min (95% CI -215,2; -62,0). Looking at SED during school hours, M2 has a significant difference compared to control, with an average increase of 15 minutes (95% CI 6.0; 23.8) per day. For time spent in MVPA boys in M1 had an average increase of 6 minutes (95% CI (1.6; 10.4) compared to control. No significant difference in full day activity level, SED or time spent in MVPA was found in either intervention groups when compared with their control school counterparts.

***Table 4.1**: Descriptive data of the student's anthropometry at baseline. Data is presented as mean (SD) unless other stated.*

	Intervention (M1)		**Intervention (M2)**		Control	
	Girls	Boys	Girls	Boys	Girls	Boys
N	115	118	120	116	160	195
Age (year)	13.9 (0.3)	13.9 (0.2)	13.9 (0.3)	14.0 (0.3)	14.0 (0.3)	14.0 (0.3)
Anthropometry						
Height (cm)	162.7 (6.4)	166.5 (9,0)	164.1 (5.6)	168.9 (8.2)	164.1 (6.3)	166.8 (7.4)
Weight (kg)	52.8 (8.9)	53.3 (10.5)	55.1 (8.9)	57.3 (12.3)	54.2 (8.7)	53.1 (10.8)
Waist (mean)	64.2 (5,6)	66.7 (7.6)	66.5 (6.0)	70.0 (8,8)	66,3 (5,6)	66,5 (8,0)
Body mass index	19.8 (2.8)	19.0 (2.5)	20.4 (2.8)	19.9 (3.3)	20.1 (2.8)	19.0 (3.1)
Overweight (%)	7.6	10.1	11.2	14.2	11.9	7.9
Obese (%)	0.8	0.8	1.6	3.1	1.1	2.8

M1= Intervention model physical active learning; M2= Intervention model Don't worry Be happy

***Table 4.2**: Descriptive data of the student's physical activity level at baseline. Data is presented as mean (SD) unless other stated.*

	Intervention (M1)		Intervention (M2)		Control	
	Girls	Boys	Girls	Boys	Girls	Boys
N	96	86	88	69	146	141
PA levels full day						
Total PA (cpm)	450.1 (145.3)	527.7 (214.3)	565.7 (234.5)	622.4 (220.3)	492.6 (173.3)	540.4 (209.1)
MVPA (min/day)	59.9 (19.8)	64.6 (23.8)	75.0 (26.7)	79.6 (30.2)	66.9 (24.9)	69.5 (25.4)
Sedentary (min/day)	561.2 (70.7)	529.7 (91.9)	543.0 (78.4)	507.0 (73.0)	544.0 (71.7)	525.1 (8.0)
N	104	97	89	76	146	156
PA levels school day						
Total PA (cpm)	318.3 (114.4)	401.9 (137.4)	527.8 (233.0)	647.7 (274.0)	433.0 (163.1)	494.4 (164.1)
MVPA (min/day)	17.9 (8.6)	21.8 (9.4)	29.3 (13.5)	35.2 (15.7)	24.6 (9.7)	27.8 (11.5)
Sedentary (min/day)	255.0 (28.5)	241.1 (29.7)	220.7 (28.0)	206.3 (26.9)	232.7 (32.2)	215.7 (29.7)

M1= Intervention model physical active learning; M2= Intervention model Don't worry Be happy

Table 4.3**: Adjusted mean values for test 1, test 2, and group differences (intervention-control) (95% CI) change in weight, waist circumference and BMI in* ***girls.

	Intervention M1		**Intervention M2**		**Control**		**Group differences M1-C**	**Group differences M2-C**
	Test 1	**Test 2**	**Test 1**	**Test 2**	**Test 1**	**Test 2**		
N	115	96	120	82	160	135		
Weight (kg)	52.8 (51.0; 54.7)	55.4 (53.5; 57.3)	54.7 (52.8; 56.6)	58.2 (56.3; 60.2)	54.1 (52.6; 55.7)	56.6 (55.1; 58.2)	0.04 (-0.99; 1.08)	0.98 (-0.12; 2.08)
Waist (mean)	65.3 (64.1; 66.5)	66.8 (6.6; 68.0)	66.4 (65.2; 67.6)	68.0 (66.7; 69.3)	66.2 (65.2; 67.3)	66.9 (65,9; 68.0)	**.8 (0.002; 1.6)**	**.9 (0.04; 1.7)**
BMI	19.8 (19.1; 20.5)	20.3 (19.7; 21.0)	20.3 (19.6; 20.9)	21.0 (20.3; 21.7)	20.0 (19.4; 20.5)	20.4 (19.9; 21.0)	0.01 (-0.24; 0.40)	0.26 (-0.01; 0.60)

M1= Intervention model physical active learning; M2= Intervention model Don’t worry Be happy. Significant findings are highlighted in bold.

