May Grydeland

School-based obesity prevention in Norway:

Correlates of weight status and intervention effects on
physical activity and body composition
The Health in Adolescents Study (HEIA)

Summary

Background: Prevention of childhood obesity is an international public health priority given the significant impact of obesity on short- and long-term functioning, health and wellbeing. Although recommended in several recent reviews, school-based obesity prevention interventions targeting physical activity and diet have been tested with mixed results.

Aim: The overall aim of the HEalth in Adolescents (HEIA) study was to design, implement and evaluate a comprehensive intervention program to promote a healthy weight development among young adolescents (11 to 13 year olds). This thesis investigates correlates of weight status and effects of the HEIA intervention program on physical activity and body composition. Furthermore, the validity of the physical activity assessment tool, the ActiGraph accelerometer, was investigated in a separate study.

Methods: The HEIA study was a school-based cluster randomized intervention trial including 1528 11-13-year-olds from 37 schools in south-eastern Norway in 2007-2009. During an intervention period of 20 months, a total of 12 intervention schools received a multicomponent program targeting physical activity, sedentary- and dietary behaviors. The pre- and post-intervention data collections included an electronic questionnaire, objectively assessed anthropometrics and accelerometer assessed physical activity. The validation study included 16 9-year-olds who simultaneously wore three generations of ActiGraph accelerometers (AM7164, GT1M, and GT3X+) for seven consecutive days in a free-living setting.

Main results: Level of parental education, breakfast consumption and moderate to vigorous physical activity were positively associated with being normal weight. Time spent watching TV was positively associated with being overweight for boys only.

The intervention showed to be effective in increasing overall physical activity (p=0.05). The effect appeared to be more profound among girls than boys, among participants in the low-activity group as compared to participants in the high-activity group (below or above median mcpm, respectively), among normal weight compared to overweight, and among participants with parents having 13-16 years of education than among participants with parents having less or more years of education. The intervention succeeded in reducing time spent being sedentary among girls only.

Beneficial intervention effects were found for body mass index (BMI) and BMI z-score in girls only. Furthermore, a beneficial effect was found for BMI in participants of parents reporting high level of

education, and a negative effect was found for waist-to-height-ratio in participants with parents reporting low level of education.

We found that the old ActiGraph accelerometer model AM7164 yields higher outputs of mean physical activity than the newer models GT1M and GT3X+ in children in free-living conditions. The GT1M and GT3X+ provided comparable outputs.

Conclusions: A comprehensive but feasible school-based obesity prevention program can increase physical activity in young adolescents, reduce time spent pursuing sedentary behaviors and reduce the group mean BMI development in adolescent girls. A social gradient was apparent both in weight status and intervention effects, and future research and public health policies should therefore address this inequality.

Keywords: Overweight, physical activity, sedentary time, parental education, diet, children, school-based, intervention, accelerometer, assessment.

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List of papers

This dissertation is based on the following original research papers, which are referred to in the text by their Roman numerals:

I.   Grydeland M, Bergh IH, Bjelland M, Lien N, Andersen LF, Ommundsen Y, Klepp KI, Anderssen SA. Correlates of weight status among Norwegian 11-year-olds: The HEIA study. BMC Public Health. 2012 Dec 6;12:1053. doi: 10.1186/1471-2458-12-1053.

II.   Grydeland M, Bergh IH, Bjelland M, Lien N, Andersen LF, Ommundsen Y, Klepp KI, Anderssen SA. Intervention effects on physical activity: the HEIA study - a cluster randomized controlled trial. Int J Behav Nutr Phys Act. 2013 Feb 5;10:17. doi: 10.1186/1479-5868-10-17.

III. Grydeland M, Bjelland M, Anderssen SA, Klepp K-I, Bergh IH, Andersen LF, Ommundsen Y, Lien N. Effects of a 20-month cluster randomized controlled school-based intervention trial on BMI of school-aged boys and girls: the HEIA study. Br J Sports Med 2013 Published Online First: (290413) doi: 10.1136/bjsports-2013-092284.

IV.   Grydeland M, Hansen BH, Larsen MR, Kolle E, Anderssen SA. Free-living comparison of three generations of the ActiGraph activity monitors: Do they provide comparable assessments of overall physical activity in 9-year old children? Submitted.

Abbreviations

BMI	Body mass index
BMIz	Age- and gender adjusted body mass index z-score (based on WHO references)
CI	Confidence interval
Cpm	Counts per minute
EBRB	Energy balance related behaviors
IOTF	International Obesity Task Force
Mcpm	Mean counts per minute
METs	Metabolic equivalent of task / metabolic equivalent
MVPA	Moderate to vigorous physical activity
OR	Odds ratio
SES	Socio-economic status
WC	Waist circumference
WHO	World Health Organization
WTHR	Waist to height ratio

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1. INTRODUCTION

1.1 Overweight and obesity in adolescents – definitions and prevalence

Overweight and obesity are defined as abnormal or excessive fat accumulation that may impair health (WHO, 2000). The fundamental cause of overweight and obesity is an energy imbalance between calories consumed and calories expended (WHO, 2000). Energy intake and expenditure are influenced by so-called energy balance-related behaviors (EBRBs); e.g. physical activity, sedentary behaviors and diet (Kremers et al., 2006). The relative contribution of these behaviors to the development of obesity in children is unclear, partly due to challenges related to measurement and the complexity of energy balance (Reilly, Ness, & Sherriff, 2007; Wareham, 2007). Other factors, including genetic variation, ethnicity, parental adiposity, birth weight, timing or rate of maturation can also affect people's propensity to gain weight, but are less- or non-modifiable (Kipping, Jago, & Lawlor, 2008). The key modifiable and common risk factors for childhood obesity include high birth weight (which is modifiable in cases of maternal diabetes mellitus), high levels of television viewing, low levels of physical activity, parents' inactivity, and consumption of dietary fat and carbohydrate, and sweetened drinks (Kipping et al., 2008).

Overweight and obesity in children and adolescents have been associated with several health risks and social consequences and often seem to track into adulthood (Shaya, Flores, Gbarayor, & Wang, 2008; Han, Lawlor, & Kimm, 2010; Singh, Mulder, Twisk, van, & Chinapaw, 2008). In addition to increased future risk of cardiovascular diseases, diabetes, musculoskeletal disorders and some cancers, obese children can experience difficulties breathing, increased risk of fractures, hypertension, early markers of cardiovascular disease, insulin resistance and psychological effects (Raj, 2012; Owen et al., 2009; Bjorge, Engeland, Tverdal, & Smith, 2008; WHO, 2000). Overweight and obesity represents a significantly increasing economic burden on society (Wang & Dietz, 2002).

Obesity was first included in the international classification of diseases in 1984 (Kipping et al., 2008). Since then, an epidemic has developed globally, affecting all age groups. The proportions of overweight and obesity among children and adolescents have increased both in developed countries, including Norway, and in several developing countries (World Health Organization, 2004; Wang & Lobstein, 2006; Andersen et al., 2005). Figure 1 shows prevalence of overweight (including obesity) among 11-year olds in 36 European countries/regions, based on self-reported weight and height in 2005/2006.
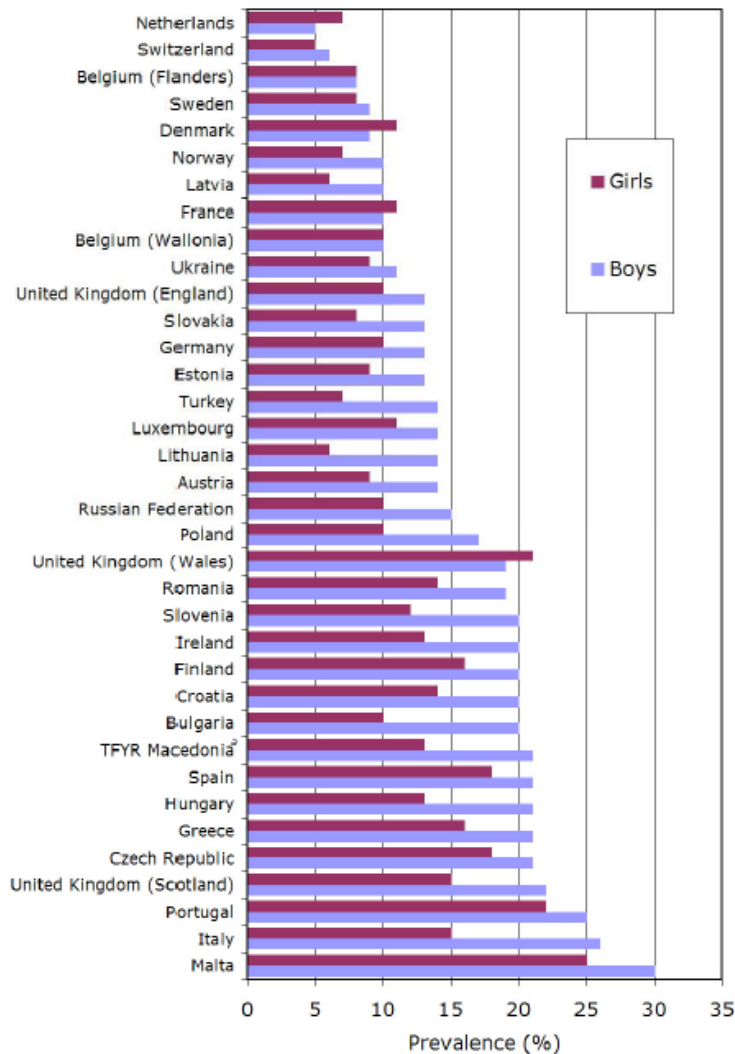
Figure 1 Prevalence of overweight (including obesity) among 11-year-olds in 36 countries and areas of the WHO European Region, 2005/2006 (HBSC data)

Illustration copied from: http://www.euro.who.int/__data/assets/pdf_file/0005/96980/2.3.-Prevalence-of-overweight-and-obesity-EDITED_layouted_V3.pdf (accessed 280213). Based on the Health Behaviour in School-aged Children (HBSC) 2005/2006 survey. *Currie C et al., eds.* Inequalities in young people's health. Health Behaviour in School-aged Children (HBSC) study: international report from the 2005/2006 survey. *Copenhagen, WHO Regional Office for Europe, 2008 (Health Policy for Children and Adolescents, No. 5) (http://www.euro.who.int/Document/E91416.pdf, accessed 7 August 2009).*

In Europe, generally, the southernmost countries have a higher prevalence of overweight and obesity (>15% prevalence) than the northernmost (<10%), and central- and east Europe (5-15%), based on self-reported data (Currie et al, 2008). The corresponding prevalence of overweight and obesity in

11-year olds from the USA was 30% (Haug et al., 2009). However, these prevalence data are based on self-report, and there is a need to document the prevalence based on objectively assessed anthropometrics as well. Recently, a leveling-off has been observed in the obesity development in some European countries (Lien, Henriksen, Nymoen, Wind, & Klepp, 2010; Lissner, Sohlstrom, Sundblom, & Sjoberg, 2010). However, this trend is primarily observed in the more benefited groups of society (Lien et al., 2010; Lissner et al., 2010).

1.1.1 Assessment of overweight and obesity in adolescents

Assessment of adiposity in adolescents is currently done by an array of methods. There is an ongoing discussion about what is the optimal measure of adiposity in larger studies of children and adolescents. Surveillance, prevention and treatment of obesity in childhood and adolescence require methods of defining obesity that are simple enough to be practical in most clinical and public health settings, but also valid (Reilly, 2006). Direct measures, such as dual-energy x-ray absorptiometry (DXA) and underwater weighing, are more accurate than indirect measures but are not practical for population level surveillance (Kipping et al., 2008). Anthropometric measures, such as assessment of weight, height, waist- and hip circumference are commonly used in large scale surveys. The measures can either be used directly or as functions giving descriptions of adiposity; weight-for-height functions (Body mass index (BMI): kg/m^2, and Ponderal index: kg/m^3), waist-to-hip ratio and waist-to-height ratio (WTHR). These measures can be objectively assessed by project staff or subjectively reported by the children/adolescents or their parents/guardians. To date, there has not been the same level of agreement over the classification of overweight and obesity in children and adolescents as in adults. Current expert opinion supports the use of BMI cutoff points to determine weight status (as underweight, normal weight, overweight or obese) for children and adolescents, and standard BMI cutoffs have been proposed by the International Obesity Task Force and the WHO (BMI for age and sex z-score) (Cole, Bellizzi, Flegal, & Dietz, 2000; de Onis et al., 2007; Cole & Lobstein, 2012). Despite this, there is no consistent application of this methodology by experts and several percentile based methods are also used, making it difficult to compare studies that have used different measures and weight outcomes (Waters et al., 2011). Also the sum of skinfolds and bioelectrical impedance provide reliable indirect estimates of adiposity and are sometimes used in research studies (Freedman et al., 2007; Nooyens et al., 2007). The choice of measurement in research studies is dependent on study objectives, sample size and available resources. The most common measure of overweight and obesity reported in studies is BMI.

1.1.2 Obesity prevention in adolescents

A general principle in public health policies is that prevention is preferred over treatment of health problems. To reverse the trend of increasing weight for height in children and adolescents has proven to be difficult.

Furthermore, as a general rule, research-based interventions and policies should be guided by the overall body of evidence, based on the amount, quality, and consistency of the evidence as summarized in systematic reviews and critical appraisals (Reilly, 2012; Summerbell et al., 2005). A number of recent systematic reviews have provided informative and concise summaries of the etiological evidence (Monasta et al., 2010; Summerbell et al., 2005; Waters et al., 2011). For instance, Monasta et al (2010) highlighted the strength, quality, and consistency of evidence supporting the view that several lifestyle factors contribute to obesity in childhood i.e.: excess TV viewing, low physical activity, excess consumption of sugar-rich beverages, lack of sleep, rapid early growth. Having identified and prioritized target behaviors, translation of this information into interventions requires evidence from intervention programs, ideally model interventions from the literature. Interventions that are likely to be generalizable and to potentially have a wide reach and high efficacy, effectiveness and cost-effectiveness, should be prioritized in policy (Reilly, 2012).

It is widely accepted that increasing energy expenditure and reducing energy intake form the theoretical basis for success. The EBRBs are modifiable and can therefore be addressed in obesity prevention programs.

1.2 Energy balance related behaviors (EBRBs)

1.2.1 Physical activity

Definition. Physical activity is a collective term for a multi-dimensional behavior that includes among others sports, exercise, fitness, play, physical education, active commuting and physical work. Dimensions of physical activity include intensity, frequency and duration, which together make up the total volume of activity. Physical activity can happen in many domains; during work/school hours, leisure time or as transport. Physical activity can be defined as "any bodily movement produced by skeletal muscles that results in energy expenditure" (Caspersen, Powell, & Christenson, 1985).

The intensity of an activity is often described in terms of metabolic equivalents (MET). One MET is considered to be equivalent to the energy expenditure of resting metabolic rate for adults, and equals approximately 3.5 ml/kg bodyweight/minute in terms of oxygen consumption (or 1 kcal/kg bodyweight/minute). Because progressively more vigorous forms of activity require proportional increases in oxygen consumption, activities can be quantified in terms of multiples of this resting oxygen consumption (Welk, 2002).

The lack of a sufficient amount of physical activity is associated with an increased risk of many chronic diseases including: coronary artery disease, stroke, hypertension, colon cancer, breast cancer, type 2 diabetes, osteoporosis as well as premature death in adults (Lee et al., 2012; Warburton, Charlesworth, Ivey, Nettlefold, & Bredin, 2010). Although many of these diseases do not appear until adulthood, their etiology can often be traced back to childhood behaviors. Regular physical activity is shown to be beneficial for several health outcomes of youth, and has a potential for reducing the incidence of chronic disease that are manifested later in life (Strong et al., 2005). Physical activity and sedentary behaviors in childhood may track into adulthood (Telama et al., 2005), therefore the promotion of healthy active lifestyles early in life is an important prevention strategy.

Recommendations. There are international and national physical activity recommendations for all age groups. The recommendations are intended to identify the least amount of physical activity required on a general basis for good health. The current Norwegian recommendations for children and adolescents state that all should participate in sports, physical activity or informal play for at least 60 minutes a day. The activities should be enjoyable and varied, yet comprehensive, and aim to develop qualities like aerobic fitness, muscular strength, agility, flexibility, speed of movement and coordination (The Norwegian Directorate of Health, 2002). The guidelines have been debated ever since they first were introduced in 1988 by the American College of Sports Medicine (American College of Sports Medicine, 1990). The evidence-base of these recommendations, the amount of time spent in physical activity and also the time spent at different intensity categories have been topics for discussions. The literature suggests different recommendations depending on health outcome (Strong et al., 2005; Andersen et al., 2006; Ekelund et al., 2012). However, not only the evidence base is taken into account when these guidelines are proposed, but psycho-social and motivational factors are accounted for as well.

Assessment. Accurate assessment of physical activity is a challenging task because of the complexity of the behavior. Choice of assessment tool is dependent on study objective, sample size and resources. In large scale surveys, objective methods as doubly labeled water and behavioral observation are less appropriate because of high costs and low feasibility. Subjective methods such as questionnaires or diaries are commonly used, but both can be affected by social desirability and recall bias (Sallis & Saelens, 2000). Motion sensors of various kinds are increasingly being used and provide objective information on activity in a feasible way for both the researcher and the participants. Generally, objective methods are preferred over subjective methods, and motion sensors such as accelerometers emerge as the preferred tool.

During the last decade accelerometry has increased in popularity relative to other objective methods and is now the most commonly used objective method of physical activity assessment in youth (Rowlands, 2007). Accelerometers provide high quality information on many important aspects of physical activity, but lack information on activity context and habits (Cain, Sallis, Conway, Van, & Calhoon, 2012). There is not any one accelerometer that can be recommended for use over others, because there have not been many direct comparisons of different accelerometers in children and adolescents, though such studies have been called for (Corder, Ekelund, Steele, Wareham, & Brage, 2008). Currently, the most frequently used accelerometers in physical activity research are various generations of the ActiGraph accelerometers (De Vries et al., 2009).

1.2.2.1 Accelerometer challenges

During the past decades, the ActiGraph monitors have developed, and changes have been made both to the hardware and the firmware. The initial ActiGraph activity monitor model 7164 (AM7164, also called CSA) has been replaced by newer generation monitors (i.e. MTI, GT1M, GT3X, GT3X+) and has during the development improved in technological features, data storage capacity and feasibility. Although the monitors have multiple technological differences, a combination of monitors is currently used by physical activity researchers with the notion that the monitors give equal outputs.

Several validation studies have been performed comparing the outputs from the different ActiGraph monitors, but the results are inconsistent. While some report no difference between monitor generations (John, Tyo, & Bassett, 2010; Robusto & Trost, 2012; Vanhelst et al., 2012b), others urges for caution when comparing data assessed by different monitor generations due to differences in outputs (Corder et al., 2007; Kozey, Staudenmayer, Troiano, & Freedson, 2010; Ried-Larsen et al., 2012; Rothney, Apker, Song, & Chen, 2008). The validation studies have mainly been performed in controlled settings (laboratory based or mechanical set up) leaving free living conditions less investigated. Although there is growing evidence among adults of differences in sensitivity between ActiGraph generations (Cain et al., 2012; Kozey et al., 2010; Rothney et al., 2008), it is unclear how model differences affect interpretation of data from children (Cain et al., 2012). A recent review concludes that the comparability of data across ActiGraph models for youth still is uncertain (Cain et al., 2012).

1.2.2 Sedentary time

Definition. Sedentary behavior has been defined as activities demanding a MET of 1.5 or less in adults (Pate, O'Neill, & Lobelo, 2008). This definition corresponds to activities undertaken while sitting, such as watching TV, deskwork or lying down. Any standing activities are classified as non-sedentary (Yates et al., 2011). It is an evolving view that sedentary behavior and physical activity should be considered independent constructs (Proper, Singh, van, & Chinapaw, 2011; Pate, Mitchell, Byun, &

Dowda, 2011; Yates et al., 2011). However, there seems to be confusion and misclassifications regarding the term sedentary behavior (Pate et al., 2011; Proper et al., 2011). Pate et al (2011) claim that many studies reporting associations between sedentary behaviors and various health outcomes have not measured sedentary behavior but a mixture of sedentary behavior and light activity (defined as $1.6 – 2.9$ METs).

Accumulating evidence shows that, independent of physical activity levels, sedentary behaviors are associated with increased risk of cardio-metabolic disease, all-cause mortality, and a variety of physiological and psychological problems (Tremblay et al., 2011b; Katzmarzyk, Church, Craig, & Bouchard, 2009; Owen, Bauman, & Brown, 2009). Tremblay et al (2011) state that most public health efforts to date have focused primarily on physical activity and that little attention has been paid to the mounting evidence to support sedentary behavior as a distinct behavior to poor health. They urge for initiatives that address both physical activity *and* sedentary behaviors.

Recommendations. As the independent associations of sedentary time and various health outcomes just recently have been established, recommendations for sedentary time exists in only a few countries. In 2011, Canada was the first country to suggest evidence-based recommendations for sedentary time. The current recommendations state that for health benefits, children (aged 5-11 years) and youth (aged 12-17 years) should minimize the time that they spend being sedentary each day. This may be achieved by (i) limiting recreational screen time to no more than 2 hours per day - lower levels are associated with additional health benefits; and (ii) limiting sedentary (motorized) transport, extended sitting time, and time spent indoors throughout the day (Tremblay et al., 2011a).

Assessment. Sedentary behavior has until recently been assessed primarily as questions about sitting time, watching TV, playing computer games or similar through questionnaires or interviews (Proper et al., 2011). Questionnaires are still the most common tool to determine sedentary behaviors in large scale surveys, but this method has several limitations with regards to bias. Recently, sedentary behaviors have increasingly been assessed objectively by accelerometers, reducing bias but lacking information on context and habits. Although accelerometry has some important limitations, it provides significant advantages over other methods for measurement of physical activity at all intensity levels, including time spent sedentary (Pate et al., 2008). There is a need to strengthen the evidence base on sedentary behavior assessed by objective methods. When sedentary behaviors are assessed by questionnaire it is most commonly referred to by this term, while it is referred to as sedentary time when assessed by accelerometers.

1.2.3 Diet

Overweight and obesity have been associated with various dietary factors (Must, Barish, & Bandini, 2009). Of dietary factors, intake of sugar-sweetened beverages and breakfast consumption have been of the most frequently studied associations with overweight (Andersen et al., 2005; Groholt, Stigum, & Nordhagen, 2008; Haug et al., 2009; Brug et al., 2012; Jansen, Mackenbach, Joosten-van, & Brug, 2010). In 2004, the WHO categorized consumption of sugar-sweetened beverages as a probable contributor to the obesity epidemic (World Health Organization, 2004). Norwegian adolescents have been shown to have a higher intake of added sugar than recommended (Overby, Lillegaard, Johansson, & Andersen, 2004). However, a recent Norwegian study observed a lower frequency of consumption of sugar-sweetened beverages among 11-13 year old pupils in 2008 than in 2001 (Stea, Overby, Klepp, & Bere, 2012).

An association between breakfast consumption and weight status has been identified in several cross-sectional studies (Andersen et al., 2005; Groholt et al., 2008; Haug et al., 2009). A negative association between breakfast consumption and BMI was found after adjusting for demographic characteristics in the NHLBI Growth and Health study, but the association did not persist after multivariate control for physical activity and energy intake (Affenito et al., 2005). The authors of the study interpreted this observation to suggest that breakfast consumption is a marker for other healthy behaviors. A large American longitudinal study reported that normal-weight children who never ate breakfast gained weight relative to peers who ate breakfast nearly every day (Berkey, Rockett, Gillman, Field, & Colditz, 2003). Must et al (2009) point out that breakfast consumption as well as consumption of sugar-sweetened beverages seem to be operating indirectly, as proxies for other dietary or activity behaviors, and warrants further studies of these relationships.

Several other dietary behaviors have been associated with overweight/obesity or weight gain, including food choices, eating patterns, intake of fruits and vegetables, snack food and calorie amount (de Vet, de Ridder, & de Wit, 2011; Kremers et al., 2006; Monasta et al., 2010; van der Horst et al., 2008), but this is not addressed in this thesis.

Recommendations . There are both national and international recommendations for a healthy diet for the general public (The Norwegian Directorate of Health, 2011). These guidelines are reviewed by experts and renewed periodically. A draft proposal for the 5th edition of the Nordic Nutrition recommendations was presented in June 2012 (http://www.helsedirektoratet.no/Om/nyheter/Sider/nye-nordiske-erneringsanbefalinger-.aspx , assessed 05.04.2013). The recommendations emphasize dietary patterns and nutrient intakes that, in combination with sufficient and varied physical activity, are optimal for development and function of

the body, and at the same time contribute to a reduction of risk factors for and risk of certain diet-associated diseases like cardiovascular diseases, overweight, type-2 diabetes, cancer and osteoporosis. In addition to detailed recommendations of certain nutrients that can be hard to assess accurately in large scale surveys, the guidelines also provide some key-messages that are easier to assess; "5-a-day" (meaning intake of 2 fruits and 3 vegetables a day), have breakfast every day, and, reduce intake of sugar-rich beverages.