Table 4.4*: Adjusted mean values for test 1, test 2, and group differences (intervention-control) (95% CI) change in weight, waist circumference and BMI in* ***boys.***

	Intervention M1		**Intervention M2**		**Control**		**Group differences M1-C**	**Group differences M2-C**
	Test 1	**Test 2**	**Test 1**	**Test 2**	**Test 1**	**Test 2**		
N	118	104	116	78	195	173		
Weight (kg)	53.2 (51.1; 55.2)	59.6 (57.5; 61.7)	57.4 (55.3; 59.5)	63.8 (61.6; 65.9)	53.6 (51.7; 55.0)	59.6 (58.0; 61.2)	0.14 (-1.09; 1.38)	0.13 (-1.25; 1.52)
Waist (mean)	66.7 (64.7; 68.6)	71.8 (69.9; 73.8)	69.8 (67.9; 68.6)	75.8 (73.8; 77.8)	66.6 (65.1; 68.2)	71.4 (69.8; 73.0)	.38 (-.9; 1.6)	1.2 (-.18; 2.6)
BMI	19.0 (18.4; 19.6)	19.9 (19.2; 20.5)	20.4 (19.4; 20.6)	20.9 (20.3; 21.6)	19.1 (18.6; 19.5)	19.9 (19.4; 20.4)	0.05 (-0.30; 0.41)	0.13 (-0.26; 0.54)

M1= Intervention model physical active learning; M2= Intervention model Don’t worry Be happy. Significant findings are highlighted in bold.

Table 4.5: *Adjusted average values (95% CI) for test 1, test 2, and group differences (intervention-control) (95% CI) for change in PA throughout school day, leisure time and all day for* ***girls.***

	Intervention M1		**Intervention M2**		**Control**		**Group differences M1-C**	**Group differences M2-C**
	Test 1	**Test 2**	**Test 1**	**Test 2**	**Test 1**	**Test 2**		
School day, N	104	76	89	62	146	112		
Total PA (cpm)	317 (245; 388)	380 (306; 454)	535 (460; 610)	357 (279; 434)	435 (374; 496)	394 (331; 457)	**104 (44.5; 164.3)**	**-137 (-200.7; -73.7)**
SED (min/day)	240 (233; 246)	233 (226; 240)	220 (213; 227)	241 (233; 248)	229 (223; 234)	234 (228; 240)	**-11.6 (-18,3; -5.0)**	**15,8 (8.6; 23.0)**
MVPA (min/day)	17.1 (12.4; 21.7)	20.3 (15.5; 25.0)	30.1 (25.3; 34.9)	21.08 (16.1; 26.0)	24.8 (20.8; 28.7)	22.1 (18.0; 26.1)	**5.9 (2.4; 9.4)**	**-6,3 (-10.1; -2.4)**
Full day, N	96	70	88	61	146	100		
Total PA (cpm)	447 (387; 506)	417 (354; 479)	560 (498; 622)	474 (409; 540)	488 (438; 622)	453 (400; 506)	4.7 (-48.4; 57.9)	-51.1 (-106.5; 4.6)
SED (min/day)	559 (550; 568)	570 (559; 580)	539 (529; 549)	566 (555; 577)	548 (541; 556)	566 (555; 577)	.42 (-12.3; 13.2)	**17.4 (4.0; 30.7)**
MVPA (min/day)	59 (50; 67)	55 (46; 64)	74 (65; 83)	63 (53; 72)	65 (58; 73)	62 (54; 69)	.05 (-7.2; 7.3)	**-8.1 (-15.7; -4.8)**

M1= Intervention model physical active learning; M2= Intervention model Don't worry Be happy; SED = time in sedate activity (<100 counts/min); MVPA = time in activity of moderate to hard intensity (>2000 counts/min). Significant findings are highlighted in bold.