Assessment. Several methodological alternatives exist to assess individual level of food intake. They all have strengths and weaknesses, and assessing children's diets are considered even more challenging than assessing the diets of adults. The choice of instrument may depend on the study objective and study design factors, all of which will influence the appropriateness and feasibility of different approaches (Magarey et al., 2010). Other considerations include participants' age, cognitive ability, weight status, physical activity level, respondent burden, reliability and validity in the context of intervention aims and research questions (Magarey et al., 2010). Because of resource constraints, large intervention studies have often relied on less precise measures of diet, including food frequency questionnaires (FFQs) and brief dietary assessment instruments (Thompson & Subar, 2013). The economic challenges has diminished with the availability of automated self-administered 24-hour recall instruments and less burdensome dietary records, such as self-administered web-based tools (Thompson & Subar, 2013). However, subjective methods of assessing diet are prone to several biases that researchers should be aware of (e.g. recall bias, social desirability, social approval bias) (Thompson & Subar, 2013). Furthermore, repeated measures of diet among study subjects in an intervention can reflect reporting bias in the direction of the change being promoted (Baranowski, Allen, Masse, & Wilson, 2006).

1.3 School-based interventions to prevent obesity in adolescents

The increasing rates of overweight and obesity in children and adolescents have resulted in several initiatives aiming to prevent its further development. School-based interventions targeting prevention of overweight and obesity in adolescents have been suggested in several recent reviews (Waters et al., 2011; Summerbell et al., 2005). However, intervention effects have yielded mixed results and questions have been raised regarding strategies, methodology and the reach of intervention efforts (Summerbell et al., 2005). A Cochrane review from 2011 states that there is strong evidence to support beneficial effects of child obesity prevention programs on BMI given a rigorous intervention and study design including healthy eating and increased physical activity in the school curriculum, support for teachers to implement health promotion strategies and activities, and parents support and home activities to encourage the children to be healthier (Waters et al., 2011). However, a systematic review and meta-analysis of controlled trials of objectively measured physical

activity concludes that physical activity interventions, yet successful, have little effect on the overall activity of children (Metcalf, Henley, & Wilkin, 2012). This may partly explain why such interventions have had limited success in preventing childhood obesity. Furthermore, possible explanations for the lack of success in obesity prevention may be poor delivery or uptake of intervention components (Reilly et al., 2006), or insufficient dose (Caballero et al., 2003). When studying the intensities and settings of interventions, it seems that comprehensive school-based interventions aimed at increasing physical activity levels through physical education classes and behavior change are most likely to be effective in preventing weight gain in children, whereas interventions aimed at reducing sedentary behavior and family-based interventions seem to be less effective (Wareham, van Sluijs, & Ekelund, 2005). The effectiveness of school-based nutrition education alone to prevent and reduce weight gain in children and adolescents gave disappointing results when BMI was main outcome, but longer interventions (>1 year) showed promising results in reducing the prevalence of overweight and obesity (Silveira, Taddei, Guerra, & Nobre, 2011). Although more than a third of the examined interventions failed to show effect, the authors believe that large-scale interventions in schools should be implemented to reduce the obesity problem in children (Doak, Visscher, Renders, & Seidell, 2006). Doak et al (2006) state: "The problem of childhood obesity is too extensive, and the consequences too severe and costly, to postpone intervention".

By comparing the conclusions in reviews from 2005 to 2011 on interventions for preventing obesity in children it is clear that the field has moved forward. In 2005, Summerbell et al (2005) concluded that the majority of interventions did not improve BMI. This was also supported by Dobbins et al (2009) who concluded that there was good evidence that school-based interventions aiming to increase physical activity level were not effective in reducing BMI or limiting the extent to which BMI increases with age. Further, Harris et al (2009) stated in a meta-analysis that school-based physical activity interventions did not improve BMI. In 2011, however, Waters et al found strong evidence to support beneficial effects of child obesity prevention programs on BMI, particularly among children aged 6-12 years. This result was also supported by others (Kriemler et al., 2010; Gorely, Nevill, Morris, Stensel, & Nevill, 2009; Simon et al., 2008). Nevertheless, studies are still equivocal. In a systematic review investigating the effectiveness of school-based nutrition education interventions to prevent and reduce weight gain in children and adolescent, eight of nine studies were not successful in reducing the participants' BMI (Silveira et al., 2011). The review concluded however, that most of the interventions with longer durations (1-3 years) demonstrated a reduction in the prevalence of overweight and obesity. Also, a two year cluster randomized school-based physical activity intervention in 7-year-old children managed to increase physical activity but had no effect on body composition (Magnusson, Hrafnkelsson, Sigurgeirsson, Johannsson, & Sveinsson, 2012). The

authors suggested for future intervention programs to be more aggressive in promoting vigorous physical activity to positively impact body composition.

1.3.1 Effect moderators (gender, SES and potential for change)

When investigating intervention effects one should be aware of possible effect moderators. In a systematic review of school-based interventions that focus on changing dietary intake and physical activity level to prevent childhood obesity, Brown and Summerbell (2007) conclude that such interventions may be more effective for younger children and girls. The authors suggested that boys and girls aged between 10 and 14 years may respond differently to different elements of the intervention. Also, a large 2-year school-based cluster randomized controlled trial from Belgium also found intervention effect on BMI and BMI z-score in girls only. The authors suggested that different causal factors may operate among boys and girls (Haerens et al., 2006). In a systematic review on intervention moderators, Yildirim et al (2011) identified gender as the most probable effect moderator, but also socio-economic status (SES) and initial measure of the outcome. Common indicators of SES include parental education, parental occupation, family income and neighborhood SES (Shrewsbury & Wardle, 2008). A systematic review of cross-sectional studies from 1990-2005 concluded that associations between SES and adiposity in children are predominantly inverse, nevertheless, more research is needed to understand the mechanisms through wich parental social class influences childhood adipoisty (Shrewsbury & Wardle, 2008). The social gradient in overweight/obesity in children and adolescents has been confirmed in Norwegian samples (Groholt et al., 2008; Juliusson et al., 2010; Lien, Kumar, Holmboe-Ottesen, Klepp, & Wandel, 2007) and in international samples (Plachta-Danielzik et al., 2007; Haug et al., 2009).

Initial weight status has been identified as a possible moderator of obesity prevention interventions, and initial level of physical activity as a possible moderator of physical activity interventions (Yildirim et al., 2011). Initial outcome value reflects variance in the potential for change. In population-based obesity prevention trials, investigating predominantly non-overweight participants, small effect sizes are to be expected, as the potential for change is limited compared to obesity treatment trials targeting obese participants only (Waters et al., 2011). Hence, it is hard to improve the weight status of participants classified as normal weight.

1.3.2 The school context

Is school the right context for overweight/obesity prevention? According to Thomas (2006), the school is an ideal context for the following reasons: First, almost all children in developed countries spend a significant amount of time in school. Second, children from all risk groups can benefit from the intervention efforts, and the fact that all the children are approached can prevent someone from feeling stigmatized and/or misclassified (Thomas, 2006). Also Booth & Okely (2005) identifies a

number of strengths and weaknesses by the use of school as a context for health promotion. In addition to facilities and infrastructure offered by the school, the delivery of health promotion messages by well-educated teachers should be considered a strength. However, there is reason to believe that students that do not like school may engage in health-risk behaviors and are likely to involve less in health promotion interventions. Furthermore, the opportunities to be physically active and the facilities offered at school may not be attractive to all students. During leisure time, there are more time to be active than during school hours. Finally, Booth and Okely state that school may already have reached its limit of tasks and responsibilities, and that many teachers do not feel competent enough to engage in physical activity promotion efforts (Booth & Okely, 2005).

1.4 Need of new knowledge

Systematically developed school-based interventions aimed to increase physical activity and promote a healthy diet are suggested as key elements in obesity prevention and treatment in children and adolescents (Summerbell et al., 2005). Such lifestyle interventions are supported in several recent reviews (Wareham et al., 2005; Khambalia, Dickinson, Hardy, Gill, & Baur, 2012; Kamath et al., 2008; Salmon, Booth, Phongsavan, Murphy, & Timperio, 2007; van Sluijs, McMinn, & Griffin, 2007) and in a number of public policies and reports (Ommundsen, 2008; The Norwegian Ministries, 2005; World Health Organization, 2004). However, recent reviews conclude that there are still relatively few methodological strong trials aimed at the primary prevention of weight gain in adolescents, and there is still a need to strengthen the evidence base (Wareham et al., 2005; Khambalia et al., 2012; Kamath et al., 2008). Moreover, most obesity prevention intervention studies lasted less than 12 months. There is a need for longer lasting interventions (Waters et al., 2011). As gender, baseline measure of outcome and SES have been identified as effect moderators (Yildirim et al., 2011), it seems important to investigate if this is apparent in systematically developed, long lasting and methodologically strong obesity prevention interventions.

In a systematic review investigating effects of interventions promoting both physical activity and healthy eating in Europe De Bourdeaudhuij et al (2011b) point to that European studies only constitute a small proportion, perhaps 10%, of the studies reported in the international literature. The recommendations for obesity prevention in children and adolescents have mainly been based on research from the USA. Thus, the evidence base on European obesity prevention needs to be further strengthened. In Norway, no large systematically developed school-based intervention study has been performed, targeting obesity prevention through physical activity and dietary behaviors in young adolescents. Moreover, the age of 10–11 years is called a "key transition age" in a preventive perspective, because adolescents are establishing behavioral patterns that may continue into

adulthood and have implications for long term health (Jago, Fox, Page, Brockman, & Thompson, 2010).

Furthermore, the current relationships between physical activity, sedentary- and dietary behaviors and weight status are mainly based on self-report data, yielding several weaknesses (Adamo, Prince, Tricco, Connor-Gorber, & Tremblay, 2009). There is a lack of information based on objectively assessed health outcomes. Accelerometers have been suggested as a valid tool for assessment of physical activity (Ekelund et al., 2001). However, validation studies of different ActiGraph accelerometer generations have yielded mixed conclusions as to whether the outputs are directly comparable or not (Corder et al., 2007; John et al., 2010; Kozey et al., 2010; Ried-Larsen et al., 2012; Robusto & Trost, 2012; Rothney et al., 2008). Given that most validation studies are performed on adults and in laboratory or controlled settings, free-living validation studies of ActiGraph accelerometers on children are lacking.

1.4.1 Objectives

The Health in Adolescents (HEIA) study, a 20 month school-based multicomponent cluster randomized intervention study, was developed based on the current best practice knowledge to affect the following core outcomes in Norwegian adolescents: a healthy weight development, increased physical activity, reduced sedentary time and a healthier diet. The aim of this thesis is to discuss defined parts of the HEIA study, with respect to correlates of weight status, intervention effects on the participants' physical activity patterns and estimates of body composition, and the accelerometers used to assess physical activity. The following objectives were formed to be dealt with in four papers:

1. To investigate associations between weight status and both modifiable correlates (dietary factors, sedentary behaviors, physical activity) and non-modifiable correlates (gender and parental education) among Norwegian 11-year-old adolescents **(Paper I)**.

2. To investigate 20 months intervention effects on accelerometer assessed physical activity and sedentary time, and to explore whether intervention effects varied by gender, pubertal status, weight status, initial level of physical activity and level of parental education **(Paper II)**.

3. To investigate 20 months intervention effects on estimates of body composition, and to explore whether intervention effects varied by gender, pubertal status, weight status and level of parental education **(Paper III)**.

4. To compare outputs from three ActiGraph accelerometer generations (AM7164, GT1M and GT3X+) when assessing physical activity in children in a free-living condition **(Paper IV)**.

2. Methods

In this section material and methods for **Papers I-III** are first outlined, followed by material and methods for **Paper IV**.

2.1 Study design, sample and data collection (Papers I-III)

The HEIA study was based on a socio-ecological framework. This framework aimed to combine personal, social and physical environmental factors hypothesized to influence overweight and obesity in children, mediated by dietary and physical activity behaviors (Kremers et al., 2006; Lien et al., 2010). The school based intervention was evaluated using a cluster randomized controlled trial. In designing the intervention, we emphasized the balance of multiple intervention efforts with feasibility and sustainability of the intervention program in the public school system. The HEIA study is described in detail elsewhere (Lien et al., 2010).

Eligible schools were those with more than 40 pupils in 6th grade and located in the 3-4 largest towns/municipalities in the seven counties surrounding the county of Oslo, illustrated in Figure 2.
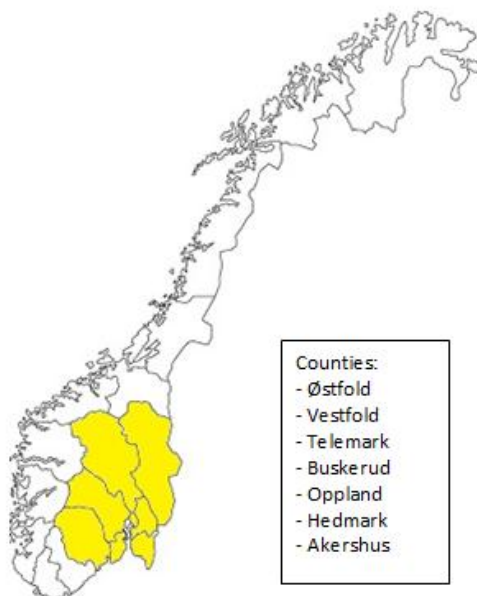
Figure 2 Counties participating in the HEIA study

Of 177 schools invited, 37 schools agreed to participate. All 6th graders in these 37 schools (n=2165) were invited to participate. Of these, 1580 adolescents accepted to participate and returned a parent

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signed informed consent form (73%). Twelve schools were randomly assigned to be intervention schools and 25 schools to be control schools. The randomization was conducted by blind draw and took place before the data collection. Figure 3 shows recruitment, randomization and participation in the HEIA study (as the questionnaire and the anthropometrics consist of several items, the numbers vary somewhat for the different items).
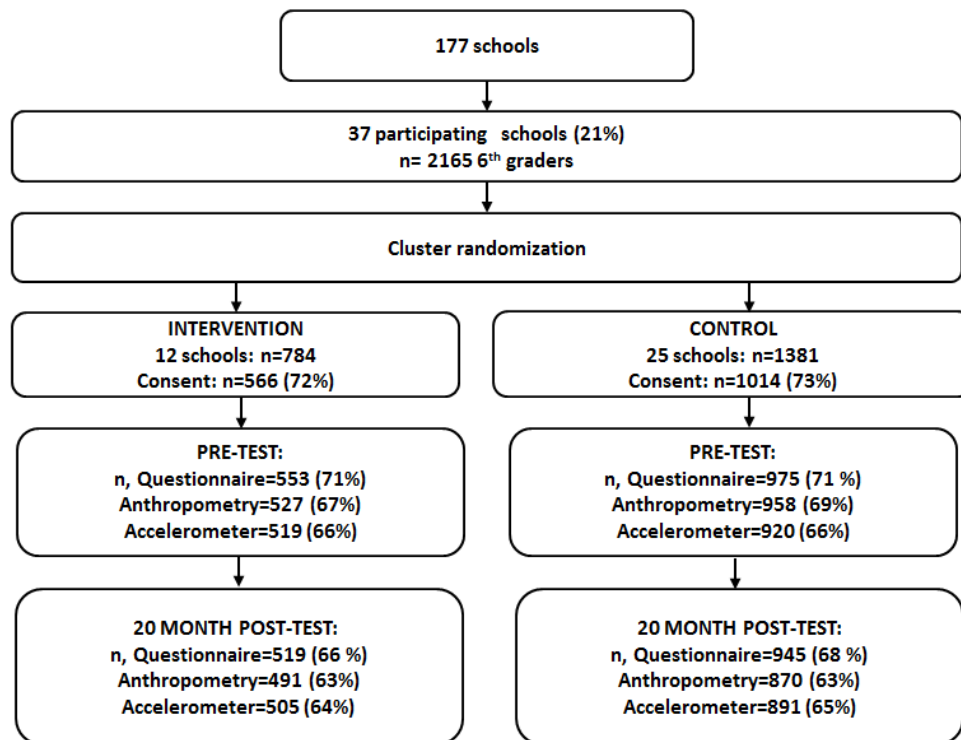
Figure 3 Flow diagram of recruitment, randomization and participation of adolescents in the HEIA study

The data collection at baseline took place during four weeks in September 2007 and was repeated post intervention in May 2009. The study timeline is illustrated in Figure 4. Three research teams of four people each, visited one school per day to collect the data. A mid-way data collection (after 8 months, May 2008), consisted of the internet-based questionnaire only, and are not further commented on in this thesis. All members of the research staff were trained prior to the data collections, and measurements were performed according to standard procedures (Lien et al., 2010). On the day of the survey the participating adolescents took part in an examination of anthropometric measures, filled in an internet-based questionnaire and a short paper questionnaire about pubertal

status. In addition, physical activity and sedentary time was measured objectively by accelerometers. Due to logistics, the accelerometer assessments were performed separately from the main survey and took place from September until the beginning of December 2007 and from March until the middle of May in 2009.
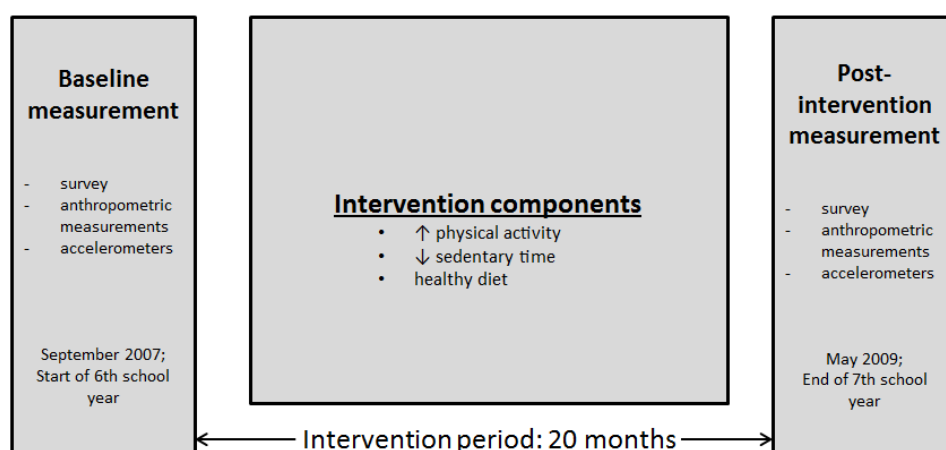
Figure 4 Timeline in the HEIA intervention study

A total of 1481 adolescents (94% of those 1580 returning consent) provided anthropometric measures (numbers based on BMI) and completed the survey at baseline, and 1361 did so at post intervention. Complete anthropometric data at both data assessments were provided by 1324 participants **(Paper III)**. At baseline and post intervention, 1439 and 1396 accelerometers were handed out, respectively. Valid accelerometer data was provided by 1129 adolescents at baseline **(Paper I)** and by 892 adolescents at the post intervention survey. Reasons for not being included in the accelerometer analysis were: not wearing the accelerometer (BL n=40, PI n=121), failing to achieve at least three days of assessment (including at least one weekend day) (BL n=247, PI n=378) and instrument malfunction (BL n=23, PI n=5). Complete accelerometer data at both data assessments were provided by 700 participants **(Paper II)**. In paper 2 and 3 only participants with complete data at both surveys were included in the main analyses. Drop out analyses were performed to investigate sample differences. No differences in anthropometric data, weight status or parental education were observed between children with and without valid accelerometer data, but there were more boys in the group without accelerometer data and complete anthropometric data **(Papers I** and **II)**. The participants lost to follow-up in **Paper III** (n=52) weighed more and had a higher BMI than the investigated sample (n=1324), but no other differences were detected.

According to WHO, 11 to 13-year-olds are defined as adolescents (World Health Organization, 1986). The term adolescents is used to describe the participants in the HEIA study, however, in **Paper III** the term children is used for the same participants, by request of the reviewers of that paper.

2.1.1 Power calculations

The power calculations were primarily based on the main outcome of the HEIA study; changes in BMI, and secondary changes in the addressed behaviors; intake of fruit, vegetables and soft drinks and physical activity (Lien et al., 2010). Taking the cluster effect of randomly assigning schools to intervention and control into account, assuming that 80% of the pupils would take part, an attrition rate of maximum 15% per year, we aimed for 40 schools with an average of 45 pupils participating from each school (n=1800). The final sample was lower (n=1580), but the attrition rate per year was only 4 %. We concluded that the final sample should have power enough to detect a difference between intervention and control schools of 0.72 kg/m^2 in BMI after 2 years. For accelerometer assessed physical activity, the power analyses were based on figures from a nationally representative population study on 9- and 15-year olds (Kolle, Steene-Johannessen, Andersen, & Anderssen, 2010). According to the calculations, the study should have power to detect a difference between intervention and control group of 62 cpm.

2.2 Measures

2.2.1 Anthropometry

We measured the participants height to the nearest 0.1 cm, using a wall-mounted tape with the child standing upright against the wall without shoes. The adolescents' weight was measured with light clothing (e.g. t-shirt and underwear) to the nearest 0.1 kg using a Tanita scale (Tanita TBF-300, Tanita Corporation of America, Illinois, USA). Waist circumference was measured to the nearest 0.1 cm by a measuring tape between the lower rib and the iliac crest at the end of a normal expiration. The adolescent was standing with straight posture, relaxed arms and with body weight equally distributed on both legs. BMI was calculated as weight/(height x height) (kg/m^2). BMI-for-age and sex z-score was calculated by adapting syntaxes for SPSS provided by the WHO available at www.who.int/growthref/tools/en (de Onis et al., 2007). The age- and gender specific BMI cut-off values proposed by the IOTF (Cole et al., 2000) were used to categorize the adolescents as normal weight or overweight/obese. Only 1.8% of the participants at baseline were obese and they were collapsed with the overweight in the analyses. Waist-to-height ratio (WTHR) was calculated as the ratio of waist (cm) to height (cm). A reliability study of the anthropometric measures was conducted prior to the survey among 114 adolescents. Pearson's test-retest average was moderate to high for

all items used in this thesis; intra-class correlation (ICC) and Pearson's r=0.76-0.99, p<0.001 (Appendix 1) (Lien et al., 2010).

The adolescents were asked to self-report their pubertal status by a separate and sex-specific paper questionnaire at the end of the data collection. The questionnaire was based on the Pubertal Category Scores (Carskadon & Acebo, 1993). Boys were asked about body hair growth, voice change and facial hair growth. Girls were asked about body hair growth, breast development and menarche. The adolescents were categorized into five puberty categories; pre-pubertal (1), early pubertal (2), mid-pubertal (3), late pubertal (4) and post-pubertal (5). For the analyses, the three last categories were collapsed into one because of low numbers in the latter, resulting in 3 categories: pre (1), early (2), mid/late/post pubertal (3). Test-retest reliability was moderate to high for all items, except voice change in boys; Pearson's r=0.38, p=0.006 (Appendix 1).

2.2.2 Physical activity and sedentary time

Physical activity and sedentary time was assessed objectively by accelerometers (ActiGraph model 7164 and GT1M, Fort Walton Beach, FL, USA). The participants were instructed to wear the accelerometers all waking hours for five consecutive days except when doing water activities (monitors are not waterproof, water activities were ignored). The output was sampled every 10 seconds for 2 weekdays and 2 weekend days. The registration was set to start at 6 AM on the day following distribution to avoid excessive activity likely to occur during the first day of wearing such a device.

After collecting the accelerometer, the stored activity counts were downloaded to a computer and analyzed by the custom made software programs named "CSA-analyzer" (http://csa.svenssonsport.dk) and Propero (University of Southern Denmark). In the analyses of accelerometer data only daytime activity (06:00-24:00 hours) was included. Sequences of 20 min or more of consecutive zero counts were interpreted to represent non-wear-time and were excluded from each individuals recording. Activity had to be registered for a minimum of three days (including at least one weekend day) and at least for 8 hours (480 min) each day to be included in the analyses.

The registered activity counts were averaged over minutes of valid wear time in order to calculate counts per minute (cpm). This is an indicator of overall physical activity that shows good agreement with physical activity energy expenditure measured by the doubly-labeled water method (Ekelund et al., 2001). Since outcomes on mean cpm (mcpm) measured by model 7164 and GT1M have been shown to differ (Corder et al., 2007), a free-living validation study of the monitors used in the HEIA study was conducted (outlined in point 2.5 Validation study – **Paper IV**). The validation study revealed 11,6% higher total mcpm from the model 7164 than from the GT1M. Consequently, a

correction factor of 0.9 was applied to the total mcpm from model 7164 (**Papers I** and **II**). This adjustment is also in accordance with the results from Corder et al (2007).

Sedentary time was defined as time spent at intensities less than 100 cpm and expressed as minutes/day of accelerometer activity measured, which equals the intensity of sitting or lying down (<1.5 MET) (Pate et al., 2008). Activity recordings at intensities between 100-2000 cpm were defined as light activity, reflecting activities such as standing, walking slowly or easy play. Activity recordings from 2000-6000 cpm were defined as moderate intensity, and from 6000 cpm and over was defined as vigorous intensity. Moderate-to-vigorous physical activity (MVPA) was defined as all activity at intensities from 2000 cpm and above. This threshold is approximately equivalent to a walking pace of 4 km/h in youth (Trost et al., 1998). These cut off points have also been used in previous studies (Cain et al., 2012; The Norwegian Directorate of Health, 2012). Sedentary time, light activity and MVPA were expressed as min/day of accelerometer activity measured. Time spent in activity of a defined intensity was determined by summing total minutes where the count met the criterion for that intensity, divided by the number of valid days of recording, giving an average (min/day) across the assessment period.

In **Paper II** participants with mcpm below the median value (mcpm=480) at baseline were categorized as "low-activity group" and participants above median as "high-activity group".

The proportion of participants who achieved the recommended 60 minutes of daily MVPA was established by dividing total time in MVPA (min) by the number of valid days of recording, giving an average across the assessment period (minutes/day).

2.2.3 Diet

Dietary behaviors were assessed by an internet based questionnaire (QuestBack). The questionnaire comprised mostly questions with pre-coded answer categories and could be completed in about 45 minutes. Only the questions used in **Paper I** will be further described in this thesis. The questions were mostly modified from existing questionnaires. Test-retest reliability of these self-reported behavioral outcomes showed moderate to high correlation (Pearson's r=0.46-0.78, p<0.001) (Appendix 1) and are further described elsewhere (Lien et al., 2010).

Intake of sugar-sweetened beverages was assessed by frequency (six categories; from never/seldom to every weekday) and amount (in glasses; from one glass to four glasses or more) for weekdays, and by amount for weekends (in glasses; eight categories; from never/seldom to seven glasses or more). Weekends were defined as Saturday and Sunday. In the questionnaire it was stated that 0.5 l of beverage was equal to three glasses, making one glass equal to 1.67 dl. Intake of snacks was assessed

by four questions; how often do you eat chocolate/candy, salty snacks, cookies and buns/cakes/pastry with seven response categories from never/seldom to twice a day or more. All variables were recoded into frequency of intake per week by using the midpoints of the categories (making 1-2 times a week equal 1.5 times per week) and summed into a sum of snacks variable. Breakfast consumption was assessed by the question; how often do you eat breakfast, with nine response categories ranging from never to every day. Since 90% of the responses were "every day", this variable was recoded to a dichotomous variable; eats breakfast every day or not.

2.2.4 Sedentary behaviors – screen time

Sedentary behaviors were assessed as time spent in front of an electronic screen by the same internet based questionnaire as described above. Two questions assessed hours of daily TV-watching (including DVD) and use of computer/electronic games on weekdays and weekends separately, each question with six response categories ranging from 0.5-5 and from 0-4 hours respectively. Test-retest reliability of these self-reported behavioral outcomes showed moderate to high correlation (Pearson's r=0.56-0.72, p<0.001) (Appendix 1).

2.2.5 Parental education

As part of the informed consent, self-reported information about parental education was collected for both mothers and fathers. This resulted in data on parental education from nearly the total sample returning a positive consent to participation (97%) (n=1527). Parental education was categorized into three levels: 12 years or less of total education, between 13 and 16 years, and 16 years or more. The information about education from the parent with the longest education was used in the analyses, or else the one available.

2.3 The intervention – settings, components and evaluation

The intervention components are outlined in Table 1. The main deliverers of the intervention components were the school teachers. Therefore, we held a kick-off meeting in the beginning of each school-year to inform and inspire the teachers to perform the implementation of the components. By request from the teachers, they received an e-mail each month from the study group giving reminders of the intervention content of the month. Questions from the teachers were highly prioritized by the study group to assure implementation and devotion.

Table 1 The HEIA study: Intervention components implemented in 6th and 7th grade in 12 Norwegian schools in 2007/08 and 2008/09.

Setting/arena	What	Timing	Purpose
Class (Initiated by classroom-teachers)	**Lessons with student booklet:** 1. Diet and physical activity 2. Meals 3. 5 a day 4. Sugar rich beverages 5. Your choice	Once a month - 6th grade winter/spring	Increase awareness of behavior-health relationship, recommended intake levels and own intake.
	Posters for classrooms - key messages, A4-size, placed on a larger "frame-poster" including the HEIA logo	Monthly - throughout the intervention	As a daily reminder of main messages (topic matched fact sheets to parents).
	Fruit and vegetable (FV) break - cutting equipment per class provided, students brought FV	Once a week –throughout the intervention	Increase FV intake; cut, serve, taste and eat FV with class mates.
	Physical activity (PA) break - 10 minutes of PA conducted in regular classrooms, booklet with ideas and CD provided	Once a week – throughout the intervention	Increase PA; introduce PA also outside of PE and by classroom-teachers.
	Sports equipment for recess activities - 1-2 large boxes per school. Examples of content: Frisbees, jump-ropes, elastic bands, hockey-sticks, a variety of balls	Every day - throughout the intervention (some refill in 7th grade)	Increase PA; stimulate PA during recess – especially among those who do not play ball games.
	Active commuting campaigns - Register days with active transport to/from school for 3 weeks (5 campaigns)	5 x 3 weeks: 6th grade: fall, winter and spring 7th grade: fall, winter	Increase PA; stimulate activity.
	Pedometer: - one class-set per school to be used in PE (SPARK), as tasks at school, as home assignment and active commuting	7th grade	Increase awareness about PA level; stimulate activity.
	Computer tailored individual advice 1. Fruit 2. Vegetables 3. Physical activity 4. Screen time 5. Sugar sweetened beverages + one-week action plans for each topic (instruction on	7th grade Fall Fall Winter/spring Winter/spring Winter/spring	Increase awareness of; - recommended intake and PA level - own intake of FV, PA level and hours of screen time Received personal advice about what and how to change.

	what, where and when to do the suggestions for behavior change)		
Home/parents	**Fact sheets** Facts on targeted behaviors. Practical tasks/challenges for leisure time/weekends in 7th grade.	Monthly - throughout the intervention, one behavior per fact sheet	To stimulate parents to evaluate and change the home environment with regards to facilitating or regulating the targeted behaviors.
	Brochures/information sheets Teachers were provided info sheets about the FV break that they could use to inform parents about these.	Once	To ensure that the fact sheets were read and discussed/applied to the home environment.
	Brochures: - "Cutting FV" - "Meals – a value worth fighting for". Handed out together with related fact sheets	Once	To provide knowledge and inspiration.
School-wide	**Kick-off meetings at each school** - Teacher manuals presented, practical activities tested, material partially provided	Once a year - 6th and 7th grade (fall), 2-3 hours each time	To inform the school management, teachers, school nurse and parent committees about the project and establish/inform the grade level teachers as the "HEIA team" at school.
	Inspirational courses for PE teachers - SPARK ideas/principles (Sallis et al., 1993)	Once a year - 6th and 7th grade (fall), 6 hours each time	Teacher training for PE teachers; methods /activities to increase activity time, enjoyment and self-efficacy for all students during PE classes.
	Resource box for school management - Offer to order free toolbox for cutting and selling FV	Optional	Focus on healthy food/drinks offered in school/during school events.
	Committee meetings - Meetings with school environment groups/parent committees	Optional	Aimed to stimulate easy-to-do changes on the school grounds that could stimulate activity (booklet/ideas provided). Increase awareness of healthy foods and beverages.
Leisure time activities (NGO's)	**Information folder and offer to receive a resource box with equipment for cutting and selling FV**	7th grade (fall)	Create awareness about leisure time activity leaders as role models for dietary habits, to reflect upon availability of food/drinks during practices and events (e.g. tournaments, weekend training sessions, etc.).

FV: fruits and vegetables, PA: physical activity, PE: physical education, NGO: non-governmental organization.

Briefly, the teachers were responsible for holding six lectures on energy balance and promoting a healthy diet to the students structured by a custom made HEIA-leaflet handed out to each participant (at 6th grade only). The teachers were also responsible for initiating classroom "HEIA-fruits&greens-breaks"; a break during class at least once a week where cut fruits and vegetables were served and "HEIA-activity-breaks"; a 10 minute physical activity break during class at least once a week. Further; hanging up "HEIA-posters" in the classrooms, carrying out active commuting campaigns, handing out fact sheets to parents once a month (including student-parent tasks in 7th grade) and implementing a computer tailored individual advise program (Ezendam, Brug, & Oenema, 2012)(in 7th grade only) for the students. The intervention schools received an "Activity-box" with sports equipment and toys (such as a variety of balls, hockey-sticks, jump-ropes, Frisbees' etc.) to promote physical activity during recess. The teachers received two inspirational courses in physical education (PE) based on the SPARK program (Sallis et al., 1993) to encourage high intensity and enjoyment for all during PE, one in 6th grade and one in 7th grade. The intention to collaborate with the local leisure time organizations did not work out and cannot be regarded as an intervention component as intended.

To test the implementation of the intervention components process evaluation of both the teachers and the participants were performed after 8 months and 20 months of intervention. This was assessed by self-administered questionnaires for the participants, their parents and the teachers. However, these data have not yet been analyzed, and only some rough estimates of implementation are available (Bergh et al., 2012a; Bjelland, 2011).

2.4 Statistics

Clustering effects due to schools being the unit of recruitment were checked by Linear Mixed Model procedure for the various outcome variables. For the adolescent's BMI and waist circumference only 2% of the unexplained variation was on group level. If there is no meaningful difference among groups when quantifying degree of clustering, data may be analyzed at individual level (Tabaknick & Fidell, 2007; Heck, Thomas, & Tabata, 2010). Additionally, students in Norwegian primary and secondary education are no longer organized by classes (but in larger and smaller groups varying by study subject) (Norwegian Education Act, 2003). Clustering effects of class and school were therefore not included in the analyses in **Papers I** and **III**. However, for accelerometer assessed physical activity **(Paper II)** the unexplained variance due to schools was >5% and multi-level analyses were performed to account for the clustering effect of schools. With respect to the effect analyses **(Papers II** and **III)**, per protocol and dropout analyses were *a priori* chosen over intention-to-treat analyses.

In general, participants' characteristics at baseline were presented as means and standard deviations (SD), unless otherwise stated. Continuous variables were tested for differences between groups with independent sample t-tests, and categorical variables were tested by chi-square tests. Paired samples t-test was used to test differences in continuous variables between weekdays and weekend days, and day parts (school hours/after school hours) **(Paper I-III)**.

The associations of the modifiable correlates with weight category in **Paper I** (normal weight/ overweight; above/below cut-off) were analyzed by univariate and multiple logistic regression by the Forced Entry Method, in which gender and pubertal status were controlled for. Variables that were associated with weight status at a $p<0.10$ in the univariate analyses were entered in the final model. The results were presented as crude and adjusted odds ratios (OR) with 95% confidence intervals (CI). To test whether gender or parental education level moderated these associations, interactions between gender and education level and each factor were tested separately in the model. Significant interactions were further inspected by rerunning the main analyses stratified on the significant moderator.

In **Paper II,** the effect analyses were conducted in linear mixed models where the clustering effect of school (11%) was controlled for. The effect was estimated by a regression of post-test values of mcpm (or other outcome variables) on condition, adjusted for grand mean centered baseline values of mcpm (or other outcome variables). All effect analyses were adjusted for covariates and confounders; gender, pubertal status, weight status, month of measuring physical activity and parental education. In the main effect analyses a few extreme outliers were replaced by the mean value + 3SD as suggested by Field (Field A, 2009). *A priori* defined subgroup analyses were performed by gender, weight category, activity category and by parental education category to explore potential differences in effect of the intervention by these subgroups.

In **Paper III,** the effect of the intervention was determined using one-way analysis of co-variance (ANCOVA) with the post-intervention value for the outcomes as the dependent variables (continuous variables), baseline values of the outcomes as covariates and group (intervention vs. control) as the independent variable. The same technique was used for categorical outcomes using logistic regressions. Interaction effects by gender, pubertal status and parental educational level were tested in separate analyses as a second step using two-way ANCOVA/logistic regressions with the interaction terms as covariates. Significant interactions were explored by rerunning the analyses stratified on the moderator.

The significance level was set to $p<0.05$ for all analyses, except for interaction analyses: $p<0.10$ (Stone-Romero & Liakhovsitski, 2002). Data were analyzed using the IBM SPSS Statistics 18 (IBM Corp., New York, NY, USA).

2.5 Validation study – Paper IV

Initially, when the HEIA study accelerometer assessments were planned and performed, the study group had the notion that the results from the different generations of ActiGraph accelerometers were comparable. Therefore, the two ActiGraph models AM7164 and GT1M were used interchangeably to assess physical activity. However, baseline outputs from 676 children (mean age 11. 2 years, SD=0.3) wearing the older ActiGraph model AM7164 showed significantly higher mcpm than 453 equal age children wearing the GT1M. Outputs from the AM7164 showed an average of 587 cpm (SD=189) and GT1M showed 488 cpm (SD=158), p<0,001. There were no differences between these two groups of participants in anthropometric data, socio-demographic data or physical activity measured by questionnaire. To test whether this difference was substantial or an methodological artifact of the monitors we conducted a validation study **(Paper IV)** comparing outputs from three generations of ActiGraph accelerometers worn simultaneously; the model AM7164, GT1M and GT3X+. The aim was to compare the three ActiGraph accelerometer generations: AM7164, GT1M and GT3X+ when assessing physical activity in children in a free-living condition.

2.5.1 Study design and participants

Eighteen accelerometers of each model AM7164 and GT1M used in the HEIA study were randomly picked out to be used in this validation study. An additional 18 of the newer GT3X+ was also used, and all 54 monitors were inspected for malfunctions.

A sample of 36 children (mean age 9.9 y, SD = 0.3) were recruited to participate in the study. The participants were randomly selected from the then ongoing "ungKan2" study (described elsewhere; (The Norwegian Directorate of Health, 2012)). The children were informed about the study and parents provided written informed consent to participation. Anthropometry was assessed by standard procedures.

The accelerometers were attached in triplets to a waist-worn elastic belt and mounted onto the children's waist at the right hip (crest iliaca). The placement of each accelerometer model was rotated and counterbalanced to avoid any potential order or placement effects. The monitors were initialized to assess activity in ten seconds epochs, and to start recording at the same time point. The children were instructed to wear the accelerometers for seven consecutive days, and only to remove the belt during night and water-activities. Since the hardware capacity of the AM7164 is limited to nearly four days at this sampling frequency, the accelerometer outputs from the first three days were used in the comparison. (Seven days of monitoring were used due the study protocol in the

ungKan2-study). The study was organized using the 18 x 3 monitors in two rounds. In the validation study we chose data processing settings to match the HEIA study and thereby described above.

2.5.2 Statistics

The participants' characteristics were presented as means and standard deviations (SD). Between monitor-agreement was evaluated by calculating ICC coefficients using a two-way mixed-model analysis of variance (ANOVA) with the assumption of absolute agreement. Bland Altman plots were produced to investigate differences between the monitor outputs. All statistical analyses were performed using IBM SPSS version 18 (SPSS Inc., Chicago IL, USA), and a two-tailed alpha level of 0.05 was used for statistical significance.

2.6 Ethical issues

Procedures and methods used in the present study are in line with the ethical guidelines for medical research defined by the World Medical Association's Declaration of Helsinki. Ethical approval and research clearance was obtained from the Regional Committees for Medical Research Ethics in Norway and from the Norwegian Social Science Data Service. Information about the study objectives and data assessments was distributed to all involved parties, and written consent was obtained from the participants' parents/guardians prior to participation. The participants were free to withdraw from the measurements at any time, without explanation. The study staff was trained according to standard procedure prior to the data assessments, and issues regarding respect and privacy of the participants were emphasized.

3. Summary of results

The following section briefly summarizes the main findings in **Papers I-IV**. For details, the reader is referred to the original papers (included at the end of the thesis).

Participants' characteristics

In **Papers I-III,** the average (SD) age for the total sample at baseline was 11.2 (0.3) years. At baseline, 13% of the participants were classified as overweight/obese, leaving 87% to be normal weight. For **Paper IV** the average (SD) age was 9.9 (0.3) years. Participants' characteristics at baseline for **Papers I-IV** are outlined in Table 2. At baseline, 59% of the participants in the HEIA study met the guidelines of physical activity, achieving the recommended 60 minutes of daily MVPA (n=1129).

Table 2 Descriptive characteristics' for the participants in **Papers I-IV**. Values are mean (SD).

Paper	Participants (n)	Weight (kg)	Height (cm)	BMI (kg/m^2)
I	Total: 1103	39.8 (8.0)	148.7 (7.0)	17.9 (2.7)
	Girls: 555	40.3 (8.1)	149.2 (7.3)	18.0 (2.7)
	Boys: 548	39.2 (7.9)	148.1 (6.6)	17.8 (2.7)
II	Total: 684	39.9 (8.0)	148.7 (6.9)	18.0 (2.7)
	I: 204	40.1 (8.1)	148.7 (6.7)	18.0 (2.8)
	C: 480	39.8 (8.0)	148.6 (6.9)	17.9 (2.7)
	Girls: 384	40.6 (8.2)	149.2 (7.1)	18.1 (2.7)
	Boys: 300	39.1 (7.8)	148.0 (6.5)	17.8 (2.7)
III	Total: 1324	39.7 (7.8)	148.6 (6.8)	17.9 (2.6)
	I: 465	39.5 (7.6)	148.6 (6.7)	17.8 (2.5)
	C: 859	39.8 (7.8)	148.5 (6.8)	17.9 (2.6)
	Girls: 643	40.2 (7.9)	149.0 (7.2)	18.0 (2.6)
	Boys: 681	39.2 (7.6)	148.2 (6.4)	17.8 (2.6)
IV	Total: 18	35.1 (5.0)	139.6 (4.6)	18.0 (2.2)

I: intervention, C: control group.

Paper I

There were no differences between genders regarding BMI, weight status or for parental education. There were significant differences between genders in consumption of sugar-sweetened beverages and snacks, watching TV, playing electronic/computer games, total physical activity and MVPA, where boys' averages were higher than girls' averages for all outcomes. Categorized by weight status, more normal weight than overweight participants reported having daily breakfast. Overweight adolescents spent more time watching TV and playing computer games than normal

weight adolescents. Normal weight adolescents showed less sedentary time, more MVPA and total physical activity than the overweight. A highly significant difference was seen for parental education (p<0.001), with parents of overweight adolescents having less education than parents of normal weight adolescents.

Crude and adjusted logistic regressions for the factors potentially associated with weight status showed that having daily breakfast was associated with weight status, both separately (OR 2.0, p=0.01) and adjusted for the other factors (OR 1.78, p=0.045). Both hours spent watching TV and playing electronic/computer games were positively associated with being overweight in the univariate analyses (p<0.001). In the adjusted model only watching TV remained associated with being overweight, with a 40% increased risk of being overweight with every additional hour of watching TV per day (p=0.001). Whereas MVPA was negatively associated with being overweight in the adjusted model (p=0.01), objectively measured sedentary time was not associated with being overweight. Adolescents with parents in the highest education category (>16 years) had a 46% reduced odds of being overweight compared to adolescents with parents in the lowest education category (≤12 years) (p=0.02). Adolescents of parents with medium education (13-16 years) had 42% lower odds of being overweight than adolescents of parents with the lowest education category.

Investigating whether gender moderated these associations, interactions between gender and each of the factors in the multiple model were tested. The only significant interaction was between gender and watching TV; OR 1.75 (CI 1.50, 2.65) p=0.009. Sub-group analyses by gender revealed that the association between weight status and watching TV was highly significant for boys (OR 2.1 (95% CI 1.58, 2.73) p<0.001) but not for girls (OR 1.2 (95% CI 0.90, 1.53) p=0.23). Parental education did not moderate the investigated associations.

Paper II

There were no significant differences between the intervention and control group at baseline for anthropometry, pubertal status or parental education.

Table 3 shows physical activity at baseline and post intervention, and intervention effects. The intervention had an effect on total physical activity at the level of p=0.05, with a net effect between intervention and control of 50 cpm in favour of the intervention group (95% Confidence Interval -0.4, 100). The subgroup analyses indicated a significant effect in girls (p<0.03) but not in boys (p=0.35).

Table 3 Physical activity (mcpm and SD) in the HEIA intervention- (n=215) and control group (n=485), and intervention effect (Estimate and 95% CI)*

Mcpm	BASELINE		POST-INTERVENTION		INTERVENTION	
	Control	Intervention	Control	Intervention	EFFECT*	p
All (n=700)	511 (146)	473 (146)**	564 (255)	570 (252)	50 (-0.4, 100)	**0.05**
Girls (n=392)	478 (128)	464 (151)	506 (230)	535 (234)	65 (5, 124)	**0.03**
Boys (n=308)	549 (157)	488 (137)**	632 (268)	622 (268)	32 (-35, 99)	0.35

* Effect analyses were adjusted for school clustering, baseline physical activity, gender, pubertal status, month of measuring physical activity, weight category and parental education. ** Intervention group mean significantly lower than control group mean, p<0.01. Test of interaction condition x gender: p=0.22. Mcpm, mean count per minute.

By investigating change in physical activity pertaining to intensity levels, we found that both groups had an increase in time spent sedentary from age 11 to 13. There was no significant intervention effect for time spent sedentary between the intervention group and the control group (p=0.16). Stratified gender analyses revealed a significant intervention effect for girls of -22 (CI -43, -2, p=0.03) minutes for time spent sedentary, reflecting a significantly smaller increase in sedentary time among girls in the intervention group versus the control group. No similar effect was seen among boys. For light activity and MVPA no significant effects were seen.

When the participants were grouped by baseline activity level we found a significant overall positive intervention effect of net 92 cpm (CI 41, 142, p<0.001) in the low activity group, while no effect was seen in the high activity group. Categorized by weight status, the analyses showed that the normal weight in the intervention group increased their physical activity significantly more than the normal weight in the control group, with a net increase of 62 cpm (CI 10, 115, p=0.02).

Finally, effect analyses were also run for participants stratified by level of parental education. There were no intervention effects for participants with parents having less than twelve years of education and for participants with parents having more than 16 years of education. However, for participants with parents in the middle parental education level category (13-16 years of education), we found a significant intervention effect on overall physical activity level (Effect estimate 98 (CI 17, 178) p=0.02) in favour of the intervention group.

Paper III

There were no significant differences between the intervention and control groups at baseline with respect to age, gender, weight, height, pubertal status and parental education, nor for estimates of body composition (outlined for descriptive purposes in Table 4).

For the total sample, there were no significant intervention effects on any of the body composition estimates outlined in Table 4, or for weight status: OR 1.6 (95%CI 0.9 – 2.7), p=0.1. Gender was identified as a moderator of the intervention effects on BMI (p=0.02), BMIz (p<0.01), WC (p=0.05) and WTHR (p=0.05). The effect on BMI was also moderated by parental education (p=0.04), likewise the effect on WTHR (p=0.06). No moderating effects of pubertal status were detected. After stratification, there was a significant intervention effect on BMI and BMIz for girls only; girls in the intervention group increased less on BMI compared to the control group. For WC and WTHR there was no significant intervention effect for either gender after stratification. Furthermore, a beneficial intervention effect on BMI among the participants of parents with high education was found, but no effect was detected among participants of parents with medium or low education. For WTHR a negative effect was found among participants of parents with low education.