Table 4.6: *Adjusted average values (95% CI) for test 1, test 2, and group differences (intervention-control) (95% CI) for change in PA throughout school day, leisure time and all day for* ***boys.***

	Intervention M1		**Intervention M2**		**Control**		**Group differences M1-C**	**Group differences M2-C**
	Test 1	**Test 2**	**Test 1**	**Test 2**	**Test 1**	**Test 2**		
School day, N	97	63	76	50	156	91		
Total PA (cpm)	410 (331; 489)	487 (404; 571)	603 (520; 687)	455 (366; 544)	483 (416; 549)	473 (402; 544)	**87.0 (15.0; 159.0)**	**-138.6 (-215.2; -62.0)**
SED (min/day)	224 (217; 232)	223 (201; 217)	209 (201; 217)	229 (220; 238)	216 (209; 222)	221 (213; 228)	-6.4 (-14.6; 1.8)	**14.9 (6.0; 23.8)**
MVPA (min/day)	20 (15; 25)	25 (20; 30)	32 (27; 37)	27 (22; 32)	27 (23; 31)	25 (21; 30)	**6.0 (1.6; 10.4)**	-4.3 (-9.0; .36)
Full day, N	86	51	69	40	141	75		
Total PA (cpm)	529 (477; 582)	473 (412; 535)	614 (557; 670)	570 (502; 637)	535 (492; 578)	531 (479; 582)	-51,6 (-124,3; 21,0)	-39.3 (-116; 38.1)
SED (min/day)	527 (514; 541)	544 (528; 559)	514 (499; 529)	536 (519; 553)	517 (506; 529)	531 (518; 544)	2.9 (-14.1; 19.9)	8.1 (-9.9; 26.2)
MVPA (min/day)	64 (57; 71)	60 (52; 68)	78 (71; 86)	72 (64; 81)	68 (62; 73)	67 (60; 73)	-3.5 (-12.8; 5.6)	-5.0 (-14.8; 4.8)

M1= Intervention model physical active learning; M2= Intervention model Don't worry Be happy; SED = time in sedate activity (<100 counts/min); MVPA = time in activity of moderate to hard intensity (>2000 counts/min). Significant findings are highlighted in bold.

5. Discussion

The purpose of this thesis was to investigate the effect of a one-year-school based PA intervention on BMI, WC and overall PA levels amongst adolescent in 9th grade in Viken county, Norway.

We found no significant effects on BMI among neither intervention groups when compared with controls. Girls in both intervention groups had a significant increase in WC when compared with controls. Further, girls and boys in M1 had a significant higher mean difference in change in PA level during and in time spent in MVPA during school hours compared to controls. The girls in M1 had a significant decrease in SED during school hours compared to controls. However, there were no significant differences in full day PA, SED or time spent in MVPA. Intervention M2 had the opposite effect in regard to PA level during school hours, both girls and boys spent significantly less time in PA and had more SED, compared to control. Further, the girls in M2 spent significantly less time in MVPA and had more SED when looking at full day results, compared to control group.

Our results corresponds with findings from other school-based intervention studies that integrated extra PA into the curriculum, but without significant intervention effect on BMI, WC or overall PA level, in children and adolescents (Martínez-Vizcaíno et al., 2020; Møller et al., 2014). However, other studies have reported significant intervention effect on BMI (Grydeland, Bjelland, et al., 2014; Kriemler et al., 2010) and overall PA level (Grydeland et al., 2013). Consequently, there is no consistent evidence in the current literature saying that school-based PA interventions effectively reduce WC or BMI at early ages.

5.1 Results discussion

5.1.1 Effect on waist circumference and body mass index

The difference findings in the literature could be due to several factors. Firstly, previously conducted school-based PA interventions included different PA dose and consisted of several different intervention components (Grydeland et al., 2014; Kriemler et al., 2010; Martínez-Vizcaíno et al., 2020; Møller et al., 2014). In the HEIA study, one 10-minute PA break and one fruit/vegetable break were implemented once a week, throughout the intervention period, in addition a variety of sport equipment became available for daily recess activities (Grydeland et al., 2014). Other components were implemented as well, at different times in the intervention period, such as active commuting campaign, pedometers, lessons about diet and PA and more. In the study by Kriemler (Kriemler et al., 2010), two extra 45 minute PE lessons were added per week, in addition to the three mandatory. Daily 5-minute PA breaks and 10 minutes of PA homework were also implemented.