Table 4 Anthropometric outcomes at baseline (mean and SD) and post-intervention effects (mean and 95% CI) of the HEIA intervention- (n=465) and control group (n=859); total sample, by gender and parental education.

| | BASELINE | | POST-INTERVENTION | | |
| | Control | Intervention | Control | Intervention | |
	Mean (SD)	Mean (SD)	Mean (95% CI)	Mean (95% CI)	p
BMI, total sample	17.9 (2.6)	17.8 (2.5)	18.9 (18.8, 18.9)	18.8 (18.7, 18.9)	0.501
Gender:					
- girls	17.9 (2.6)	18.1 (2.6)	19.2 (19.1, 19.3)	19.0 (18.8, 19.3)	**0.024**
- boys	17.9 (2.7)	17.4 (2.4)	18.5 (18.4, 18.6)	18.6 (18.5, 18.7)	0.306
Parental education:					
-low	18.2 (2.8)	18.3 (3.0)	19.3 (19.1, 19.4)	19.4 (19.2, 19.7)	0.189
-medium	17.9 (2.6)	17.5 (2.3)	18.7 (18.6, 18.8)	18.7 (18.5, 18.8)	0.742
-high	17.7 (2.3)	17.6 (2.3)	18.6 (18.5, 18.8)	18.4 (18.2, 18.6)	**0.027**
BMIz, total sample	0.13 (1.08)	0.06 (1.03)	-0.01 (-0.04, 0.02)	-0.04 (-0.09, 0.00)	0.227
Gender:					
- girls	0.05 (1.02)	0.12 (1.00)	0.03 (-0.01, 0.08)	-0.8 (-0.14, -0.02)	**0.003**
- boys	0.19 (1.13)	-0.00 (1.07)	-0.05 (-0.09, -0.00)	-0.01 (-0.07, 0.05)	0.322
WC, total sample	63.3 (6.5)	62.7 (6.1)	66.2 (66.0, 66.5)	66.4 (66.0, 66.7)	0.502
Gender:					
- girls	62.0 (6.2)	62.5 (6.1)	66.0 (66.0, 66.3)	65.7 (65.3, 66.1)	0.279
- boys	64.4 (6.6)	62.8 (6.0)	66.4 (66.1, 67.5)	67.0 (66.5, 67.5)	0.089
WTHR, total sample	0.43 (0.04)	0.42 (0.04)	0.416 (0.415, 0.418)	0.418 (0.415, 0.420)	0.412
Gender:					
- girls	0.42 (0.04)	0.42 (0.04)	0.414 (0.412, 0.416)	0.413 (0.416, 0.421)	0.344
- boys	0.43 (0.04)	0.42 (0.04)	0.419 (0.416, 0.421)	0.422 (0.419, 0.425)	0.089
Parental education:					
-low	0.43 (0.04)	0.43 (0.04)	0.420 (0.417, 0.423)	0.426 (0.422, 0.430)	**0.020**
-medium	0.43 (0.04)	0.42 (0.03)	0.417 (0.414, 0.419)	0.415 (0.412, 0.419)	0.484
-high	0.42 (0.04)	0.41 (0.03)	0.413 (0.410, 0.416)	0.413 (0.410, 0.416)	0.978

Intervention effects determined by ANCOVA adjusted for baseline value, WC: waist circumference, WTHR: waist-to-height-ratio. Test of interaction gender x BMI (p=0.02), gender x BMIz (p<0.01), gender x WC (p=0.05), gender x WTHR (p=0.05), parental education x BMI (p=0.04), parental education x WTHR (p=0.06).

Paper IV

A total of 16 participants provided data from all three monitors for at least 3 days and are included in the analyses. Table 5 shows descriptive outputs from the three generation monitors in total physical activity (mcpm), mean wear time and time spent at different intensity categories.

Table 5 Outputs from the AM7164, GT1M and GT3X+ among 16 Norwegian 9-year-olds.

Mean (SD) (n=16)	AM7164	GT1M	GT3X+
Wear-time (accepted minutes/day)	767.7 (69.7)	759.7 (69.7)	761.9 (69.8)
Total physical activity (cpm)	821.5 (287.3)	735.3 (245.1)	750.6 (260.4)
Time spent at intensities:			
Sedentary activity <100 cpm	429.9 (72.0)	456.9 (72.8)	455.5 (75.6)
Light activity 100<2000 cpm	249.3 (41.5)	221.7 (48.9)	222.6 (45.5)
Moderate act. 2000<6000 cpm	71.5 (27.3)	69.4 (28.0)	71.7 (28.2)
Vigorous act. ≥6000 cpm	17.0 (9.1)	11.6 (7.6)	12.1 (8.0)
MVPA ≥2000 cpm	88.5 (33.0)	81.0 (30.2)	83.8 (31.3)

Cpm: counts per minute, MVPA: moderate to vigorous physical activity.

The intra-class correlation for the three generation monitors assessing overall physical activity (mcpm) was 0.985 (95% CI=0.898, 0.996). The agreement between each monitor generation when assessing overall physical activity and time spent at different intensities is shown in Table 6. All correlations were highly significant (p<0.001). When comparing activity counts categorized into intensity levels the accelerometers showed diverging results (Table 6). A negative relationship was seen for sedentary time, and positive relationships were seen for the higher intensities. The greatest mean difference between monitor outputs was found in the highest intensity level, where the participants accumulate the least amount of counts.

Bland–Altman plots (Figure 1 in **Paper IV**) showed that observations assessed by the AM7164 for total physical activity on average were 11.6% higher than observations assessed by GT1M (p<0.001) and 9.8% higher than GT3X+ (p<0.001). A correction factor of 0.9 is suggested when results on mcpm from AM7164 are compared with results from GT1M and GT3X+ (mcpm GT1M=mcpm AM7164 · 0.9 and mcpm GT3X+=mcpm AM7164 · 0.9). The output of total physical activity assessed by GT3X+ was 2.1% higher than the output from GT1M, but this was a non-significant difference.

Table 6 Agreement between outputs from AM7164, GT1M and GT3X+ in mcpm and time spent at different intensities (minutes/day).

	Mean difference in %*	ICC (95% CI)
Total physical activity (mcpm)		
Model 7164 – GT1M	11.7	.961 (0.368, 0.991)
Model 7164 - GT3X+	9.4	.977 (0.387, 0.995)
GT1M - GT3X+	2.1	.995 (0.984, 0.998)
Sedentary activity <100 cpm		
Model 7164 – GT1M	-5.9	.951 (0.189, 0.989)
Model 7164 - GT3X+	-5.6	.956 (0.289, 0.990)
GT1M - GT3X+	-0.3	.994 (0.982, 0.998)
Light activity 100 <2000 cpm		
Model 7164 – GT1M	12.4	.880 (-0.105, 0.973)
Model 7164 - GT3X+	12.0	.865 (-0.060, 0.968)
GT1M - GT3X+	0.4	.993 (0.982, 0.998)
Moderate activity 2000<6000		
Model 7164 – GT1M	3.0	.979 (0.943, 0.993)
Model 7164 - GT3X+	-0.3	.989 (0.967, 0.996)
GT1M - GT3X+	3.3	.990 (0.971, 0.997)
Vigorous activity ≥6000 cpm		
Model 7164 – GT1M	46.6	.876 (-0.133, 0.973)
Model 7164 - GT3X+	40.5	.893 (-0.067, 0.976)
GT1M - GT3X+	4.3	.991 (0.973, 0.997)
MVPA ≥ 2000 cpm		
Model 7164 – GT1M	9.3	.968 (0.799, 0.991)
Model 7164 - GT3X+	5.6	.985 (0.929, 0.996)
GT1M - GT3X+	3.5	.991 (0.970, 0.997)

All correlations are significant at the 0.001 level. Mcpm: mean count per minute, MVPA: moderate to vigorous physical activity. *Mean differences in percent are calculated based on the summed mean values.

4. Discussion

This thesis is built upon a large school-based cluster randomized controlled trial with a main aim to promote a healthy weight development among Norwegian 11 to 13 year olds **(Paper I-III)**, and a validation study of accelerometers assessing physical activity in 9-year-olds in a free-living condition **(Paper IV)**. In the following results from **Paper I-IV** will be discussed taking into account also methodological issues. Strengths and weaknesses of the studies are considered, and generalizability of the findings and implications for future research will then be dealt with. In the following paragraphs, the main findings in the total sample will first be discussed, followed by the more nuanced picture by subgroups.

4.1 Associations of weight status – Paper I

The main findings in this study were that level of parental education, daily breakfast consumption and MVPA were inversely associated with weight status. No associations were found between intake of sugar-sweetened beverages and snacks, playing computer games and weight status. Watching TV was positively associated with weight status for boys, but not for girls.

These results indicate that modifiable EBRB's such as breakfast consumption, MVPA and time spent watching TV are important factors to address in obesity prevention initiatives in this age group. The lack of association between sugar-sweetened beverages and weight status was surprising as this association repeatedly have been shown in other studies (Haug et al., 2009; Jansen et al., 2010; Overby et al., 2004), and WHO has suggested sugar-sweetened beverages as a probable contributor to obesity (World Health Organization, 2004). However, the lack of association could be a result of a relatively low intake in both groups. The results should be considered promising in a public health perspective, and they are in support of recent results showing a decline in sugar-sweetened beverages intake among Norwegian youth (Stea et al., 2012). Another promising result is that 90% of the 11-year olds in this study reported having breakfast every day. However, the proportion of participants that reported not eating breakfast daily was significantly higher among overweight than among normal weight. Nevertheless, given that daily breakfast consumption is inversely associated with weight status, it is still important to address this issue for both the normal weight and the overweight.

We chose to include MVPA and objectively assessed sedentary time (ST) in the main analysis. We did not include total physical activity (mcpm), as this variable was highly correlated to both MVPA and ST. However, when we repeated the analysis and replaced MVPA and ST with mcpm (Appendix 2) we also found a significant impact of total physical activity on weight status (p=0.04). This strengthens

our belief that it is important to increase total physical activity in obesity prevention among adolescents.

In the main analysis we adjusted for the non-modifiable factors gender, age and pubertal stage, and investigated the association of parental education and modifiable dietary-, sedentary and physical activity behaviors with weight status. Although significant associations were revealed, our final model explained only less than 10% of the variation of weight status in the population. Hence, regardless that we investigated factors that are considered key element behaviors in obesity prevention; the variance of several factors potentially important to the participants' weight status are left unexplained.

The prevalence of overweight and obese adolescents in the present study does not differ substantially from that found in recent studies of Norwegian adolescents (Andersen et al., 2005; Groholt et al., 2008; Kolle, Steene-Johannessen, Holme, Andersen, & Anderssen, 2009), but are higher than self-reported figures of Norwegian 11-year-olds in the HBSC-study (Haug et al., 2009). This could be due to possible underreporting in the HBSC-study, as such bias is a common problem of self-report in weight related outcomes (Himes, 2009). Some studies have suggested a deflating of the obesity epidemic in some countries (Lissner et al., 2010; Olds et al., 2011). The method of assessment of anthropometric measures and definition of weight status must be considered when evaluating these results (Kakinami et al., 2012; Himes, 2009).

4.2 Intervention effects – Papers II and III

In **Paper II** we found an intervention effect on total physical activity at the 5% alpha level for the total sample, with a net effect between intervention and control of 50 cpm in favour of the intervention group. Both intervention and control groups increased from baseline to post intervention. This was unexpected, as a decline in physical activity with increasing age is common at this age (Kolle et al., 2010; Riddoch et al., 2004). While the control group had a 10% increase in mcpm from age 11 to 13, the intervention group increased by 20.5%. With an effect at alpha level 0.05 there is a degree of uncertainty to the results that needs to be considered. There is a 5% chance that the findings are not attributed to the intervention, which means the greatest value of uncertainty conventionally accepted before the findings are dismissed as non-significant. The sample providing valid accelerometer measures according to the inclusion criteria at both baseline and post intervention was smaller than expected; n=700, making it harder to detect significant differences between groups. The results are somewhat in contrast to similar intervention studies that found effects on MVPA but not total physical activity (Bugge et al., 2012; Kriemler et al., 2010; Magnusson, Sigurgeirsson,

Sveinsson, & Johannsson, 2011). However, these studies aimed to affect MVPA while in our study we aimed to affect total physical activity and not MVPA in particular.

The relatively large increase in physical activity from baseline to post intervention in both groups could be attributed to seasonal variation. The baseline physical activity assessment was conducted during fall and post intervention assessment during spring. Kolle et al (2009) observed seasonal variations in physical activity among 9 year old Norwegian children, but not among 15 year olds. The intervention effect should, however, not be affected by season, as both groups were measured simultaneously. The increase could also be a result of contamination effects of being the control group in a study aimed at increasing physical activity. When recruiting schools, most schools stated that they were hoping to become an intervention school to receive the intervention efforts. This could have stimulated the control schools to initiate their own "intervention". A possible contamination effect would make it more difficult to detect a significant effect of the intervention.

In **Paper III** we found an intervention effect on BMI for the total sample of 0.1 kg/m^2, this was not statistically significant. The significant intervention effect on BMI for girls was 0.2 kg/m^2. Although this figure can be considered small, it is bigger than the average intervention effects found in the latest Cochrane review investigating school-based obesity prevention studies (n=55 studies) among children and adolescents; -0.15kg/m^2 (95% CI -0.23 to -0.08) (6-12 years), and -0.09kg/m^2 (95% CI -0.20 to 0.03) (13-18 years) (Waters et al., 2011).

Reasons for the lack of intervention effects on BMI for the total sample could be a result of several factors. Whereas the intervention successfully increased physical activity in the total sample (at p=0.05), it did not succeed in reducing sedentary time. However, results from mid-way assessments showed that the intervention successfully reduced time spent watching TV/DVD and time spent on computer/game-use during weekend days (Bjelland et al., 2011a). Preliminary results of intervention effects of dietary behaviors indicate that the intervention successfully increased the children's intake of fruit and decreased their intake of squash with sugar, however, the intervention did not contribute to an increase in intake of vegetables (Bjelland et al, unpublished observations). Favorable changes in these EBRBs were hypothesized to produce a healthy weight development among adolescents in the HEIA study, indicated by an intervention effect on BMI. As the intervention showed favorable effects on many but not all of the EBRB outcomes, it could be that the intervention components were not sufficiently effective to produce overall effect sizes that would have a significant impact on the weight development. The intervention components were delivered through the teachers, and degree of implementation was dependent on the teachers' devotion to the study. We tried to ensure implementation according to the study protocol by monthly e-mail reminders to the teachers, but

because of this "hands-off" approach, we were left with little control of the true implementation dose and fidelity. The process evaluation of the intervention is yet to be analyzed, but examination of determinants of physical activity and sedentary time in terms of intervention dose estimates indicate a decline in the proportion participants reporting a high dose received from mid-way (56%) to post intervention (31%) (Bergh et al., 2012a). Additionally, mid-way results from teacher reports indicate that the overall degree of implementation was moderate (Bjelland, 2011). These results indicate that the missing intervention effects on the total sample could be caused by insufficient implementation rather than insufficient intervention strategies.

4.3 Effect moderators – Papers I-III

For all investigated outcomes in **Papers I-III** interactions or effect moderators were found. These findings reflect that the results in the total sample were masking a more nuanced picture.

4.3.1 Differences by gender

Gender was identified as the most convincing effect moderator in a systematic review on school-based energy balance behavior interventions (Yildirim et al., 2011), and this was supported by the results from **Papers I-III.** There were gender differences in behavioral correlates of weight status but not for weight status itself **(Paper I)**. Boys had a doubled risk of being overweight for every additional hour of watching TV per week; for girls there were no association. Boys had higher scores on overall physical activity measures and MVPA at all time-points than girls **(Paper II).** The analyses showed significant intervention effects for physical activity and sedentary time in girls only. Furthermore, the intervention had a beneficial effect on BMI and BMI z-score in girls, but not in boys **(Paper III)**.

Gender differences was also seen for dietary factors (Bjelland et al., 2011b), but not for potentially mediating personal, social and physical-environmental factors of physical activity (Bergh et al., 2012b). Bjelland et al (2011a) found an intervention effect for girls only at the 8 months mid-way assessment of SSB intake during weekend days, and for watching TV/DVD and computer game use. These results suggest that girls responded better to the HEIA intervention than boys for most outcomes. This is in line with several recent reviews (Waters et al., 2011; Yildirim et al., 2011; Brown & Summerbell, 2009; De Bourdeaudhuij et al., 2011b). Brown and Summerbell (2009) claims this gender diversity may be relevant for 10-14 year olds in particular. The fact that planning and implementation of the intervention were mainly done by females may be seen as a possible explanation for the gender differences in the HEIA study, in that we unintentionally have reached girls better. However, a systematic review of European school-based interventions promoting both physical activity and healthy eating to prevent obesity development in children and adolescents also revealed gender differences in intervention effects (De Bourdeaudhuij et al., 2011b). The effects

were larger on BMI and other obesity measures in girls than in boys. The authors stated that this could not be due to different interventions delivered to boys or girls as all interventions were school-based and exposed both gender to the same extent. Investigating physical activity and psychological health among Norwegian adolescents, Haugen et al (2011) found a stronger relationship between physical activity and self-worth through physical appearance in females than in males. Physical attractiveness is found to be more strongly associated with self–worth for girls than for boys (Allgood-Merten, Lewinsohn, & Hops, 1990). It may be that girls had a higher orientation and motivation to meet the intervention components provided in the HEIA intervention based on physical appearance than boys. Bere et al (2008) found that Norwegian girls ate healthier than boys, and preference seemed to explain much of the variation in dietary behaviors between genders. Boys had higher levels of physical activity than girls at baseline, and a lower potential for change. Similar to our study, the American "Planet Health" study significantly reduced the prevalence of obesity in 12 year old girls by promotion of physical activity, modification of dietary intake and reduction of sedentary behaviors, but found no effect on boys (Gortmaker et al., 1999). On the other hand, another American intervention study targeting environment, policy and social marketing (M-SPAN), showed a significant reduction in BMI in 11-13 year old boys over two school years, but not in girls (Sallis et al., 2003). Future initiatives addressing obesity prevention through EBRBs in this age group should be aware of this gender difference, and emphasize how to affect both genders positively.

4.3.2 Differences by initial outcome value (activity level and weight status)

The issue of different responses on different groups are discussed in the before mentioned review by Brown and Summerbell (2009). They suggest that next to gender those differentiating in weight status in the age range of 10 to 14 seem to respond differently to different elements of the interventions.

Weight status. In **Paper I** we found associations between some EBRBs and weight status. In **Paper II** we investigated the effect of the intervention on physical activity on initial weight status as moderator, and found a significant effect of the intervention among normal weight, but not among overweight/obese. Among the overweight, the participants in the control group were more physically active at both time points and had a more positive development than participants in the intervention group. Addressing energy related behaviors may have been perceived stigmatizing for some. It is possible that the overweight/obese participants perceived more explicit expectations from their peers to participate in physical activities and retreated in fear of not coping. If so, this would be an unintended negative effect among this group.

In **Paper III** we investigated the effect of the intervention on weight status, but we found no difference between groups. We acknowledge that the intervention, while aiming to reach all adolescents, did not manage to affect those most at risk; the overweight and obese.

We investigated the intervention effects by weight status at baseline because this has been called for in the literature (Yildirim et al., 2011), and because of important differences in potential for change in these two groups. When considering the results, we need to keep in mind the participants' potential for change. In the investigated sample, only 13% of the participants were overweight, and of those, only 1.8% was obese. This means that only a small proportion of the participants had a potential for improvement with respect to change of weight status category. In obesity prevention trials, rather than obesity treatment trials, investigating predominantly non-overweight participants, small effect sizes are to be expected (Waters et al., 2011).

Activity level. In **Paper II** we stratified the participants by baseline physical activity level. The intervention participants in the low-activity group demonstrated a significant increase in physical activity from baseline to post intervention. These results are encouraging, as increasing the activity level among the least active can cause larger health benefits than among participants already active (Strong et al., 2005). It is also noteworthy that we did not observe a significant decrease in the high-activity group as a decline in physical activity with increasing age was to be expected (Kolle et al., 2010; Riddoch et al., 2004). The intervention managed to positively affect the least active participants, as we had these particularly in mind when designing the physical activity intervention components.

4.3.3 Differences by parental education

Differences in main outcomes were found by level of parental education. We found an inverse relationship between weight status and level of parental education measured at baseline in **Paper I**. Adolescents of parents with low level education had a 42% higher risk of being overweight than adolescents of parents with medium level education. The social gradient in the prevalence of overweight and obesity among Norwegian children and adolescents is previously demonstrated in several cross-sectional studies (Groholt et al., 2008; Haug et al., 2009; Juliusson et al., 2010; Lien et al., 2007; Andersen et al., 2005). The same gradient was also seen in the intervention effects on BMI and WTHR post intervention **(Paper III)**, picturing social inequalities among Norwegian adolescents. However, the latest Cochrane review on obesity prevention studies concludes that that most of the investigated interventions did not appear to increase health inequalities although this was examined in fewer studies (Waters et al., 2011).

For physical activity **(Paper II)**, the pattern was somewhat different. Participants from all SES groups increased their total physical activity from baseline to post intervention, but only the participants with parents reporting a "mid-range" educational level demonstrated a significant intervention effect. De Bourdeaudhuij et al (2011a) compared intervention effects of three European physical activity interventions in 11-15 year olds and found conflicting results. The authors concluded that they were not able to show a significant widening or narrowing of inequalities in European adolescents in this matter, but urged researchers to systematically study intervention effects by SES groups in the future. Investigating other outcomes in the HEIA study, Bergh et al (2012a) found moderating effects of parental education for perceived social support from parents and teachers, while Bjelland et al (2011a) found no moderating effects of parental education for boys or girls with respect to intake of sugar-sweetened beverages, time used for watching TV/DVD and computer/game-use.

As higher prevalence rates of unhealthy behaviors among lower socioeconomic groups contribute substantially to socioeconomic inequalities in health in adults, preventing the development of these inequalities in unhealthy behaviors early in life is an important strategy to tackle socioeconomic inequalities in health. Reasons for this difference between SES groups are not clear. It has been suggested that some individuals, driven by their personal charachteristics such as knowledge, values, skills and capacities, possesses a general orientation towards healthy lives or risky lives in respect to health behaviors (Wickrama, Conger, Wallace, & Elder, Jr., 1999). Individuals who are oriented towards healthy lives choose and adopt otherwise uncorrelated healthy behaviors. Also social structures are suggested to influence health behaviors, in that socially disadvantaged people have less autonomy, information and resources to choose healthy behaviors (Wickrama et al., 1999). To prevent transmission from one generation to the next of unhealthy behaviors in low SES groups, intervention early in life is important. Little is known, however, about health promotion strategies particularly effective in lower socioeconomic groups in youth (van Lenthe et al., 2009). Results from the HEIA study have contributed to fill some of the research gap showing different effects dependent on outcome, however, there is still a need for further investigations into the matter of social inequalities of health outcomes in adolescents.

4.4 Methodological considerations

4.4.1 Study sample – who were reached?
The study sample represents 11-13 year-olds attending 37 public schools in south-eastern Norway. At baseline, 87% of the sample was normal weight. The participants were equally distributed between SES-categories. About 90% of the participants reported having breakfast every day. Nearly

60% of the participants met the guidelines of physical activity achieving 60 minutes of daily MVPA, both at baseline and post intervention, and irrespective of intervention or control group. Comparing to figures from a national representative sample of 9 and 15-year-olds regarding weight status and level of physical activity; these figures fall adequately in between (Kolle et al., 2010). The majority of participants in the HEIA study were not at risk with respect to the addressed EBRB's and weight status.

The initial plan of the study was to recruit participants from two counties lying close to Oslo; Vestfold and Østfold. We disregarded the county of Oslo because its inhabitants are very commonly approached for investigation and we expected a certain tiredness of study participation. After the first recruitment phase, we realized that we had to broaden the geographical area to which recruit from due to large declines. To be able to get the final sample size of 37 schools we had to ask 177 schools. Whereas a potential non-response bias cannot be ruled out, attrition analyses showed no differences between the participating schools (n=37) and schools which declined to participate (n=140) in terms of number of students at 6th grade and overall size (Gebremariam et al., 2012). Investigating school food environment in 35 of the 37 participating schools in the HEIA study, Gebremariam et al (2012) found that after adjustment for student characteristics the school-level variance was low (<3%). This is in line with several other studies in this age group (Johansen, Rasmussen, & Madsen, 2006; Krolner et al., 2009; Maes & Lievens, 2003; van der Horst et al., 2008). This indicates that the initial school level per se does not explain much of the variance, suggesting a low problem of participation bias, and by such a higher potential of generalizing the intervention findings.

During the last decade, recruiting schools to extra-curricular projects have become a challenging undertaking in Norway, as the curricular demands have increased substantially. Based on the impressions from the recruitment phase, the HEIA study was considered comprehensive by many principals, and as it has been more common to include the affected teachers in making the final decisions about participation we think that many declined the invitation because of concerns for the extra demands. In addition, weighing of children is a controversial issue in Norway, and this has been debated repeatedly in the national media.

The number of participants varies between **Papers I-III** depending on outcome. In **Paper I** we wanted to include objectively assessed physical activity and sedentary time when investigating correlates of weight status, and the number of participants providing adequate accelerometer data was the limiting factor of the sample. In **Papers II** and **III** we based the analyses on the participants providing data at both baseline and post-intervention for physical activity **(Paper II)** and BMI **(Paper III)**. The

participants not providing complete data were compared to the investigated sample by drop out analyses. In **Paper II** more boys than girls were lost to follow up and in **Paper III** more overweight participants were lost than normal weight. The reasons for this selection remain unknown as we did not ask why the participants were lost to follow up. Non-random loss to follow up challenges the generalizability of a RCT in that it no longer describes the recruited sample. This is acknowledged and further discussed as a limitation of this study.

4.4.2 Choice of analyses

Intention-to-treat (ITT). The decision to do per protocol analysis and not to do ITT in this study was made *a priori*. In an ITT analysis, the data from each participant are analyzed in accordance with the treatment to which the participant was randomized, regardless of whether or not that participant actually received that treatment (Sim & Wright, 2000). The alternative to ITT is usually to analyze data per protocol, meaning that participants with incomplete data are excluded from the analysis (Montori & Guyatt, 2001; Wright & Sim, 2003; Sim & Wright, 2000). In public health and "free-living" trials as this one, ITT is less common than in clinical RCTs. We performed the effect analyses on participants who provided data at both baseline and post-intervention, and attrition analyses were conducted to detect potential selection biases (Shadish, Cook, & Campbell, 2002). In **Paper II,** the analyzed sample (n=700) was somewhat lower than the original/initial sample (n=1580). At baseline, 1129 participants provided valid accelerometer data, of those only 700 provided valid accelerometer data at both assessments. The majority of the participants excluded from the analyses did not meet the preset criteria of providing minimum three days of accelerometer data (>8 hours a day) including one weekend day both at baseline and post intervention. The criteria may seem too strict as it excludes such a large proportion of the sample, however, this is in line with similar studies using accelerometers to assess physical activity and sedentary time (Cain et al., 2012). We did rerun the analysis on total physical activity including n=178/n=235 subjects having registered accelerometer data for only two days at baseline and post intervention, respectively. The results from this analysis were of the same magnitude as from the reported sample (>three days registration) of this study, indicating a robustness of the reported results.