In contrast, studies that reports nonsignificant intervention effects have different approaches, like the CHAMPS study DK who increased mandatory PE program from 2 to 6 lessons per week for the sport schools (Møller et al., 2014), and the MOVI-KIDS intervention who included three 60 minutes of basic sports each week (Martínez-Vizcaíno et al., 2020). In short, the two ScIM interventions intended to implement 120 minutes of additional PA into the school curriculum by one additional PE lesson and 60 minutes of additional PA with different approaches in the M1 and M2. We can therefore speculate that higher PA dosage and different PA components than implemented in the ScIM study, the CHAMPS-study DK and the MOVI-KIDS study, could be more effective in affecting WC and BMI (Martínez-Vizcaíno et al., 2020; Møller et al., 2014).

Secondly, different lengths of the PA- intervention is another possible factor for the difference in intervention effect. Our intervention lasted for approximately nine months, which is the same length as in the study by Kriemler (Kriemler et al., 2010). However, whilst our interventions had no significant effect on BMI, the study by Kriemler reported beneficial intervention effect on BMI in favor of the intervention group (Kriemler et al., 2010). Other studies such as the HEIA study, which lasted for 20-months, reported beneficial intervention effect on BMI in girls (Grydeland et al., 2014). The CHAMPS-study DK had the longest intervention period of three years, in despite of that- there were no significant intervention effect on BMI (Møller et al., 2014). We can only speculate that if the intervention period for the ScIM intervention were prolonged for an extended period of time, that the results would be more significant. Having said that, the impact of the intervention length is unclear.

Thirdly, the characteristics of the participants could potentially be a factor influencing the results. One is the age group of the participants; another factor is the percentage of normal weight, overweight and obese participants in the study. In this thesis, the sub sample included were mostly categorized as normal weight, which can limit the intervention effect (Silveira et al., 2011). In other studies the participants have been of younger age, usually from the age 11 and younger (Grydeland, Bjelland, et al., 2014; Kriemler et al., 2010; Martínez-Vizcaíno et al., 2020; Møller et al., 2014). In the HEIA study which reported a beneficial effect on BMI in girls, the participants were of the age 11 and there was no significant difference in BMI status between intervention group and control group at baseline. Most of the girls were categorized as normal weight.

There is no consistent answer to which of the factors who have the highest impact on the intervention effect, but it is probably a sum of the intervention components, intervention length and the participants age and growth. Confounding factors such as dietary habits and pubertal status could also influence WC. If the energy intake is higher than the energy expenditure excess fat accumulates (Kumar et al., 2014). Even if participants in a specific intervention study is the same age, difference in pubertal status is normal. Puberty is a period associated with changes in body shape, size and composition, which can (Bini et al., 2000; Brufani et al., 2009; Rogol et al., 2002). However, these factors were not measured in the ScIM study.

5.1.2 Effect on physical activity level

Results from our study indicates that intervention M1, which focused on dose and intensity of the activity, had a significant positive effect on total PA during school hours, for both girls and boys, when compared to control group. This correspond to findings in other school-based intervention studies, where a significant higher PA level during school hours have been registered in favor of the intervention group compared to control (Kriemler et al., 2010; Møller et al., 2014). Full day PA level were not significant when comparing participants in M1 to controls, which are similar to findings in the study by Kriemler and The CHAMPS-study DK (Kriemler et al., 2010; Møller et al., 2014). The HEIA study however, had a positive intervention effect on overall PA (Grydeland et al., 2013).

Intervention M2 focused more on the social aspects of the activity, which seem to have had a negative effect on PA level during school hours when compared to control group. This was equal for both the girls and boys. Boys and girls in M2 had a significant reduction in PA level and a significant increase in SED during school hours, when compared to control group. However, there were no significant difference in full day PA level. Further, the girls in M2 spent less time in MVPA both during school hours and full day, when compared to control group. Time spent SED were also significantly higher during full day.

There are many factors that can influence BMI, one of those is PA, and the increase in WC for girls in M2 could potentially be due to the reduced PA level during school hours, as well as less time in MVPA and more SED on average in a full day. Lower activity level means lower energy expenditure, which again is related to adiposity (Kumar et al., 2014). An increase in WC were also significant for the girls in M1, even though they had a significantly higher PA level during school hours compared to control and more time in MVPA as well as less SED. However, despite the increase in PA during school hours, the intervention had no significant effect on full day PA level. Girls in M1 and M2 did not have a significantly higher PA level than the girls in the control group, which might explain the lack of positive intervention effect on WC. Having said that, the HEIA study had no significant effect on WC despite the significant effect on full day PA level (Grydeland et al., 2014; Grydeland et al., 2013).