We were not able to collect data on height and weight from 99 participants that returned a consent to participate, but that were absent at baseline data collection or declined the anthropometric assessments (**Paper III**). We did not impute values for missing data or from participants that withdrew from the study, because this can be problematic and bias the outcome (Montori & Guyatt, 2001). Of the 1376 children that provided height and weight values at baseline, 1324 also provided height and weight post intervention. The 4% drop out was equally distributed between intervention and control group, this diminishes the risk of non-random dropout. We regard the ITT principle of

'last observation carried forward' of the participants with baseline values to be imprecise, as an increase in these outcomes in 11 to 13 year olds are an inevitable human development during puberty and growth-spurt. To impute post-test mean values in the intervention and control groups could be a better approach to overcome the "problem" of human development, however, this can give a false positive result of the intervention effect by narrowing the range of observations (Sim & Wright, 2000). To choose per-protocol analysis instead of ITT can be problematic by means of loss of statistical power due to reduced sample size, and thus limits the generalizability (Sim & Wright, 2000).

Cluster. I the HEIA study, schools were the unit of recruitment while adolescents were the unit of analysis. In theory, individuals within a defined group are more similar to each other than other groups. The ICC is used to quantify the degree of clustering of individuals at the group level. We investigated all study outcomes (anthropometric- and behavioral outcomes) for clustering effects by Linear Mixed Models and only 1-3% of the unexplained variance in the anthropometric outcomes, dietary- and sedentary behaviors was on group level (Appendix 3). For accelerometer assessed physical activity and sedentary time we found a higher clustering effect within schools; 11%. Both Tabachnick & Fidell (2007) and Heck et al (2010) state that if the ICC is small when quantifying degree of clustering (i.e. <5%), there is no meaningful difference among groups and the data may be analyzed at the individual level. We therefore chose to use multilevel analyses, adjusting for the clustering effect of schools when accelerometer assessed physical activity and sedentary time was main outcome **(Paper II)**, and to analyze without adjusting for cluster for the anthropometric outcomes **(Papers I** and **III)**.

Moreover, school effects on health behaviors seem to be behavior specific (West, Sweeting, & Leyland, 2004). A review by de Vet et al (2011) reports that no school or neighborhood factors were related to dietary behaviors, while interpersonal factors such as family cohesion, modeling and parental monitoring played a more important role. This was confirmed within the HEIA study, by Gebremariam et al (2012) investigating the influence of the school food environment on the dietary behaviors at baseline – concluding that most of the variance in the dietary behaviors investigated was at the personal level.

Furthermore, as students in the Norwegian primary and secondary education are no longer organized by classes, but in larger and smaller groups varying by study subject (Norwegian Education Act, 2003), clustering effects of class was therefore not investigated.

Subgroup analyses. The use of subgroup analyses are called for by some and criticized by others (Petticrew et al., 2012). The HEIA study was based on a need for intervention strategies tested in

real-life situations aimed to answer if low-cost changes can be beneficial to public health. For this purpose subgroup analyses are called for and justified (Yildirim et al., 2011). However, from a statistical perspective, subgroup analyses conducted without preceding tests of significant interaction effects can be criticized. In the current case, interaction tests were performed for all investigated outcomes. In **Papers I** and **III** only significant interactions led to further investigations. In **Paper II** though, we performed a few subgroup analyses without a significant interaction, and this could be criticized. However, as these subgroups were identified *a priori*, we would argue that there was a rationale for exploring intervention effects by these subgroups based on the concepts of the HEIA study. By going through the list of eleven "Criteria to assess the credibility of subgroup analyses" presented by Sun et al (2010), we evaluated the credibility of the results. By meeting most, but not all these criteria, we found support for doing the follow-up subgroup analyses in those cases, but we also acknowledge a degree of uncertainty of these exploratory findings.

4.4.3 Assessment of anthropometry

BMI was the main outcome variable in the HEIA study. BMI is the most commonly used measure of adiposity in large scale surveys, and therefore several authors claim that BMI is the best measure of adiposity in children and adolescents (Harris et al., 2009; Cole, Faith, Pietrobelli, & Heo, 2005). Himes et al (2009) claims that compared to BMI, no other measures of body fat are sufficiently practical or provide appreciable added information to be used in the identification of overweight/obesity in children and adolescents. However, BMI is by some considered controversial as a measure of overweight/obesity since it does not distinguish between fat mass and fat-free mass such as muscle mass. A person with high muscle mass can misclassified as overweight based on BMI. Doak et al (2006) underline that outcomes based on height and weight (BMI) may be inappropriate to use when physical activity is an intervention component, since lean mass tends to increase during physical activity. BMI-for-age z-score (BMI adjusted for age and sex) is also a widely used measure of overweight/obesity in children and adolescents, and some claims this to be a better measure than BMI in growing children (Inokuchi, Matsuo, Takayama, & Hasegawa, 2011). BMI cut offs developed by Cole and colleagues on behalf of the IOTF to separate between normal weight, overweight and obese are commonly used since it was developed in 2000 (Cole et al., 2000). Different cut offs based on growth curves also exist and are widely used. A systematic review concludes that there is no compelling evidence for use of either waist circumference or BMI cut points proposed by the IOTF in preference to the use of national BMI percentiles for the identification of children and adolescents with excess fatness (Reilly, Kelly, & Wilson, 2010). WTHR is a relatively new measure of obesity in children and adolescents, but studies have shown promising results for this measure in terms of specifying the health risks associated with central obesity (Garnett, Baur, & Cowell, 2008; Nambiar,

Truby, Abbott, & Davies, 2009). Some argue that ponderal index (kg/m^3) provides a better measure of fat accumulation in children than BMI, since it reflects three dimensions rather than two (Resaland, Mamen, Anderssen, & Andersen, 2009). However, as there currently is no consensus on what is the best measure of adiposity in children and adolescents, we chose to present several estimates of body composition in addition to the main outcome variable BMI **(Paper III)**. This is supported by a recent meta-analysis; to determine whether a school-based intervention is an effective means to reduce body fat it may be necessary to assess it using a number of different anthropometric variables (Gonzalez-Suarez, Worley, Grimmer-Somers, & Dones, 2009).

4.4.4 Assessment of physical activity and sedentary time

In the HEIA study we assessed physical activity and sedentary behaviors both through questionnaire and by accelerometers. Assessing physical activity accurately is difficult due to its variation in mode, context and dimensions. Until recently, most studies investigating activity behaviors have largely used questionnaires. Questionnaires are very feasible tools because of relatively low cost, they are easy to distribute and have the potential to capture both context, mode, frequency and duration of activity. However, questionnaires have several weaknesses that made this a less preferred tool in our study. Recall bias is common in all age groups and especially among young children (Sallis & Saelens, 2000). Additionally, the recall bias of physical activity tends to be non-systematic, meaning that some groups (e.g. females, high BMI) tend to over-report more than others (Adamo et al., 2009; Prince et al., 2008; Ferrari, Friedenreich, & Matthews, 2007). The bias can also be connected to social desirability, and by the respondents trying to please the investigators. Difficulties to evaluate intensity of activity are common, as this is based on individual perception and yields large variation. To meet these validity and reliability issues, the use of objectively assessed physical activity and sedentary time is preferred. In an attempt to compare subjective and objective measures of assessing physical activity in the pediatric population Adamo et al (2009) made a comprehensive systematic review, including 83 studies, and found substantial discrepancies and moderate correlations between indirect and direct measures. Alarmingly, the overall overestimation of physical activity assessed by indirect methods to accelerometers were 114% (range= -57 to 2 695%) in males and 584% (range= -95% to 13 025%) in females. These results are similar to findings from adult populations (Prince et al., 2008). Because of the weaknesses mentioned above, data from accelerometers were used as main variables for physical activity and sedentary time.

However, when we investigated the data on physical activity and sedentary time assessed by accelerometers we found a surprising discrepancy between outputs assessed by the old monitors AM7164 and the newer generation GT1M. This led to the validation study described in 2.5 and **Paper IV.**

In **Paper IV** we found a significant difference between the older ActiGraph accelerometer AM7164 and the newer generations GT1M and GT3X+ when assessing overall physical activity among 9-year-olds in a free living condition. These results suggest that data assessed by AM7164 should not be compared to newer generation ActiGraph accelerometers directly. The newer monitors GT1M and GT3X+ gave similar outputs and data are according to our results comparable. Comparisons of data assessed with the AM7164 with newer accelerometer generations at different intensities should be done with caution as differences may reflect methodological artifacts rather than real differences in scores. Several validation studies including these monitors have been done over the last years and the conclusions vary. Most validations are done in mechanical setups or in a controlled laboratory settings (John et al., 2010; Kozey-Keadle, Libertine, Lyden, Staudenmayer, & Freedson, 2011; Kozey et al., 2010; Rothney et al., 2008; Robusto & Trost, 2012; Sasaki, John, & Freedson, 2011), while a few have investigated the monitor outputs based on free living conditions (Ried-Larsen et al., 2012; Corder et al., 2007; Vanhelst et al., 2012a; Vanhelst et al., 2012b). One explanation for the varying conclusions can be that the results are population specific and different results can be expected dependent on age and activity type (Ried-Larsen et al., 2012). However, Reilly et al (2008) suggests that ActiGraph accelerometer outputs have little age- or size-related systematic variation for the same behavioral input across a wide age/size range (3–10 years). Cain et al (2012) state that there is growing evidence among adults for differences in sensitivity of ActiGraph accelerometers, and that it still is unclear how model differences affect interpretation of data from children. Our results support the limited cluster of research stating that there is a difference between the old AM7164 and the newer ActiGraph models and that these findings might affect interpretation of accelerometer data obtained from children and adolescents (Corder et al., 2007; Tanha, Tornberg, Wollmer, & Dencker, 2013). Our results also support the growing number of studies showing that data assessed by the newer generation ActiGraph's, from GT1M and forward, can be compared and used interchangeably without a correction factor (Ried-Larsen et al., 2012; Robusto & Trost, 2012; Vanhelst et al., 2012b; Kaminsky & Ozemek, 2012).

In the validation we found that the AM7164 on average gave a 11.6% higher output on total physical activity comparing to the GT1M. As we can assume that the GT1M gives more stable outputs than the AM7164 (Rothney et al., 2008), we chose to adjust the mcpm assessed by the AM7164 in the HEIA study by applying a correction factor of 0.9 to the data. Adjustment of data was not our number one choice, as we rather would leave all data "untouched". Yet, the detected differences in accelerometer outputs from the two different accelerometer generations in the HEIA study were too large to be neglected, and when this difference were reconfirmed in the validation study and also found by others (Corder et al., 2007; Rothney et al., 2008), we adjusted the data accordingly. This can

be criticized, as we introduced a bias to the data by doing so. For time spent at different intensities we did not apply a correction factor, as our validation study and the literature (Corder et al., 2007; Ried-Larsen et al., 2012) showed that the magnitude of differences between monitor generations varied by intensity level. In the effect analyses of time spent at different intensities we rather applied dummy variables to correct for monitor combination. In belated wisdom, we should not have used different generations of ActiGraph to assess physical activity and sedentary time in the HEIA study. However, as different monitor generations were used for economic and logistic reasons, adjusting the data were one solution to correct for the differences in outputs that seemed more correct than to leave the demonstrated differences to affect the outcomes.

4.4.5 Assessment of dietary behaviors and parental education

Assessing dietary behaviors by questionnaire is also influenced by the biases described above (recall bias, social desirability bias, pleasing bias) (Thompson & Subar, 2013). However, the objective alternatives to questionnaires (observation, interview) were rejected due to feasibility and cost.

Information on parental education was collected from nearly all of the participants' parents (97% of the participating adolescents). We asked the parents directly on the consent form, and this increases the validity of the information, as compared to asking the adolescents. Use of public register data would probably give even more precise information by reducing the biases connected to subjective reporting. However, we think by adding a few questions to the consent form it contributed to the large response rate on parental education.

4.4.6 Strengths and limitations of the study

The strengths of the present study include the study design and the large number of participants. The multicomponent intervention, lasting 20 months, was theoretically informed and systematically developed based on the current best practice and designed to be feasible to the school system and not financially demanding. Also, measures including objectively assessed anthropometrics, pubertal maturation (self-reported), self-reported parental education and whole sample measurement of physical activity and sedentary time by accelerometers are clear strengths of this study.

We acknowledge that our study has limitations. While a number of limitations have already been discussed, a few more issues could be considered. According to the power-calculations of the study (Lien et al., 2010), the number of participants providing valid accelerometer data **(Paper II)** and anthropometrics **(Paper III)** at both time points was lower than what we opted for. A higher number of participants with valid recordings may have made it easier to detect significant intervention effects on these outcomes. However, the power-calculations on physical activity may also have been overestimated, since investigating change in such large groups using objective measurement tools

has rarely been done previously. The large drop-out reduces the generalizability of the results. However, few differences were seen between those who provided accelerometer data at both time points and those who did not **(Paper II).** In **Paper III** a difference was seen between the completers and the dropouts where the dropouts had higher values of adiposity. We may unintentionally have investigated a sample including less overweight and obese participants than what this segment actually consist of. Furthermore, the potential for generalization of our findings might also be limited as the sample was recruited from a limited geographical area. However, comparing the HEIA study sample to nationally representative figures for 9 and 15-year-olds, the measures from the participants in the HEIA study lie adequately between the measures of the 9 and 15-year-olds when it comes to objectively measured height, weight and total physical activity (The Norwegian Directorate of Health, 2012). This strengthens the belief of the generalizability of the results. Finally, when investigating intervention effects of a multi-component intervention, it is not possible to sort out whether or how the components worked separately.

5. Conclusion

The following conclusions can be drawn on the basis of the results presented in **Papers I-IV** and the discussions in this thesis:

1. The results from the HEIA study showed a social gradient in weight status in 11-year-olds; picturing an inverse relationship between participants' weight status and parental education. Both breakfast consumption and moderate to vigorous physical activity were inversely associated with weight status. Watching TV was positively associated with weight status for boys, but not for girls. No associations were found between intake of sugar-sweetened beverages and snacks, playing computer games and weight status.

2. A comprehensive but feasible, multi-component school-based intervention can affect physical activity patterns in adolescents by increasing overall physical activity. This intervention effect seemed to be more profound in girls versus boys, low-active adolescents compared to high-active adolescents, participants with normal weight compared to overweight and for participants with parents with middle educational level as opposed to those with high and low educational level respectively. The effect did not vary by pubertal status.

3. The intervention successfully affected BMI and BMI z-score in adolescent girls, but not in boys. No intervention effects were seen for waist circumference, weight status or WTHR. A beneficial effect on BMI was seen among participants of parents with high educational level. However, a negative intervention effect on WTHR was seen among participants of parents reporting low educational level. The social gradient was present not only in cross sectional associations, but also when investigating intervention effects on estimates of body composition. The effect on BMI did not vary by pubertal status.

4. We found a significant difference between the older ActiGraph accelerometer AM7164 and the newer generations GT1M and GT3X+. These results suggest that data assessed by AM7164 should not be compared to newer generation ActiGraph accelerometers without careful considerations, and possibly including a correction factor. The newer monitors GT1M and GT3X+ gave similar outputs and data are according to our results comparable.

Comparisons of data assessed with the AM7164 with newer accelerometer generations at different intensities should be done with caution as the differences are not systematic.

6. Recommendations for future research

This thesis discusses selected issues related to school-based obesity prevention and health promotion in Norwegian young adolescents, based on experiences from the HEIA intervention study. These topics are important to investigate further, as the rapid development and consequences of overweight and obesity among children and adolescents are still not fully understood. There are a number of issues that should be further investigated, among them a few recommendations for future research:

- Based on our experience with low participation rate from schools, strategies to facilitate school enrollment in future health promoting research projects should be investigated.

- Future research should investigate how to better reach both genders with school-based interventions on EBRBs.

- Future research should be aware of social inequalities in health related behaviors and investigate how to diminish social inequality in school-based health promotion intervention strategies.

- Future school-based interventions on health promotion should emphasize implementation strategies and proper assessment of how well the intervention components were implemented.

- Efforts should be done to reach consensus on accelerometer settings, use of cut points and data processing's to ease comparisons across studies and bring the field of objectively assessed physical activity and sedentary time forward.

- Comparisons of data assessed by the ActiGraph model 7164 with data assessed by newer generations ActiGraphs should be aware of differences in outputs, and further research should be done on how to compare such data on different intensities and if the differences are age-specific.

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Correlates of weight status among Norwegian 11-year-olds: The HEIA study

May Grydeland[1,2*], Ingunn H Bergh[3], Mona Bjelland[1], Nanna Lien[1], Lene F Andersen[1], Yngvar Ommundsen[3], Knut-Inge Klepp[1] and Sigmund A Anderssen[2]

Abstract

Background: The underlying mechanisms of overweight and obesity in adolescents are still not fully understood. The aim of this study was to investigate modifiable and non-modifiable correlates of weight status among 1103 Norwegian 11-year-old adolescents in the HEalth in Adolescents (HEIA) study, including demographic factors such as gender and parental education, and behavioral factors such as intake of sugar-sweetened beverages, snacks and breakfast consumption, watching TV and playing computer games, physical activity and sedentary time.

Methods: Weight and height were measured objectively, body mass index (BMI) was calculated and International Obesity Task Force cut-offs were used to define weight status. Physical activity and sedentary time were measured by accelerometers. Other behavioral correlates and pubertal status were self-reported by questionnaires. Parental education was reported by the parents on the consent form for their child. Associations were investigated using logistic regressions.

Results: There were gender differences in behavioral correlates of weight status but not for weight status itself. Adolescents with parents in the highest education category had a 46% reduced odds of being overweight compared to adolescents with parents in the lowest education category. Adolescents with parents with medium education had 42% lower odds of being overweight than adolescents with parents with the lowest education category. Level of parental education, breakfast consumption and moderate to vigorous physical activity were positively associated with being normal weight, and time watching TV was positively associated with being overweight for the total sample. Gender differences were detected; boys had a doubled risk of being overweight for every additional hour of watching TV per week, while for girls there was no association.

Conclusions: The present study showed a social gradient in weight status in 11-year-olds. Both breakfast consumption and moderate to vigorous physical activity were inversely associated with weight status. No associations were found between intake of sugar-sweetened beverages and snacks, playing computer games and weight status. Watching TV was positively associated with weight status for boys but not for girls. Interventions are needed to gain more insight into the correlates of change in weight status.

Keywords: Overweight, Physical activity, Sedentary time, Parental education, Diet, Children, Adolescents

* Correspondence: may.grydeland@nih.no
[1]Department of Nutrition, Faculty of Medicine, University of Oslo, Oslo, Norway
[2]Department of Sports Medicine, Norwegian School of Sport Sciences, PB 40 Ullevaal Stadion, NO-0807 Oslo, Norway
Full list of author information is available at the end of the article

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Background

Overweight and obesity in children and adolescents have been associated with several health risks and social consequences [1], and often seem to follow into adulthood [1-3]. Over the last decades the proportions of overweight and obesity among children and adolescents have increased both in developed countries, including Norway, and in several developing countries [4-6]. Recently, however, a leveling-off has been observed in this development in some European countries, but this trend seems not to have reached the lower socio-economic groups equally well as the more benefited groups of society [7,8].

Identifying modifiable correlates of overweight/obesity in specific age-groups is important to be able to develop intervention strategies targeting the most important weight determinants in order to combat the overweight epidemic. Overweight and obesity in children and adolescents have been associated with certain dietary behaviors, physical activity and sedentary behaviors [9-13]. However, most results are based on self-reported anthropometric measures and/or physical activity and sedentary behaviors.

Of dietary factors intake of sugar-sweetened beverages and breakfast consumption have been the most frequently studied associations [6,9,14-16]. Norwegian adolescents have been shown to have a higher intake of added sugar than recommended [17]. Watching TV is the most studied sedentary behavior, and some authors suggest that TV-viewing influences weight through the impact on energy intake rather than displacement of more energy demanding activities [18]. Computer use and video games do not seem to represent such a high risk compared to watching TV, as long as it does not replace physical activity [19]. More studies investigating the association between sedentary behaviors and weight status have been called for [20]. While some reviews state that there is no conclusive evidence for an association between body composition measures and children's self-reported physical activity [12,21], some studies with accelerometer-assessed physical activity have shown that a higher BMI and percentage body fat are associated with less physical activity [22,23]. Yet, a recent meta-analysis of prospective studies reported no association between objectively measured physical activity and fat mass in children [24].

Both BMI and correlated behaviors tend to change over time and differ substantially by age group. The age of 10–11 years is called a "key transition age" in a preventive perspective [25], because adolescents are establishing behavioral patterns that may continue into adulthood and this has implications for long term health. In their systematic review of school-based interventions to prevent childhood obesity, Brown and Summerbell (2009) conclude that interventions seem to reach genders differently [26]. Further, a systematic review of cross-sectional studies investigating the association of socioeconomic status (SES) and childhood adiposity concludes that associations exist and are predominantly inverse [27]. Stratified by parental education level, Bjelland et al. (2011) found significant differences in anthropometric characteristics and prevalence of overweight in the HEIA study [28]. These results indicate a need to explore whether modifiable behavioral correlates of weight status differ by non-modifiable demographic variables such as gender and SES. The present study investigates adolescents at the start of puberty. To our knowledge few studies have been published that include both objectively measured weight, height, physical activity and sedentary time, which assess dietary information and screen time/sedentary behavior, and also include self-reported parental education on a large cohort of adolescents in the beginning of puberty.

The aim of this study was to investigate both modifiable correlates (dietary factors, sedentary behaviors, physical activity) and non-modifiable correlates (gender and parental education) of weight status among Norwegian 11-year-old adolescents.

Methods

The HEalth in Adolescents Study (HEIA) study is based on a socio-ecological framework that aims to combine personal, social and physical environmental factors hypothesized to influence overweight and obesity in children, mediated by dietary and physical activity behaviors [29,30]. The design and procedure of the HEIA study are thoroughly described elsewhere [30], and thus only a brief description will follow.

Study design and subjects

Eligible schools were those with more than 40 pupils in 6th grade and located in the 3–4 largest towns/municipalities in the 7 counties surrounding the county of Oslo. Of 177 schools invited, 37 schools agreed to participate. All 6th graders in these 37 schools (n = 2165) were invited to participate. Of these, 1580 adolescents accepted to participate and returned a parent signed informed consent form (73%).

The main data collections took place in September 2007 and were conducted by trained staff. On the day of the survey the participating adolescents took part in an examination of anthropometric measures, filled in an Internet-based questionnaire and a short paper questionnaire about pubertal status. In addition, physical activity was measured objectively by accelerometers. The physical activity data collection was performed separately from the main survey due to logistics, and took place from September until the beginning of December 2007.

A total of 1481 adolescents (94% of those 1580 returning a consent) provided anthropometric measures and completed the survey. Valid accelerometer data was provided by 1129 adolescents. Reasons for not being included in the accelerometer analysis were: not wearing the accelerometer (n = 247), failing to achieve at least three days of assessment (including at least one weekend day) (n = 40) and instrument malfunction (n = 23). The adolescents present at the day of the data collection with complete anthropometric measures and valid accelerometer data (n = 1103) are included in this paper. No differences in anthropometric data, weight status or parental education were observed between children with and without valid accelerometer data, but there were more boys in the group without accelerometer data and complete anthropometric data (p = 0.008) (data not shown).

Ethical approval and research clearance was obtained from the Regional Committees for Medical Research Ethics and the Norwegian Social Science Data Service.

Anthropometric measurements

Height was measured to the nearest 0.1 cm, using a wall-mounted tape with the child standing upright against the wall without shoes. The adolescents' weight was measured with light clothing (i.e. t-shirt and underwear) to the nearest 0.1 kg using a Tanita scale (Tanita TBF-300, Tanita Corporation of America, Illinois, USA). BMI was calculated as weight/(height x height) (kg/m^2). The age and gender specific BMI cut-off values proposed by the International Obesity Task Force [31] were used to categorize the adolescents as non-overweight or overweight. The obese participants (1.8%) were included with the overweight in the analyses.

Data from questionnaires

Intake of sugar-sweetened beverages was assessed by frequency (six categories; from never/seldom to every weekday) and amount (in glasses; from one glass to four glasses or more) for weekdays, and by amount for weekends (in glasses; eight categories; from never/seldom to seven glasses or more). Weekends were defined as Saturday and Sunday. In the questionnaire it was stated that 0.5 l of beverage was equal to three glasses, making one glass equal to 1.67 dl. Intake of snacks was assessed by four questions; how often do you eat chocolate/candy, salty snacks, cookies and buns/cakes/pastry with seven response categories from never/seldom to twice a day or more. All variables were recorded into frequency of intake per week by using the midpoints of the categories (making 1–2 times a week equal 1.5 times per week) and summed into a sum of snacks variable. Breakfast consumption was assessed by the question; how often do you eat breakfast, with nine response categories ranging from never to every day. Since 90% of the responses were "every day", this variable was recorded to a dichotomous variable; eats breakfast every day or not. Two questions assessed hours of daily TV-watching (including DVD) and use of computer/electronic games on weekdays and weekends separately, each question with six response categories ranging from 0.5-5 and from 0–4 hours, respectively. The questions were mostly modified from existing questionnaires. Test-retest reliability of these self-reported behavioral outcomes showed moderate to high correlation (mostly r > 0.6) and is further described elsewhere [30].

The pubertal scale utilized in the study is based on the Pubertal Category Scores (PCS) [32]. PCS for boys included body hair growth, voice and facial hair. For girls, PCS included body hair growth, breast development and menarche. The adolescents were categorized into 5 groups, but due to low numbers in the last two categories, the final puberty score consisted of 3 categories (Pre, Early and Mid/Late/Post-pubertal). Test-retest of the puberty questionnaire showed a reasonable reproducibility (data shown elsewhere [30]).

As part of the informed consent, self-reported information about parental education was collected for both mothers and fathers. Parental education was categorized into three levels: 12 years or less of total education, between 13 and 16 years, and 16 years or more. The information about education from the parent with the longest education was used in the analyses, or else the one available.

Sedentary time and physical activity measured by accelerometers

The children were instructed to wear accelerometers (ActiGraph GT1M/CSA model 7164, Fort Walton Beach, FL, USA) all waking hours for 5 consecutive days except when doing water activities (monitors are not waterproof, water activities were ignored). The output was sampled every 10 seconds for 2 weekdays and 2 weekend days. The registration was set to start the second day of wearing the monitors to avoid excessive activity likely to occur during the first day. Activity should be registered during a minimum of 3 days (including at least one weekend day) and at least for 8 hours (480 min) each day to be considered as acceptable use.

After collecting the accelerometer, the stored activity counts were downloaded to a computer and analyzed by a software program named "CSA-analyzer" (http://csa.svenssonsport.dk). In the analyses of accelerometer data only daytime activity (06:00–24:00 hours) was included. Sequences of 20 min or more of consecutive zero counts were interpreted to represent non-wear-time and were excluded from each individuals recording.

The average number of minutes that the participants wore the accelerometer and the number of activity counts per minute (cpm) were calculated. Mean cpm (mcpm) as a summary measure of total physical activity in children is commonly used and has been validated against the "gold standard measurement" doubly labeled water and found valid [33]. Since outcomes on mcpm measured by model 7164 and GT1M have been shown to differ [34], a free-living validation study of the monitors used in the HEIA study was conducted (Grydeland et al., unpublished observations). In accordance with results from Corder et al. (2007), model 7164 was shown to measure 11% higher total mcpm than GT1M and a correction factor of 0.9 was applied to the total mcpm from model 7164 to be comparable to the GT1M outcome.

Sedentary time was defined as activity at intensities less than 100 cpm and expressed as min/day of accelerometer activity measured, which equals the intensity of sitting or lying down (<1.5 MET) [35]. Activity recordings at intensities between 100–2000 cpm were defined as light activity, reflecting activities such as standing, walking slowly or easy play. Moderate to vigorous physical activity (MVPA) was defined as all activity at intensities above 2000 cpm. This threshold is approximately equivalent to a walking pace of 4 km/h in youth [36]. These cut off points have been used in previous studies [37,38]. Sedentary time, light activity and MVPA were expressed as min/day of accelerometer activity measured.

Statistics

Clustering effects due to schools being the unit of recruitment were checked by Linear Mixed Model procedure (analyses available upon request). No clustering effect was found for the adolescent's BMI, and only 2% of the unexplained variation was on group level. If there is no meaningful difference among groups when quantifying degree of clustering, data may be analyzed at individual level [39,40]. Additionally, pupils in Norwegian primary and secondary education are no longer organized by classes (but in larger and smaller groups varying by study subject) (Norwegian Education Act, 2003). Clustering effects of class are therefore not investigated. Based on these arguments we decided not to do multilevel analyses in this paper.

Anthropometric characteristics were presented as means and standard deviations (SD), unless otherwise stated. Continuous variables were tested for differences between genders and between weight categories with independent sample t-tests, and categorical variables were tested by chi-square tests. Paired samples t-test was used to test differences in continuous variables between weekdays and weekend days.

The associations of the modifiable correlates with weight category (non-overweight/overweight; above/below cut-off) were analyzed by univariate and multiple logistic regression by the Forced Entry Method, controlled for gender and pubertal status. Variables that were associated with weight status at a $p < 0.10$ in the univariate analyses were entered in the final model. The results are presented as crude and adjusted odds ratios (OR) with 95% confidence intervals (CI).

To test whether gender or parental education level moderated these associations, interactions between gender and education level and each factor were tested separately in the model. Significant interactions were further inspected.

The significance level was set to $p < 0.05$ for all analyses (interaction analyses $p < 0.10$). Data were analyzed using the PASW Statistics, version 18 (SPSS) (IBM Corp., New York, NY, USA).

Results

Girls were slightly taller and heavier than boys, and had a higher puberty scale score than boys (Table 1). There were no differences in BMI or weight status between genders. No differences were found between genders for parental education. There were significant differences between genders in consumption of sugar-sweetened beverages and snacks, watching TV and playing electronic/computer games, where boys' averages were higher than girls' averages for all outcomes. There were also differences in these behaviors with regard to weekdays and weekend days. On average the accelerometers were worn for 784 ± 62 min/day (girls 779.3 (62.8) and boys 788.1 (60.8), $p = 0.02$). There were no gender differences in time spent sedentary and in light physical activity. Girls spent 7.8% of the monitored time in MVPA while boys spent 9.5% ($p < 0.001$). Boys showed more total physical activity than girls.

When the adolescents were categorized by weight status into groups of non-overweight and overweight/obese, there were no differences in gender or age between groups (Table 1). No differences were seen in puberty score by weight status, but a highly significant difference was seen for parental education ($p < 0.001$), with parents of overweight adolescents having less education.

Furthermore, Table 1 shows no differences between the two weight categories for dietary factors, except for breakfast consumption for which more non-overweight than overweight reported having breakfast daily.

Overweight adolescents spent more time watching TV and playing computer games than non-overweight adolescents. Both weight categories reported watching more TV and playing more computer games during weekend days than weekdays ($p < 0.001$). The overweight

Table 1 Descriptive characteristics for all, by gender and by weight status [a] in 11-year-old Norwegian adolescents

Characteristics	All (n = 1103)	Girls (n = 555)	Boys (n = 548)	p	Non-overweight (n = 962)	Overweight/obese (n = 141)	p
Girls (% (n))	50 (555)				50 (482)	52 (73)	0.7
Age (years)	11.2 (0.3)	11.2 (0.3)	11.2 (0.3)	0.4	11.2 (0.3)	11.2 (0.3)	1.0
Weight (kg)	39.8 (8.0)	40.3 (8.1)	39.2 (7.9)	**0.03**	37.8 (5.9)	53.4 (7.4)	**<0.001**
Height (cm)	148.7 (7.0)	149.2 (7.3)	148.1 (6.6)	**0.01**	148.2 (6.9)	151.8 (6.9)	**<0.001**
BMI (kg/m^2)	17.9 (2.7)	18.0 (2.7)	17.8 (2.7)	0.2	17.1 (1.7)	23.1 (2.1)	**<0.001**
Overweight/obesity [a] (% (n))	13 (141)	13 (73)	12 (68)	0.7			
Pubertal score (% (n))							
Pre-puberty	18.3 (202)	8.5 (46)	31.5 (156)		19.4 (176)	19.8 (26)	
Early-puberty	33.9 (374)	20.2 (109)	53.4 (265)		37.0 (335)	30.0 (39)	
Mid/late/post puberty	41.7 (460)	71.3 (385)	15.1 (75)	**<.001**	43.5 (395)	50.4 (66)	0.2
Parental education (% (n))							
≤12 years	29.1 (321)	30.2 (163)	29.6 (158)		28.1 (264)	42.5 (57)	
13-16 years	34.8 (384)	33.0 (178)	38.6 (206)		36.1 (339)	33.6 (45)	
>16 years	33.5 (369)	36.9 (199)	31.8 (170)	0.1	35.9 (337)	23.9 (32)	**<0.001**
SSB (dl/week)	10.2 (10.9)	8.7 (9.1)	11.7 (12.3)	**<.001**	10.1 (10.6)	10.9 (12.9)	0.5
SSB (dl/weekday)	1.1 (1.6)	1.0 (1.3)	1.4 (1.9)	**<.001**	1.1 (1.6)	1.3 (2.2)	0.3
SSB (dl/weekend day)	2.2 (1.9)	2.0 (1.7)	2.4 (2.1)	**.001**	2.2 (1.9)	2.2 (2.0)	0.7
Sum snacks (times/week) [b]	4.5 (4.4)	4.1 (3.4)	4.9 (5.2)	**0.01**	4.5 (4.5)	4.2 (4.2)	0.5
Breakfast daily (% (n))	90 (996)	90 (499)	91 (497)	0.4	92 (876)	85 (120)	**0.01**
TV(hrs/day/week)	1.7 (1.0)	1.6 (0.9)	1.7 (1.0)	**0.005**	1.6 (0.9)	2.1 (1.2)	**<0.001**
TV(hrs/weekday)	1.4 (1.0)	1.4 (1.0)	1.5 (1.0)	**0.02**	1.4 (0.9)	1.9 (1.2)	**<0.001**
TV(hrs/weekend day)	2.2 (1.2)	2.1 (1.1)	2.3 (1.3)	**0.001**	2.1 (1.2)	2.6 (1.4)	**<0.001**
Computer game (hrs/day/wk)	1.2 (0.9)	1.0 (0.8)	1.4 (1.0)	**<.001**	1.1 (0.9)	1.4 (1.0)	**<0.001**
Computer game (hrs/weekday)	1.1 (0.9)	0.9 (0.8)	1.2 (1.0)	**<.001**	1.0 (0.9)	1.4 (1.1)	**0.001**
Computer game (hrs/weekend day)	1.5 (1.1)	1.2 (1.0)	1.8 (1.1)	**<.001**	1.4 (1.1)	1.7 (1.2)	**0.013**
Sedentary time (min/day)	490.0 (67.5)	493.8 (66.9)	486.1 (68.0)	0.06	488.4 (67.6)	500.5 (66.3)	**0.05**
Light activity (min/day)	225.8 (43.1)	224.9 (40.6)	226.9 (45.3)	0.5	225.6 (42.5)	225.2 (46.5)	0.9
MVPA (min/day)	67.5 (23.3)	60.6 (18.5)	74.5 (25.6)	**<.001**	68.4 (23.6)	61.5 (20.9)	**<0.001**
PA total (cpm)	512.3 (166.7)	474.9 (140.2)	550.1 (182.2)	**<.001**	517.9 (165.8)	473.7 (168.4)	**0.003**
PA weekday (cpm)	548.4 (178.9)	508.9 (164.2)	588.3 (184.3)	**<.001**	553.0 (180.6)	516.5 (163.5)	**0.02**
PA weekend (cpm)	463.2 (235.1)	428.8 (188.7)	498.0 (270.0)	**<.001**	471.3 (235.2)	407.7 (227.2)	**0.003**

Values are Mean (SD), except for overweight/obesity, puberty, parental education and breakfast % (n). The numbers (n) vary slightly for the different measures.
[a] Age and gender specific cutoffs for overweight/obesity at age from 10.5 to 12.5 as defined by International Obesity Task Force [31].
[b] Sum of intake of chocolate/candy, salty snacks, cookies, buns/cakes/pastry. *SSB* = sugar-sweetened-beverages, *MVPA* = moderate-to-vigorous physical activity, *PA* = physical activity, P = *t*-test/chi-square (between genders and weight status).

adolescents spent on average 37% and 21% more time in front of the TV than non-overweight during weekdays and weekend days, respectively (p < 0.001). Additionally, the overweight adolescents spent 32% and 19% more time playing computer games than non-overweight during weekdays and weekend days, respectively. Differences by weight status were seen for accelerometer data as well, with the non-overweight adolescents showing less sedentary time, more MVPA and total physical activity than the overweight.

Crude and adjusted logistic regressions for the factors potentially associated with weight status are presented in Table 2. Since variables for weekdays and weekend days on each of the studied behaviors were highly correlated (e.g. TV and computer use r = 0.7, p < 0.001), both variables could not be included in one regression analysis but were summed per week. Total physical activity (cpm) was highly correlated with both MVPA and sedentary time and was therefore left out of the analysis.

Table 2 Factors associated with being overweight/obese [a] in a group of 11-year-old Norwegian adolescents (n = 1103)

	Crude			Adjusted		
	OR	95%CI	*p*	OR	95%CI	*p*
Parental education ≤12 y	1			1		
13-16 y	0.62	0.40, 0.96	**0.03**	0.58	0.37, 0.92	**0.020**
>16 y	0.47	0.29, 0.75	**0.002**	0.54	0.33, 0.89	**0.015**
SSB (dl/week)	1.00	0.98, 1.02	0.93			
Sum snacks (times/week)	0.97	0.92, 1.03	0.30			
Breakfast daily (yes/no)	2.00	1.17, 3.40	**0.01**	1.78	1.01, 3.11	**0.045**
TV (hrs/day)	1.53	1.28, 1.82	**<0.001**	1.40	1.14, 1.72	**0.001**
Computer game (hrs/day)	1.43	1.18, 1.74	**<0.001**	1.18	0.94, 1.48	0.16
ST (min/day)	1.00	1.00, 1.01	0.07	1.00	0.996, 1.003	0.81
MVPA (min/day)	0.99	0.98, 0.995	**0.003**	0.99	0.974, 0.996	**0.010**

[a] Age and gender specific cutoffs for overweight/obesity at age from 10.5 to 12.5 as defined by International Obesity Task Force [31]. Numbers are adjusted for gender and puberty.

Adolescents with parents in the highest education category (>16 years) had a 46% reduced odds of being overweight compared to adolescents with parents in the lowest education category (≤12 years) (p = 0.02). Adolescents of parents with medium education (13–16 years) had 42% lower odds of being overweight than adolescents of parents with the lowest education category (p = 0.02).

Consumption of sugar-sweetened beverages and snacks was not associated with weight status. Having daily breakfast was associated with weight status, both separately (OR 2.0) and adjusted for the other factors (OR 1.78).

Hours spent in front of the TV and playing electronic/computer games were both positively and significantly associated with being overweight in the univariate analyses. In the adjusted model only watching TV remained highly associated with being overweight, with a 40% increased risk of being overweight with every additional hour of watching TV per day.

Whereas MVPA was negatively and significantly associated with being overweight in the adjusted model, objectively measured sedentary time was not associated with being overweight.

Investigating whether gender moderated these associations, interactions between gender and each of the factors in the multiple model were tested. The only significant interaction was between gender and watching TV; OR 1.75 (CI 1.50, 2.65) p = 0.009. Sub-group analyses by gender revealed that the association between weight status and watching TV was highly significant for boys (OR 2.1 (95% CI 1.58, 2.73) p < 0.001) but not for girls (OR 1.2 (95% CI 0.90, 1.53) p = 0.23).

Investigating whether parental education moderated the investigated associations, interactions between parental education and each of the factors in the multiple model were tested. No significant interactions were found.

Discussion

The main findings in this study were that level of parental education, daily breakfast consumption and MVPA were inversely associated with weight status, and time spent watching TV was positively associated with weight status in a sample of Norwegian 11-year-olds. The association between watching TV and weight status turned out to be significant for boys only.

The prevalence of overweight and obese adolescents in the present study does not differ substantially from other recent studies of Norwegian adolescents [6,9,14,41].

The lack of association between sugar-sweetened beverages and weight status may be surprising given that WHO has categorized it as a probable contributor [4]. However, the intake of sugar-sweetened beverages was low in both groups, which has also been observed in another recent Norwegian study [42]. Yet, underreporting by the overweight cannot be ruled out, especially due to the high awareness about the sugar-sweetened beverages and health.

The association between weight status and consumption of unhealthy snacks was not significant. As a matter of fact, overweight adolescents tended to eat less snacks than non-overweight. This finding might be explained by underreporting or changed dietary patterns by overweight adolescents as a consequence of dieting. However, prospective studies of snack food consumption have consistently failed to show a link between snack food intake and excess weight [43]. Our results add to these findings.

An association between breakfast consumption and weight status has been identified in other cross-sectional studies [6,9,14]. We found a significant negative association in the univariate analyses, and also when adjusting for other factors. Affenito et al. (2005) found a negative association between breakfast consumption and BMI

after adjusting for demographic characteristics in the NHLBI Growth and Health study, but the association did not persist after multivariate control for physical activity and energy intake [44]. The authors of the study interpreted this observation to suggest that breakfast consumption is a marker for other healthy behaviors. A large US longitudinal study reported that normal-weight children who never ate breakfast gained weight relative to peers who ate breakfast nearly every day [45]. Must et al. (2009) points out that breakfast consumption as well as consumption of sugar-sweetened beverages and TV-viewing seem to be operating indirectly, as proxies for other dietary or activity behaviors, and warrants further studies of these relationships [43].

Regarding time watching TV and playing computer games, the differences between non-overweight and overweight adolescents were quite high, especially during weekdays. Watching TV was strongly associated with being overweight in our study, with 40% increased odds of being overweight with every additional hour of watching TV per day in the total sample. However, gender moderated this association and the subgroup analyses revealed a significant association for boys only. A review from prospective studies on modifiable risk factors in relation to changes in BMI and fatness concluded that sedentary behaviors effect on weight status seems to differ by gender, with many studies but not all showing greater positive associations among girls [43]. Possible gender differences are important to be aware of when designing intervention efforts targeting overweight/obesity prevention. Watching TV is the most studied sedentary behavior, and some studies suggest that TV-viewing operates through the impact on energy intake rather than displacement of more energy demanding activities. Cross-sectional data from the Danish part of European Youth Heart Study showed inverse associations between watching TV and both healthy food preferences and healthy food habits in school aged children [46]. In a laboratory-based study including 9 to 14-year-old boys, watching TV during a meal seemed to delay normal mealtime satiation and reduce satiety signals from recently consumed food, increasing energy intake [18]. It has also been suggested that exposure to commercials advertising energy-dense food while watching TV can work as an indirect mechanism and increase the energy intake even more [13]. However, in Norway there are legislations restricting such TV commercials aimed at children and this issue should only be of limited importance.

We found a strong association between use of computer games and weight status in the univariate analysis, but this association did not remain when adjusting for the other factors, indicating a confounding effect of other variables on this relationship. Tremblay et al.

(2011) found a dose–response relationship between increased sedentary behavior and unfavorable health outcomes in a large systematic review of sedentary behavior on health indicators based on 232 studies of school-aged children and youth [47]. The results are based on data from almost 1 million young people. However, these are self-reported sedentary behaviors measured as a mixture of hours/minutes/times per week of watching TV/playing computer games/screen time or self-reported sedentary time. A Canadian study using an objective measure of sedentary behavior (Actiwatch) found that fat mass and percentage body-fat were positively correlated with time spent sedentary for girls but not boys [48]. We found no significant association with time spent sedentary measured by accelerometer and weight status. The lack of consistency observed in the studies of sedentary behavior and sedentary time may reflect the range of variable definitions, measurement challenges, and also the changing nature of electronic media.

For total physical activity (mcpm) we found a significant difference between genders and between non-overweight and overweight adolescents. We found a significant inverse association between MVPA and being overweight, but no moderating effect of gender on this association. Ekelund et al. (2012) combined data from multiple cohorts of accelerometer assessed physical activity of 20 871 children and adolescents (age 4–18 years) and found that both total physical activity and time in MVPA were significantly and negatively associated with waist circumference [49]. However, in a systematic review of prospective studies of objectively measured physical activity and obesity prevention in children, adolescents and adults, the authors conclude that physical activity might not be a key determinant of excessive gain in adiposity [50]. Currently, the literature is inconsistent in the relationship between physical activity and adiposity.

Earlier findings from the HEIA study showed differences in anthropometric characteristics and prevalence of overweight when stratified by parental education level [28]. The current results show that these differences by parental education level remain when adjusting for behavioral factors. Level of parental education was inversely associated with weight status in the adjusted model, and this association was not moderated by gender. These results confirm previous studies suggesting a social gradient in the problem of overweight/obesity among Norwegian adolescents [6,27,51]. While earlier international research (from 1941–1989) found inconsistent relationships between SES and childhood adiposity [52], more recent research indicates a shift in trends where most studies show inverse relationships [27]. The ENERGY Project, a recent school-based survey among 10–12 year olds conducted in seven European countries

(n = 7234), found more favorable indicators of weight status in children of higher educated parents than in children of lower educated parents [15]. Our results support the evidence that adolescents of parents with low education have a higher risk of being overweight than adolescents of parents with higher education independent of behavioral correlates and gender.

Limitations and strengths

There are several limitations that should be considered when interpreting the findings from this study. It is impossible to infer causal relationships and to determine its direction from cross-sectional data. We cannot be certain that other unmeasured confounders could not have impacted our findings. Although accelerometers are considered a preferred tool when assessing physical activity and sedentary time in large surveys, it has weaknesses when it comes to measuring water-activities, cycling, skiing/skating, carrying loads, inclines and upper-body movements. We made no attempts to correct for these weaknesses, as to our knowledge there are no valid techniques to do so for a large scale survey. This may represent a possible underreporting of total physical activity. Furthermore, there was a rather large proportion of invited schools that declined to take part in the study. Recruiting schools in Norway to extra-curricular projects has become a challenging undertaking the last decade, as the curricular demands the last years have increased substantially. In addition, weighing of children is a controversial issue in Norway and has been debated in the national media repeatedly. However, attrition analyses showed no differences between the participating schools (n = 37) and schools which declined to participate (n = 140) in terms of number of students in 6th grade and overall size (data not shown) [53]. Also, the sample is collected from seven counties surrounding the county of Oslo, and this may limit the possibility to generalize the results for 11-year-olds outside this area. However, comparing the HEIA study sample to nationally representative figures for 9 and 15-year-olds, the measures from the participants in the HEIA study lie adequately between the measures of the 9 and 15-year-olds when it comes to objectively measured height, weight and total physical activity [54].

One of the major strengths of the study is the relatively large sample of adolescents at a very narrow age range. The age of 10–11 years is an important age group for addressing efforts to promote healthy behaviors [25]. The fact that many adolescents at this age have entered puberty makes this specific age group considered as hard to study and therefore less studied than pre- and post-pubertal adolescents. We adjusted for pubertal development and taking this into account is one of the strengths in this study. Other strengths of the study are that we measured height, weight, physical activity and sedentary time objectively. All adolescents in the present study had valid accelerometer measures of physical activity and sedentary time. An additional strength is that we were able to collect data on parental education from nearly all the parents giving their consent for their child to participate in the study. Finally, investigating both behaviors related to energy intake and expenditure in the same study concerning weight status can be considered as a strength, as the intrinsic interplay among dietary behaviors, physical activity and sedentary time still needs further understanding.

Conclusions

The present study shows that parental education, breakfast consumption, MVPA and TV-viewing were associated with weight status in a sample of Norwegian 11-year-olds. The social gradient in overweight remains a challenge for future interventions to target. While parental education cannot be regarded as a modifiable correlate of adolescents' weight status, breakfast consumption, MVPA and watching TV can, and should be properly addressed in future interventions targeting overweight in this age group.

Abbreviations

HEIA: HEalth in Adolescents; BMI: Body mass index; IOTF: International Obesity Task Force; SES: Socioeconomic status; PCS: Pubertal Category Scores; cpm: Counts per minute; MVPA: Moderate to vigorous physical activity.

Competing interests

The authors declare that they have no competing interests.

Authors' contributions

MG worked on the statistical analyses, wrote the first draft of the manuscript and made the greatest contribution to the paper. MG, IHB, MB, NL, LFA, YO, KIK and SAA participated in designing the study and project planning. NL was the project coordinator and participated in all parts of the work. KIK initiated the study. All authors provided critical revision of the paper, and read and approved the final manuscript.

Author details

[1]Department of Nutrition, Faculty of Medicine, University of Oslo, Oslo, Norway. [2]Department of Sports Medicine, Norwegian School of Sport Sciences, PB 40 Ullevaal Stadion, NO-0807 Oslo, Norway. [3]Department of Coaching and Psychology, Norwegian School of Sport Sciences, Oslo, Norway.