5.2 Methodical assessment

5.2.1 Study design

This study was based on a three-arm cluster- RCT. RCT studies are well suited and commonly used to evaluate public health interventions (Moberg & Kramer, 2015). The sample were randomly assigned to one of the interventions- or control group. Randomization of the groups minimizes the allocation bias and selection bias (Thomas et al, 2011, p.336). High cost and logistical challenges might be challenging with an RCT, where it can be demanding to organize and supervise multiple locations and groups. However, the three-arm design makes the study simpler, quicker and cheaper (Parmar et al., 2014). Because the interventions takes place at the same time, and share the same control group, the three-arm cluster- RCT is time efficient and effective (Freidlin et al., 2008). For ScIM this study design allowed the study to try out two different intervention models at the same time and compare it to one control group. By sharing control group, the total sample required can be dramatically reduced, compared to having two separate RCTs (Freidlin et al., 2008).

5.2.2 Selection and attendance percentage

The included sample consisted of 886 14-15-year-old adolescents from 11 schools in Viken county. 50% of the schools invited to participate accepted. The sample had an even distribution of girls and boys, and in total the participation rate was 77%. Participants included in this thesis is a subgroup of the whole study sample in addition to that the power calculation was not done for BMI or WC. Therefore, our study is not powered to detect any significant differences in BMI and WC.

5.2.3 Anthropometric measurements

Hight, weight and WC were objectively registered by qualified test team from NIH, which reduces the possible sources of error that could have occurred at self-reporting. Everyone used the same equipment and followed the same test procedure. The reliability and precision of anthropometric methods can potentially be affected by the equipment, the skills of the test staff and the population being studied (Heyward & Wagner, 2004). If the individuals being measured are overweight or obese, it might be more difficult to find a defined waist, which can lead to unprecise results when measuring WC pre- and post- intervention (Lohman, Roche & Martorell, 1988).

5.2.4 Objectively measured physical activity and sedentary time

ActiGraph accelerometers were used as the objective measurement of PA and SED in this study. Advantages of using accelerometer is that it objectively measures assessment of frequency, intensity, and duration of activity, for prolonged periods with minimal interference in daily life (Rowlands, 2007). However, there are some limitations related to the use of accelerometer that can influence the results, such as the inability to quantify PA from activities such as swimming, cycling and strength training (Hildebrand & Ekelund, 2017; Plasqui et al., 2013). If the students in M2 for example choose strength training for their extra activity at school, then the activity would be under-registered. Same applies if any of the participants in ScIM used cycling as the means of transport, exercise, or were participating in swimming activities, this would not be registered, which can give a lower estimate of full day PA level. If sitting on a spinning bike for example, the activity measured with the accelerometer might be mistaken for SED. Further, when the accelerometer is placed on the hip, it has difficulty in detecting higher counts measurements with increasing intensity during a run (Brage, Wedderkopp, et al., 2003). This can influence the results of total PA level and especially activity in VPA.

5.3 Practical implications

Data on BMI status and objectively measured PA can contribute to improved knowledge and valuable information in regard to the amount of PA needed to prevent overweight and obesity in adolescent. Measures to reduce the prevalence of adolescents with unhealthy BMI may be to implement more PA, PE and active learning in curriculum, in addition to other components.

5.4 Further research

Further research is required to establish successful interventions targeting BMI and PA level in adolescents. PA level is generally too low in adolescents, which increases the risk of unhealthy BMI. The ScIM were successful in terms of implementation and PA, in this thesis only a subgroup was studied, and those results differ from the original project. However, future school-based interventions in adolescents are of importance to increase knowledge about how PA and BMI change with increasing age, there is a need of studies that follow adolescents over several years. Longitudinal studies would be well suited.

6. Conclusion

The two intervention models in the ScIM project had different intervention effect on PA level, time spent in MVPA and SED during school hours, for the subgroup in this thesis. Intervention M1 focused mainly on the dose and intensity of the activity, and girls and boys in M1 had a significant increase in PA level and time spent in MVPA during school hours compared to controls, and the girls had significantly less SED. However, there were no significant intervention effect on full day PA, time spent in MVPA or SED. Intervention M2 focused more on the social aspect of the activity, which resulted in a significant decrease in PA level, time spent in MVPA and increase in SED amongst the girls. The girls in M2 had significantly more SED and less time in MVPA in full day, compared to controls. Boys in M2 spent significantly less time in PA and had more SED during school hours, compared to controls. The interventions had no significant effect on BMI when compared to controls, however, girls in both M1 and M2 had a significant increase in WC.

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