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Paper II

RESEARCH   **Open Access**

Intervention effects on physical activity: the HEIA study - a cluster randomized controlled trial

May Grydeland[1,2*], Ingunn Holden Bergh[3], Mona Bjelland[1], Nanna Lien[1], Lene Frost Andersen[1],
Yngvar Ommundsen[3], Knut-Inge Klepp[1] and Sigmund Alfred Anderssen[2]

Abstract

Background: Although school-based interventions to promote physical activity in adolescents have been suggested in several recent reviews, questions have been raised regarding the effects of the strategies and the methodology applied and for whom the interventions are effective. The aim of the present study was to investigate effects of a school-based intervention program: the HEalth in Adolescents (HEIA) study, on change in physical activity, and furthermore, to explore whether potential effects varied by gender, weight status, initial physical activity level and parental education level.

Methods: This was a cluster randomized controlled 20 month intervention study which included 700 11-year-olds. Main outcome-variable was mean count per minute (cpm) derived from ActiGraph accelerometers (Model 7164/GT1M). Weight and height were measured objectively. Adolescents reported their pubertal status in a questionnaire and parents reported their education level on the consent form. Linear mixed models were used to test intervention effects and to account for the clustering effect of sampling by school.

Results: The present study showed an intervention effect on overall physical activity at the level of p = 0.05 with a net effect of 50 cpm increase from baseline to post intervention in favour of the intervention group (95% CI −0.4, 100). Subgroup analyses showed that the effect appeared to be more profound among girls (Est 65 cpm, CI 5, 124, p = 0.03) and among participants in the low-activity group (Est 92 cpm, CI 41, 142, p < 0.001), as compared to boys and participants in the high-activity group, respectively. Furthermore, the intervention affected physical activity among the normal weight group more positively than among the overweight, and participants with parents having 13–16 years of education more positively than participants with parents having either a lower or higher number of years of education. The intervention seemed to succeed in reducing time spent sedentary among girls but not among boys.

Conclusions: A comprehensive but feasible, multi-component school-based intervention can affect physical activity patterns in adolescents by increasing overall physical activity. This intervention effect seemed to be more profound in girls than boys, low-active adolescents compared to high-active adolescents, participants with normal weight compared to the overweight, and for participants with parents of middle education level as opposed to those with high and low education levels, respectively. An implementation of the HEIA intervention components in the school system may have a beneficial effect on public health by increasing overall physical activity among adolescents and possibly among girls and low-active adolescents in particular.

Keywords: Obesity prevention, Overweight, Accelerometers, Intervention, Children, Adolescents

* Correspondence: may.grydeland@nih.no
[1]Department of Nutrition, Faculty of Medicine, University of Oslo, Oslo, Norway
[2]Department of Sports Medicine, Norwegian School of Sports Sciences, PB 4014 Ullevaal Stadion, Oslo NO-0806, Norway
Full list of author information is available at the end of the article

Background

A decline in physical activity with increasing age has seemed to be a consistent finding in physical activity epidemiology [1,2]. To combat this unfavorable development, the school has been regarded as an advantageous context for health promoting initiatives. Schools may be the only means to reach a large number of young people from diverse socio-economic backgrounds [3]. Although the value of school-based interventions to promote physical activity has been emphasized in several recent reviews, the effects of the strategies and methodology applied have been questioned [4-6]. Furthermore, until recent years physical activity in children and adolescents has primarily been assessed by questionnaires, yielding several weaknesses [7]. Objectively measured physical activity reduces bias and is preferred over subjective methods such as questionnaires. In a recent systematic update of reviews, Kriemler et al. (2011) confirmed the public health potential of high quality, school-based interventions for increasing physical activity in healthy youth, but highlighted that the effect of the reviewed interventions was mostly seen in school-related physical activity while effects outside of school were often not observed or assessed [8]. Cox et al. (2006) stated that physical activity outside of the school environment is a key contributor to a child's overall level of physical activity and emphasized the need for interventions targeting family and the community as well as the school environment [9]. The most recent reviews have concluded that there is still a lack of high quality school-based interventions on change in physical activity, using objective measures of physical activity among the whole study sample [4,6,8].

Another question that has been raised with regards to recent school-based interventions is for whom interventions are effective. One intervention strategy may not cover the diverse needs of various subgroups, and interventions tailored to specific groups have been suggested and tested with diverging results [6]. It has been a concern when designing interventions that the intervention strategies might not reach the ones that need the efforts the most, e.g. interventions aiming at increasing physical activity might not reach the least active participants but make the active participants even more active. Yildirim et al. (2011) identified gender as the most common moderator of school-based interventions aimed at energy balance related behaviors, and pointed out that girls seem to respond better to such interventions [10]. Previous studies and reviews support this finding, reporting that obesity prevention interventions seem to be more successful among females [11,12]. Nevertheless, in a review of young peoples' views of effective interventions, Rees et al. (2006) showed that adolescent girls in particular identified barriers to physical activity provided in school. Also, baseline values regarding outcome variables, initial weight status and socioeconomic status have been identified as potential moderators in interventions targeting energy balance related behaviors [10]. Recent reviews have concluded that there is still a lack of knowledge concerning which interventions work for whom, and further investigation of underlying mechanisms of intervention effects have been suggested [6,10,13].

Earlier findings from the HEalth in Adolescents (HEIA) study have shown intervention effects on psychological and social-environmental determinants of physical activity [14] and on sedentary behavior such as watching TV/DVD during weekdays and playing computer games during weekend days after 8 months of intervention [15]. Gender, parental education and weight status moderated these effects. The aim of the present study is to investigate the intervention effects after 20 months of intervention on accelerometer assessed physical activity, and to explore if the intervention reached *a priori* identified subgroups differently; namely girls, participants that are overweight, have parents with low education level or who currently have a low physical activity level.

Methods

The HEIA study, a school-based multicomponent cluster randomized intervention study (2 academic years), was developed based on the current best practice knowledge to ensure effect on core outcomes (healthy weight development, increased physical activity, reduced sedentary time and a healthier diet), feasibility and sustainability of the intervention program in the public school system [16]. The HEIA study is based on a socio-ecological framework that aims to combine personal, social and physical environmental factors hypothesized to influence overweight and obesity in children, mediated by dietary and physical activity behaviors [17]. The design and procedure of the HEIA study are thoroughly described elsewhere [16]. The CONSORT Statement for reporting a randomized trial is followed according to applicability (http://www.consort-statement.org).

Study design and subjects

Eligible schools were those with more than 40 pupils in 6th grade and located in the 3–4 largest towns/municipalities in 7 counties in south-eastern Norway. Of 177 schools invited, 37 schools agreed to participate. All 6th graders (11–12 year olds) in these 37 schools (n = 2165) were invited to participate. Of these, 1580 (73%) adolescents returned a parent signed informed consent form. Twelve schools were randomly assigned by simple draw to the intervention group (n = 784) and 25 schools to the control group (n = 1381). Figure 1 shows randomization and participation in the HEIA study. Neither participants nor investigators were blinded for condition.

Figure 1 Flow diagram of recruitment, randomization and participation of adolescents in the HEIA study.
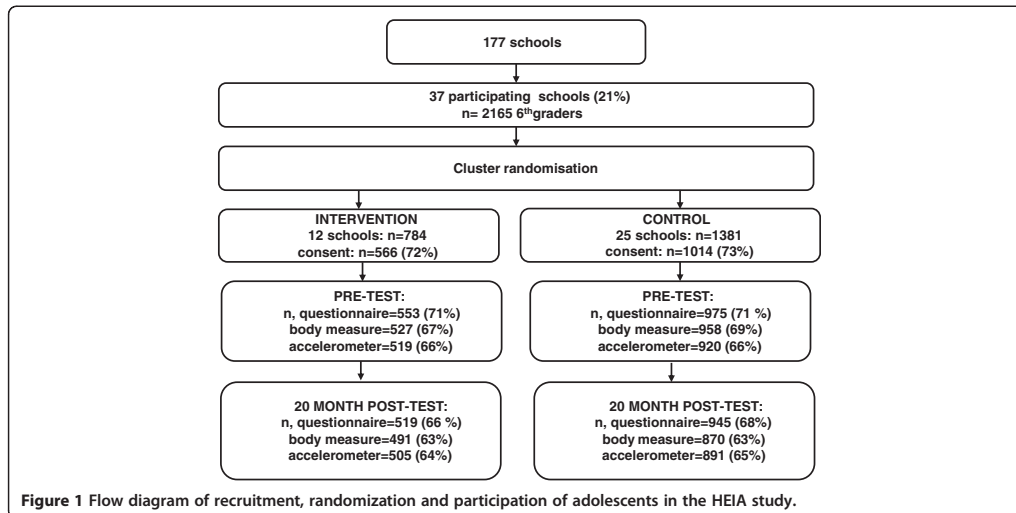
At baseline, 1528 adolescents completed the survey, of which 1439 were present and willing to wear an accelerometer, and of which 1129 (79%) obtained accelerometer data that were regarded as valid according to pre-set criteria in the study. At post intervention, 1418 completed the survey, and 1396 accelerometers were worn resulting in 892 (64%) participants with valid accelerometer data.

The main baseline data collection was conducted by trained staff at each school in September 2007. On the day of the survey, the participating adolescents completed an examination of anthropometric measures, and they filled in an Internet-based questionnaire and a short paper questionnaire about pubertal status. Physical activity was measured objectively by accelerometers. The physical activity data collection was performed separately from the main data collection due to logistics, and the baseline collection of accelerometer data took place from September until the beginning of December 2007. The post intervention main survey took place in May 2009, and the accelerometer assessments were conducted from March to the middle of May 2009.

Ethical approval and research clearance was obtained from the Regional Committees for Medical Research Ethics in Norway and from the Norwegian Social Science Data Service.

Intervention

Multiple efforts were made and targeted to promote participants' overall physical activity and to reduce sedentary behavior during the 20 month intervention period (outlined in Table 1 and further described elsewhere [16]). The HEIA study also included intervention strategies to promote a healthy diet, described in Table 1, but these are not further commented on in this paper. Through collaboration with school principals and teachers, and school health services and parent committees, the intervention efforts were orchestrated to increase participants' physical activity during school hours and in leisure time in order to reduce screen-time activities such as watching TV/DVD, playing computer games, etc.

A kick-off meeting for the teachers was held at each intervention school at the beginning of each school year to inform and encourage the efforts launched, as the teachers were the key persons to implement the intervention efforts. Briefly, the teachers were responsible for holding one structured lecture on energy balance for the students, initiating "HEIA-breaks" - a 10 minute physical activity break during class at least once a week, hanging up "HEIA-posters" in the classrooms, carrying out active commuting campaigns, handing out fact sheets to parents once a month (including student-parent tasks in 7th grade), and implementing a computer tailored program [18] (in 7th grade only) for the students. The intervention schools received an "Activity box" with sports equipment and toys (such as balls, hockey-sticks, jump ropes, Frisbees, etc.) to promote physical activity during recess. Teachers received two inspirational courses in physical education (PE) based on the SPARK program [19] to encourage high intensity and enjoyment for all during PE, one course in 6th grade and one in 7th grade. The intervention strategies were aimed to increase the total physical activity level of all participants in general and to specifically reach the least active participants, in particular inactive girls.

Table 1 The HEIA-study: Intervention components implemented in 6th and 7th grade in 12 Norwegian schools in 2007–2009

Setting/arena	What	Timing	Purpose
Class (Initiated by classroom-teachers)	**Lessons with student booklet:**	Once per month - 6th grade winter/ spring	Increase awareness of behavior-health relationship, recommended intake levels and own intake
	1. Diet and physical activity		
	2. Meals		
	3. 5 a day		
	4. Sugar rich beverages		
	5. Your choice		
	Posters for classrooms	Monthly – throughout the intervention	As a daily reminder of main messages (topic matched fact sheets to parents)
	- Key messages, A4-size, placed on a larger "frame-poster" including the HEIA logo		
	Fruit and vegetable (FV) break	Once a week – throughout the intervention	Increase FV intake; cut, serve, taste and eat FV with class mates
	- Cutting equipment per class provided, students brought FV		
	Physical activity (PA) break	Once a week – throughout the intervention	Increase PA; introduce PA also outside of PE and by classroom-teachers
	- 10 minutes of PA conducted in regular classrooms, booklet with ideas and CD provided		
	Sports equipment for recess activities	Every day - throughout the intervention (some equipment refill at beginning of 7th grade)	Increase PA; stimulate PA during recess – especially among those who do not play ball games
	- 1–2 large boxes per school. Examples of content: Frisbees, jump-ropes, elastic bands, hockey-sticks, a variety of balls		
	Active commuting campaigns	5 x 3 weeks: 6th grade: fall, winter and spring	Increase PA; stimulate activity
	- Register days with active transport to/from school for 3 weeks (5 campaigns)	7th grade: fall, winter	
	Pedometer:	7th grade	Increase awareness about PA level; stimulate activity
	- One class-set per school to be used in PE (SPARK), as tasks at school, as home assignment and active commuting		
	Computer tailored individual advice	7th grade	Increase awareness of;
	1. Fruit	Fall	- recommended intake and PA level
	2. Vegetables	Fall	- own intake of FV, PA level and hours of screen time
	3. Physical activity	Winter/spring	Received personal advise about what and how to change
	4. Screen time	Winter/spring	
	5. Sugar sweetened beverages	Winter/spring	
	+ one-week action plans for each topic (instruction on what, where and when to try one of the pieces of advice for behavior change)		

Table 1 The HEIA-study: Intervention components implemented in 6th and 7th grade in 12 Norwegian schools in 2007–2009 (*Continued*)

	Component	Frequency/timing	Aim
Home/parents	**Fact sheets** Facts on targeted behaviors. Practical tasks/challenges for leisure time/weekends in 7th grade	Monthly - throughout the intervention, one behavior per fact sheet	To stimulate parents to evaluate and change the home environment with regards to facilitating or regulating the targeted behaviors
	Brochures/information sheets Teachers were provided info sheets about the FV break that they could use to inform parents about these	Once	To ensure that the fact sheets were read and discussed/applied to the home environment
	Brochures: - "Cutting FV" - "Meals – a value worth fighting for". Handed out together with related fact sheets	Once	To provide knowledge and inspiration
School wide	**Kick-off meetings at each school** - Teacher manuals presented, practical activities tested, material partially provided	Once a year - 6th and 7th grade (fall), 2–3 hours each time	To inform the school management, teachers, school nurse and parent committees about the project and establish/inform the grade level teachers as the "HEIA-team" at school
	Inspirational courses for PE teachers - SPARK ideas/principles [20]	Once a year - 6th and 7th grade (fall), 6 hours each time	Teacher-training for PE teachers; methods/activities to increase activity time, enjoyment and self-efficacy for all students during PE classes
	Resource box for school management - Offer to order free tool box for cutting and selling FV	Optional	Focus on healthy food/drinks offered in school/during school events
	Committee meetings -Meetings with school environment groups/parent committees	Optional	Aimed to stimulate easy-to-do changes on the school grounds that could stimulate activity (booklet/ideas provided). Increase awareness of healthy foods and beverages
Leisure time activities (NGO's)*	**Information folder and offer to receive a resource box with equipment for cutting and selling FV**	7th grade (fall)	Create awareness about leisure time activity leaders as role models for dietary habits, to reflect upon availability of food/drinks during practices and special events (i.e. tournaments, weekend training sessions, etc.)

FV, fruits and vegetables, PA, physical activity, PE, physical education, NGO, non-governmental organization. *Not successfully implemented.

Outcome measures; physical activity

The children were instructed to wear the accelerometers (ActiGraph models 7164 and GT1M, ActiGraph, Pensacola, FL, USA) all waking hours for five consecutive days except when doing water activities (monitors are not waterproof). The output was sampled every ten seconds for two weekdays and two weekend days. The registration was set to start the second day of wearing the monitors to avoid excessive activity likely to occur during the first day of wearing the device. After collecting the accelerometer, the stored activity counts were downloaded to a computer and analysed by the customized software programs "CSA analyzer" and "Propero" (University of Southern Denmark, Odense, Denmark). In the analyses of accelerometer data only daytime activity (06:00–24:00 hours) was included. Sequences of 20 minutes or more of consecutive zero counts were interpreted to represent non-wear-time and were excluded from each individual's recording. Data were considered valid if a child had at least three days (including one weekend day) with at least eight hours (480 min) of activity recorded per day. Reasons for not being included in the accelerometer analysis were: not wearing the accelerometer (baseline n = 40, post intervention n = 121), failing to achieve at least three days of assessment (including at least one weekend day) (baseline n = 247, post intervention n = 378) and instrument malfunction (baseline n = 23, post intervention n = 5). The adolescents with valid accelerometer data at both baseline and post intervention (n = 700) are included in this paper. A secondary analysis was done including those registering only for two days, in order to investigate the impact of this attrition.

Sedentary time was defined as activity at intensities less than 100 counts per minute (cpm), and expressed as min/day of accelerometer activity measured which equals the intensity of sitting or lying down (<1.5 MET) [20]. Activity recordings at intensities between 100–2000 cpm were defined as light activity, reflecting activities as standing, walking slowly or easy play. Moderate to vigorous activity (MVPA) was defined as all activity at intensities above 2000 cpm. This threshold is approximately equivalent to a walking pace of 4 km/h in youth [21]. These cut off points have been used in previous studies [22,23]. Sedentary time, light activity and MVPA were expressed as min/day of accelerometer activity measured.

The average number of minutes that the participants wore the accelerometer and the number of activity counts per minute (cpm) were calculated, and mean cpm (mcpm) was used as the main outcome variable. Mcpm as a summary measure of total physical activity in children is commonly used and has been validated against the "gold standard measurement" doubly labelled water and found valid [24]. Since outcomes on mcpm measured by model 7164 and GT1M have shown to differ [25], a free-living validation study of the monitors used in the HEIA study was conducted (Grydeland et al., unpublished observations). As model 7164 showed to measure 11% higher total mcpm than GT1M, a correction factor of 0.9 was applied to the total mcpm from model 7164 to be comparable to the GT1M outcome. This correction factor was applied to all analyses where mcpm was the outcome. To correct for differences in accelerometer model output in minutes spent at different intensity level, a dummy variable was entered into the analyses to adjust for accelerometer model/combination.

Estimate categories were made to detect potential differences in "at school activity" (08:00–15:00) and "after school activity" (15:00–22:00). These estimates were based on accelerometer recordings on weekdays only. The participating schools started and ended school hours at different hours, but no school started before 08.15 hours or ended later than 15.00. Only one school ended at 15.00 hours on one weekday, all else ended earlier. Commuting time is therefore included in "at school activity" time. Participants with mcpm below the median value (mcpm = 480) at baseline were categorized as "low-activity group" and participants above median as "high-activity group".

Anthropometric and demographic measures

Height and weight were measured by trained staff according to standard procedures. Body mass index (BMI) was calculated as weight/(height × height) (kg/m^2). The age- and gender specific BMI cut-off values proposed by the International Obesity Task Force [26] were used to categorize the adolescents as normal weight or overweight. As only 1.9% of the participants at baseline were obese these were included with the overweight in the analyses. The pubertal scale utilized in the study is based on the Pubertal Category Scores (PCS) [27].

Parents reported their educational level as part of the informed consent for their adolescents. Parental education was categorized into three levels: high-school (12 years or less), university/college <3 years (between 13 and 16 years), and university/college >3 years (16 years or more). The information about education from the parent with the highest education was used in the analyses, or else the one available.

Power calculations

The power calculations were primarily based on the main outcome of the HEIA study; changes in BMI, and secondary changes in the addressed behaviors; intake of fruit, vegetables and soft drinks and physical activity [16]. Taking the cluster effect of randomly assigning schools to intervention and control into account, assuming that 80% of the pupils would take part, an attrition rate of maximum 15% per year, we aimed for 40 schools

with an average of 45 pupils participating from each school (n = 1800). The final sample was lower (n = 1580), but the attrition rate per year was only 4%. We concluded that the final sample should have power enough to detect a difference between intervention and control schools after two years. For accelerometer assessed physical activity, a difference of 62 cpm was used in the power analyses, based on a nationally representative population study on 9- and 15-year olds [23].

Data preparation and statistics

For descriptive statistics and dropout analysis, independent t-tests and chi-square tests were used to examine differences between groups (Table 2). The effect analyses were conducted in linear mixed models to be able to take the clustering effect of sampling by school into account. The effect was estimated by a regression of post-test values of mcpm (or other outcome variables) on condition, adjusted for grand mean centered baseline values of mcpm (or other outcome variables). In the main effect analyses (Table 3) a few extreme outliers were replaced by the mean value + 3SD as suggested by Field [28]. All effect analyses were adjusted for covariates and confounders; gender, pubertal status, weight status, month of measuring physical activity and parental education. Analyses were also performed to detect differences in activity on weekdays and weekend days. Intervention effects on time spent at different intensity levels were also tested. Subgroup analyses were performed on gender, weight category, activity category and by parental education category to explore potential differences in effect of the intervention by these subgroups. These subgroups were pre-specified based on the nature of the study (trying to affect the least active and girls in particular). We expected girls to be more conscientious to the intervention components than boys [10,11], the

least active participants to have a larger potential for change, and the overweight and participants of parents from the lowest parental education category to be harder to affect [10]. The significance level was set to 0.05. Data were analysed using the IBM SPSS, version 18 (SPSS Inc., Chicago, IL, USA).

Results

Dropout analyses showed no differences with regard to age, BMI, weight category or parental education between the participants who provided valid accelerometer measures at both time points (n = 700) against the ones who did not provide valid accelerometer measures at both time points (n = 828). There were, however, significantly more boys in the group without valid accelerometer measures (p < 0.001).

There were no significant differences between the intervention and control group at baseline for anthropometric or socio-demographic values (presented in Table 2).

Table 3 shows physical activity at baseline and post intervention and intervention effects. The intervention had an effect on total physical activity at the level of p = 0.05, with a net effect between intervention and control of 50 cpm in favour of the intervention group (95% Confidence Interval –0.4, 100. Mean (SD) accelerometer wear time at baseline was 780 (61) min/day and 793 (58) min/day for intervention and control groups, respectively, with corresponding numbers for post intervention of 771 (73) min/day and 792 (66) min/day. We did rerun the analysis on total physical activity including n = 178/ n = 235 subjects having registered accelerometer data for only two days at baseline and post intervention, respectively. The results from this analysis were of the same magnitude as when applying the full sample (three days registration) of this study (Effect estimate 52 (CI –0.03,

Table 2 Baseline characteristics for the HEIA-study participants [Mean (SD) or %]

	Intervention group (n = 215)	Control group (n = 485)	p
Age (years)	11.2 (0.3)	11.2 (0.3)	0.3
Girls (%)	54	60	0.2
BMI (kg/m^2)	18.0 (2.7)	17.9 (2.7)	0.7
Overweight/obesity[a] (%)	13	14	0.7
Puberty scale score (%)			
Pre-pubertal	17	19	0.8
Early pubertal	34	35	
Mid-late-post pub.	49	47	
Parental education (%)			
<12 years	25	33	0.08
13-16 years	34	34	
>16 years	40	33	

[a]As defined by International Obesity Task Force's cutoffs for overweight/obesity at age from 10.5 to 12.5 [26].

Table 3 Physical activity in the HEIA intervention- (n = 215) and control group (n = 485), and intervention effect*

	BASELINE		POST-INTERVENTION		INTERVENTION EFFECT*	
	Control	Intervention	Control	Intervention		
Counts/min	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Estimate (CI)	p
Overall PA, all (n = 700)	511 (146)	473 (146)**	564 (255)	570 (252)	50 (−0.4, 100)	**0.05**
PA weekdays	553 (165)	509 (164)**	573 (233)	574 (255)	35 (−14, 83)	0.16
PA weekend days	453 (197)	424 (180)	549 (356)	560 (353)	60 (−15, 136)	0.11
Estimated PA at school	621 (189)	604 (188)	582 (223)	559 (208)	2 (−56, 60)	0.94
Estimated PA after-school	504 (248)	432 (217)**	599 (381)	622 (421)	69 (−20, 144)	0.13
Overall PA, girls (n = 392)	478 (128)	464 (151)	506 (230)	535 (234)	65 (5, 124)	**0.03**
PA weekdays	514 (140)	496 (171)	517 (207)	551 (252)	54 (−3, 111)	0.06
PA weekend days	431 (193)	418 (185)	488 (316)	505 (292)	74 (−12, 159)	0.09
Estimated PA at school	561 (170)	559 (186)	500 (182)	527 (181)	30 (−32, 92)	0.34
Estimated PA after-school	480 (213)	453 (239)	565 (352)	608 (416)	81 (−18, 181)	0.11
Overall PA, boys (n = 308)	549 (157)	488 (137)**	632 (268)	622 (268)	32 (−35, 99)	0.35
PA weekdays	598 (181)	528 (152)**	639 (244)	608 (257)	12 (−52, 76)	0.72
PA weekend days	478 (200)	434 (173)	622 (388)	643 (417)	32 (−75, 139)	0.55
Estimated PA at school	691 (186)	673 (170)	679 (228)	606 (237)	−40 (−119, 40)	0.32
Estimated PA after-school	532 (281)	401 (177)**	639 (410)	643 (429)	37 (−70, 144)	0.50

PA, physical activity. * Effect analyses were adjusted for school clustering, baseline physical activity, gender, pubertal status, month of measuring physical activity, weight category and parental education. ** Intervention group means significantly lower than control group means, p < 0.01. Test of interaction condition x gender: p = 0.22.

104), p = 0.05). The subgroup analyses indicated a significant effect in girls (p < 0.03) but not in boys (p = 0.35).

Change in physical activity pertaining to intensity levels is shown in Table 4. There was no significant intervention effect for time spent sedentary between the intervention group and the control group (p = 0.16). At baseline both intervention and control participants spent on average 63% of the monitored time sedentary, and both groups had an increase in time spent sedentary from age eleven to 13. Stratified gender analyses revealed a significant intervention effect for girls of 22 minutes (CI 5, 124, p = 0.03) for time spent sedentary, reflecting

Table 4 Minutes distributed at intensity levels in the HEIA intervention- and control group, and intervention effect*

	BASELINE		POST-INTERVENTION		INTERVENTION EFFECT*	
	Control	Intervention	Control	Intervention		
Minutes in:	Mean (SE)	Mean (SE)	Mean (SE)	Mean (SE)	Estimate (CI)	p
All (n = 700):						
Sedentary activity	495 (3.0)	496 (4.6)	519 (3.4)	506 (5.2)**	−14 (−33, 6)	0.16
Light activity	229 (1.8)	224 (2.9)	202 (2.0)	195 (3.1)**	−5 (−15, 5)	0.33
MVPA	68 (1.0)	63 (1.6)**	71 (1.3)	67 (2.0)	2 (−3, 7)	0.45
Girls (n = 392):						
Sedentary activity	499 (4.0)	496 (6.0)	533 (4.3)	510 (6.1)	−22 (−43, -2)	**0.03**
Light activity	229 (2.3)	221 (3.5)	201 (2.6)	193 (3.8)	−3 (−14, 9)	0.63
MVPA	62 (1.2)	60 (1.8)	62 (1.4)	62 (2.0)	5 (−2, 12)	0.13
Boys (n = 308):						
Sedentary activity	490 (4.3)	495 (7.3)	502 (5.4)	499 (8.7)	−9 (−36, 18)	0.50
Light activity	228 (2.9)	228 (4.9)	202 (3.2)	197 (5.1)	7 (−20, 7)	0.33
MVPA	75 (1.7)	68 (2.9)	81 (2.2)	75 (3.5)	1 (−10, 7)	0.77

Intervention group n = 215, control group n = 485. Sedentary activity <100 cpm, Light activity ≥100 < 2000 cpm, MVPA ≥2000 cpm. MVPA: moderate to vigorous physical activity. Mean values are adjusted for accelerometer model at baseline and post intervention. * Effect analyses were adjusted for school clustering, baseline physical activity, gender, pubertal status, accelerometer model, month of measuring physical activity, weight category and parental education. ** Intervention group means significantly lower than control group means, p < 0.05. Test of interaction condition x gender: p = 0.22.

a significantly smaller increase in sedentary time among girls in the intervention group versus the control group. No similar effect was seen among boys.

Table 5 shows mcpm and intervention effect with participants grouped by baseline activity level and weight status. In the low activity group there was a significant overall positive intervention effect of net 92 cpm (CI 41, 142, p < 0.001), while no effect was seen in the high activity group. The intervention participants in the low-activity group showed a significant net increase of 96 cpm compared to the control group during weekdays (Effect estimate 96 (CI 46, 145) p < 0.001), whereas no intervention effects were seen during weekend days (data not shown). There was no intervention effect during school hours. Regarding after school hours physical activity, participants in the low-activity category from the intervention group had a net increase of 159 cpm more than the control group (Effect estimate 159 (CI 77, 241) p < 0.001). There was no intervention effect on participants in the high-activity category (data not shown).

Categorized by weight status, the analyses show that the normal weight in the intervention group increased their physical activity significantly more than the normal weight in the control group, with a net increase of 62 cpm (CI 10, 115, p = 0.02). Physical activity during weekdays and weekend days, and during school hours and after school hours was investigated, but no differences were found between groups (data not shown).

Finally, effect analyses were also run for participants stratified by level of parental education (Table 6). There were no intervention effects for participants with parents having less than twelve years of education and for participants with parents having more than 16 years of education. But, for participants with parents in the middle parental education level category of 13–16 years of education, we found a significant intervention effect on overall physical activity level (Effect estimate 98 (CI 17, 178) p = 0.02) and for physical activity during weekend days (Effect estimate 157 (CI 43, 271) p = 0.008) in favour of the intervention group.

Discussion

The present study showed an intervention effect on overall physical activity at the 5% alpha level. The intervention effect appeared to be more profound among girls, and among participants in the low-activity group compared to boys and to participants in the high-activity group, respectively. Further, the intervention appeared to have a stronger effect among normal weight participants and participants with parents reporting 13–16 years of education compared to their counterparts.

With an intervention effect at alpha level 0.05 there is a degree of uncertainty to the results that needs to be considered. There is a 5% chance that the findings are not attributed to the intervention, which means the greatest value of uncertainty conventionally accepted before the findings are dismissed as non-significant. Keeping this in mind, the intervention effect on total physical activity is somewhat in contrast to results from the KISS intervention; a Swiss cluster randomized controlled school based physical activity programme. The KISS study, while comprising a bit younger participants, showed a favourable intervention effect on moderate to vigorous activity at school and all day, and also on total physical activity at school, but no effect on overall daily physical activity [29]. No intervention effect on overall physical activity was shown in the Danish CoSCIS study either, with an intervention including a doubling of time for PE among 6–7 year olds [30]. Compared to the KISS programme and the CoSCIS study, the HEIA intervention had less promotion of high intensity activities but focussed on increasing overall physical activity. While the HEIA study used a multi-facetted approach to increase physical activity including several small reminders and opportunities to increase all day physical activity level, the KISS study was oriented toward PE and using expert PE teachers and extracurricular mandatory PE. The CoSCIS study also used PE as their main intervention component, including a doubling of lessons per week, teacher training and an upgrade of PE and playing facilities. From the effect analyses it is not possible to

Table 5 Physical activity by baseline activity level and weight status, and intervention effect*

| | BASELINE | | POST-INTERVENTION | | INTERVENTION EFFECT* | |
| | Control | Intervention | Control | Intervention | | |
Counts/min: All (n = 700)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Estimate (CI)	p
Low-activity group (n = 350)	392 (66)	373 (59)**	499 (231)	557 (261)§	92 (41, 142)	**<0.001**
High-activity group (n = 350)	615 (114)	608 (115)	621 (263)	587 (239)	10 (−67, 87)	0.79
Normal weight (n = 591)	517 (142)	482 (146)**	565 (252)	585 (248)	62 (10, 115)	**0.02**
Overweight (n = 93)	468 (160)	406 (115)	566 (283)	432 (173)	−96 (−211, 19)	0.10

* Analyses were adjusted for school clustering, baseline physical activity, gender, pubertal status, month of measuring physical activity, weight category and parental education. ** Intervention group mean significantly lower than control group mean, p < 0.05. § Intervention group mean significantly higher than control group mean, p < 0.05. Test of interaction condition x activity level: p = 0.16, condition x weight status: p = 0.16.

Table 6 Physical activity by level of parental education and intervention effect*

	BASELINE		POST-INTERVENTION		INTERVENTION EFFECT*	
	Control	Intervention	Control	Intervention		
Parental education/Counts/min	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Estimate (CI)	p
≤12 years (n = 211)	504 (156)	481 (141)	559 (278)	554 (236)	43 (−37, 123)	0.29
PA weekdays	564 (177)	538 (158)	563 (240)	570 (249)	38 (−40, 115)	0.34
PA weekend days	421 (196)	405 (167)	551 (370)	538 (364)	55 (−53, 163)	0.31
Estimated PA at school	637 (202)	645 (197)	602 (246)	557 (185)	−6 (−77, 66)	0.88
Estimated PA after-school	508 (245)	457 (208)	550 (353)	625 (403)	107 (−9, 223)	0.07
13-16 years (n = 236)	505 (141)	465 (145)**	568 (233)	617 (284)	98 (17, 178)	**0.02**
PA weekdays	537 (149)	500 (161)	595 (225)	597 (272)	39 (−32, 109)	0.27
PA weekend days	454 (198)	415 (176)	529 (331)	621 (381)	157 (43, 271)	**0.008**
Estimated PA at school	593 (178)	588 (199)	591 (197)	576 (221)	27 (−40, 94)	0.41
Estimated PA after-school	500 (257)	424 (193)**	646 (419)	665 (485)	47 (−98, 192)	0.52
>16 (n = 240)	521 (136)	478 (152)**	556 (252)	546 (230)	2 (−90, 94)	0.96
PA weekdays	552 (159)	501 (170)**	551 (228)	561 (248)	31 (−43, 104)	0.40
PA weekend days	483 (193)	444 (194)	562 (366)	529 (321)	−28 (−166, 109)	0.67
Estimated PA at school	632 (182)	596 (171)	551 (226)	543 (214)	−13 (−92, 66)	0.74
Estimated PA after-school	496 (226)	426 (246)**	580 (347)	593 (376)	50 (−53, 153)	0.33

* Effect analyses were adjusted for school clustering, baseline physical activity, gender, pubertal status, month of measuring physical activity and weight category
** Intervention group means significantly lower than control group means, p < 0.05. Test of interaction condition x parental education: p = 0.03.

disentangle specific intervention components to account for our findings. Some intervention components may have been more effective than others, or results may reflect synergistic effects of the intervention program as a whole. Thus, in concordance with suggestions in recent reviews [6,8], the HEIA study aimed to affect physical activity in adolescents through multiple components and by combining personal, social and physical environmental factors. The increase in physical activity from baseline to post intervention in the control group was unexpected, as previous literature has shown decreasing physical activity with increasing age in youth [1,23,30]. Since both groups increased, an increase as a result of the intervention may have been harder to detect, yet the intervention showed a positive effect. The intervention group was significantly less active than the control group at baseline, and it can be argued that the intervention group had a larger potential for change. However, these issues were taken care of by controlling for baseline-values in the effect analyses.

The relatively large increase in physical activity from baseline to post intervention in both groups can be attributed to seasonal variation. The baseline physical activity assessment was conducted during fall and post intervention assessment during spring. Kolle et al. (2009) observed seasonal variations in physical activity among 9 year old Norwegian children, but not among 15 year olds [31]. The intervention effect should, however, not be affected by season, as both groups were measured simultaneously. The increase might also be a result of contamination effects of being the control group in a study aimed at increasing physical activity. When recruiting schools, most schools stated that they were hoping to become an intervention school to receive the intervention efforts. This could have stimulated the control schools to initiate their own "intervention".

The overall increase in physical activity from baseline to post intervention was seen both on weekdays and weekend days, but with a larger increase on weekend days. The larger increase during weekend days may reflect the larger potential for change since the baseline values within that period of the week were considerably lower than during weekdays. The intervention components addressed both weekday and weekend day activity. The finding that the physical activity level was higher during weekdays than weekend days is consistent with earlier cross-sectional findings from Norwegian 9 and 15 year olds [23].

The participants' mean distribution of activity in our study differed between the two time points. Physical activity during school hours declined and physical activity after school hours and during weekend days increased for both groups and both genders. The decline in physical activity at school might be due to more demanding school curricula in 7th grade than 6th grade, and happened despite several intervention efforts aimed at increasing physical activity at school. A reason for the demonstrated decline in physical activity during school

hours may also be a lack of facilities perceived as attractive by the adolescents as they grow older. Nettlefold et al. (2011) studied physical activity during the school day in Canadian 8–11 year olds and observed low physical activity during parts of the school day [32]. The authors pointed out an urgent need to increase the intensity of activity during PE, and to provide more and/or facilitated opportunities for physical activity during school breaks. Haug et al. (2010) found that outdoor facilities in Norwegian secondary schools were associated with students' daily physical activity participation during school breaks [33]. Students in schools with many facilities had significantly higher odds of being physically active compared to students in schools with fewer facilities [33]. The activity increase in both groups after school hours is hard to explain. A possible reason may be increased volume of exercise in leisure time sports activities with increasing age. The participants may also have been stimulated to increase leisure time physical activity in line with the HEIA study aims. There was, however, no intervention effect on these outcomes. Concerning time spent at different intensity levels, no intervention effect was seen for time spent in MVPA. Nevertheless, this was not a targeted aim of the study. However, reducing sedentary time was a clear aim of the study but no intervention effect was seen for the total sample. Exploring subgroups, boys appeared to have higher overall physical activity on all time points than girls, but the difference in increase from baseline to post intervention was significantly higher among girls in the intervention group compared to girls in the control group. The gender difference in intervention effect was also seen with time spent at different intensity levels as outcome. Girls in the intervention group increased significantly less in sedentary time from baseline to post intervention than girls in the control group. This is promising, as a recent comprehensive systematic review revealed a dose–response relationship between increased sedentary behaviour and unfavourable health outcomes in school-aged children [34]. When the intervention strategies were planned and developed, the study group had a particular focus on making sure that it should appeal to inactive girls. By offering low threshold activities the aim was to make the physically less active participants want to take part rather than fear to take part. Intervention strategies aimed to target certain groups have earlier showed diverging results [6]. These results suggest that having an inclusive approach but focusing on certain subgroups within the intervention can be successful. However, when interpreting the findings one should be aware of the lack of significant interaction between condition and gender. When an interaction term shows $p < 0.1$ subgroup analysis is conventionally required for statistical reasons. We based our subgroup analyses on pre-specified hypotheses based on the nature of the study and previous findings [10,14,15]. To evaluate the credibility of subgroup analyses Sun et al. (2010) have suggested eleven criteria [35]. By meeting most, but not all these criteria, we find support for doing these secondary investigations, but we also acknowledge a degree of uncertainty of these exploratory findings.

Gender aside, the intervention appeared to affect other subgroups differently as well. The intervention participants in the low-activity group demonstrated a significant increase in physical activity from baseline to post intervention. These results are encouraging, as increasing the activity level among the least active can cause larger health benefits than among participants already active [36]. As a decline in physical activity with increasing age can be expected [1,23], it is also noteworthy that we did not observe a significant decrease in the high-activity group. Among those overweight, the participants in the control group were more active at both time points and had a more positive development than participants in the intervention group. The issue of different responses on different groups are discussed by Brown and Summerbell (2009) in a comprehensive review on obesity-prevention in school-children [11]. They suggest that particularly boys and girls and those differentiating in weight status in the age range of 10 to 14 seem to respond differently to different elements of the interventions [11]. Participants from different parental education categories were also affected differently by the intervention. An intervention effect was observed only among participants with parents having a "mid-range" educational level. However, investigating other outcomes in the HEIA study, Bjelland et al. (2011) found no moderating effects of parental education for boys or girls with respect to intake of sugar-sweetened beverages, time used for watching TV/DVD and computer/game-use [16]. The results of this intervention study are important to public health, as feasibility and sustainability were high priorities when designing the intervention. This has been recommended in previous studies and reviews [6,8,37]. Although comprehensive, the intervention components were designed to be able to fit into current school curricula without substantial extra costs. With limited instructions and material provided by the study group, teachers were key deliverers of the intervention components. No extra personnel or costly material are needed to carry out such components in the current school system, and all components could easily be incorporated into existing curricula for this age group.

Strengths and limitations

The strengths of the present study include the study design and the large number of participants. The multicomponent intervention, lasting 20 months, was designed to be feasible

to the school system and not financially demanding. Also, measures including objectively assessed anthropometric measures, pubertal maturation, self-reported parental education and whole sample measurement of physical activity by accelerometers are clear strengths of this study.

We acknowledge that our study has several limitations. Firstly, the use of two different generations of accelerometers (for practical reasons) represents an element of uncertainty compared to using only one kind. To address this issue we explored the potential difference between generations of monitors, and adjusted the values accordingly. Secondly, at baseline physical activity was assessed during fall and at post intervention physical activity was assessed during spring. However, the measurement month was adjusted for in the effect analyses, and this issue was also taken care of by the study design. Thirdly, according to the power-calculations of the study [16], the number of participants providing valid accelerometer data at both time points was lower than opted for, and a higher number of participants with valid recordings may have made it easier to detect significant intervention effects on physical activity. However, the power-calculations on physical activity may also have been overestimated, since investigating change in such large groups objectively has rarely been done in previous studies. The large drop-out reduces the generalizability of the results. However, few differences were seen between those who provided accelerometer data at both time points and those who did not. Fourthly, the use of subgroup analysis is criticized by some and called for by others [38]. We chose to include subgroup analyses based on the nature of the study where specific groups were targeted when planning the intervention efforts. Furthermore, the HEIA intervention components were primarily delivered through the teachers at the intervention schools. Unpublished process evaluation revealed that the degree of implementation differed between schools [39], with a reduced dose of intervention received by the participants observed from mid-way to post intervention [14]. Also, when investigating intervention effects of a multi-component intervention, it is not possible to sort out whether or how the components worked separately. Finally, the potential for generalization of our findings might be limited as the sample was recruited from a limited geographic area. However, comparing the HEIA study sample to nationally representative figures for 9 and 15-year-olds, the measures from the participants in the HEIA study lie adequately between the measures of the 9 and 15-year-olds when it comes to objectively measured height, weight and total physical activity [40].

Conclusions

A comprehensive but feasible, multi-component school-based intervention can affect physical activity patterns in adolescents by increasing overall physical activity. This intervention effect seemed to be more profound in girls than boys, low-active adolescents compared to high-active adolescents, participants with normal weight compared to overweight, and for participants with parents having middle education level as opposed to high and low education level, respectively. An implementation of these intervention components in the school system may have a beneficial effect on public health by increasing overall physical activity among adolescents and possibly among girls and low-active adolescents in particular.

Authors' contributions
All authors are responsible for the reported research. MG worked on the statistical analyses, wrote the first draft of the manuscript and made the greatest contribution to the paper. NL was the project coordinator and participated in all parts of the work. KIK, LFA, YO and SAA were mainly involved in designing the study while IHB, MB and MG were mainly responsible for planning and conducting the data collections and the intervention. KIK initiated the study. All authors provided critical revision of the paper, and read and approved the final manuscript.

Author details
[1]Department of Nutrition, Faculty of Medicine, University of Oslo, Oslo, Norway. [2]Department of Sports Medicine, Norwegian School of Sports Sciences, PB 4014 Ullevaal Stadion, Oslo NO-0806, Norway. [3]Department of Coaching and Psychology, Norwegian School of Sport Sciences, Oslo, Norway.

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Paper III

Effects of a 20-month cluster randomised controlled school-based intervention trial on BMI of school-aged boys and girls: the HEIA study

May Grydeland,[1,2] Mona Bjelland,[2] Sigmund Alfred Anderssen,[1] Knut-Inge Klepp,[2] Ingunn Holden Bergh,[3] Lene Frost Andersen,[2] Yngvar Ommundsen,[3] Nanna Lien[2]

[1]Department of Sports Medicine, Norwegian School of Sport Sciences, Oslo, Norway
[2]Department of Nutrition, Faculty of Medicine, University of Oslo, Oslo, Norway
[3]Department of Coaching and Psychology, Norwegian School of Sport Sciences, Oslo, Norway

Correspondence to
May Grydeland, Department of Sports Medicine, Norwegian School of Sport Sciences, PB 4014 Ullevaal Stadion, NO-0806, Oslo 0806, Norway; may.grydeland@nih.no

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ABSTRACT

Background School-based interventions that target prevention of overweight and obesity in children have been tested with mixed results. Thus, successful interventions are still called for. The aim of the present study was to investigate effects of a multicomponent school-based intervention programme targeting physical activity, sedentary and dietary behaviours on anthropometric outcomes.

Methods A 20-month intervention was evaluated in a cluster randomised, controlled study of 1324 11-year-olds. Outcome variables were body mass index (BMI), BMI-for-age z-score (BMIz), waist circumference (WC), waist-to-height ratio (WTHR) and weight status (International Obesity Task Force's cut-offs). Weight, height and WC were measured objectively; pubertal status was self-reported and parental education was self-reported by the parents. Intervention effects were determined by one-way analysis of covariance and logistic regression, after checking for clustering effects of school, and moderating effects of gender, pubertal status and parental education.

Results Beneficial effects were found for BMI ($p=0.02$) and BMIz ($p=0.003$) in girls, but not in boys. While a beneficial effect was found for BMI ($p=0.03$) in participants of parents reporting a high level of education, a negative effect was found for WTHR in participants with parents reporting a low level of education ($p=0.003$). There were no intervention effects for WC and weight status.

Conclusions A multicomponent 20-month school-based intervention had a beneficial effect on BMI and BMIz in adolescent girls, but not in boys. Furthermore, children of higher educated parents seemed to benefit more from the intervention, and this needs attention in future interventions to avoid further increase in social inequalities in overweight and obesity.

BACKGROUND

The increasing rates of overweight and obesity in children and adolescents have resulted in several initiatives aiming to prevent further development of the epidemic. School-based interventions targeting prevention of overweight and obesity in children have yielded mixed results.[1] [2] However, evidence supports beneficial effects of child obesity prevention programmes on body mass index (BMI) in systematically developed interventions that promote healthy eating and physical activity and emphasise support from teachers and parents and home activities.[1]

A recent systematic review and meta-analysis of controlled trials of objectively measured physical activity concluded that successful physical activity interventions have only had a small effect on children's overall activity levels,[3] which may partly explain why they have had limited success in preventing childhood obesity. Methodological shortcomings have also been used as an explanation for the lack of intervention effects.[2] Many intervention studies are underpowered to detect small differences between groups, particularly on adiposity outcomes.[1] Longer term programmes and comprehensive school-based interventions may be more effective than shorter programmes.[4–6] There is ongoing discussion regarding the optimal measure of adiposity in larger studies of children and adolescents. Some authors claim that BMI-for-age z-score (BMIz) is the best measure as it adjusts for the age and gender of the child[7] while others claim that BMI most aptly represents a child's adiposity.[8] [9] BMI and BMIz are merely estimates of body fatness as these indices do not differentiate between the types of tissue that contribute to body weight (fat, muscle or bone mass).

To determine whether a school-based intervention is truly an effective means to reduce body fat, it may be necessary to assess it using a number of different anthropometric variables.[4] Questions have also been raised about intervention reach.[2] Gender and socioeconomic status may moderate intervention effects.[10] There are still relatively few methodologically strong trials aimed at the primary prevention of weight gain in older children, thus indicating a need to strengthen the evidence base.[6] [11] [12]

Previous results from the HEalth in Adolescents (HEIA) study have shown intervention effects both in psychological and social-environmental determinants of physical activity[13] and in targeted behaviours like time spent watching TV/DVD, computer/game use, consumption of sugar-sweetened beverages[14] and physical activity[15] in either the total sample or the subgroups.

Therefore, we address the following primary objective: to investigate the effects of a systematically developed, 20-month multicomponent school-based intervention programme, the HEIA study, on BMI.

Our secondary objectives were to investigate whether the effect of the intervention on anthropometry was influenced by gender, pubertal status or level of parental education.

METHODS

The HEIA study was based on a socioecological framework and the intervention was designed so that it was

Original article

feasible to implement and of low cost so that it could be sustained in the public school system. The design and procedures of the HEIA study are thoroughly described elsewhere.[16] The CONSORT Statement for reporting a randomised trial was followed according to applicability (http://www.consort-statement.org).

Study design and participants
Eligible schools were those with more than 40 students in the sixth grade and located in the largest towns/municipalities in seven counties in south-eastern Norway. Of the 177 schools invited, 37 agreed to participate (figure 1). All sixth graders in these 37 schools (n=2165) were invited to participate. Of these, 1580 (73%) children returned a parent-signed informed consent form. Twelve schools were randomly assigned by blind draw with all investigators present to the intervention group (n=784 children) and 25 schools to the control group (n=1381 children). Neither participants nor investigators were blinded for condition.

The data collections took place at each school in September 2007 (baseline) and in May 2009 (postintervention). Anthropometrics were measured by trained staff, and participants filled in a short-paper questionnaire about pubertal status; 1376 children (87% of those returning consent) provided data at baseline and 1361 children at postintervention. A total of 1324 children provided data at both time points which constitute the analysed sample in this paper. A priori, per protocol and drop-out analyses were chosen over intention-to-treat.[17] Power calculations were based on changes in BMI. Taking the cluster effect of randomly assigning schools to intervention and control into account, assuming that 80% of the students would participate and that the attrition rate would not exceed 15%/year, we aimed for 40 schools (10 intervention and 30 control) with an average of 45 students participating from each school. According to these assumptions, we calculated that we should be able to detect a difference between intervention and control schools after 2 years of 0.72 kg/m^2 in BMI.[16]

Ethical approval and research clearance were obtained from the Regional Committees for Medical Research Ethics in Norway and from the Norwegian Social Science Data Service.

Intervention
The multilevel approach included collaboration with school principals and teachers, school-health services and parent committees. Multiple intervention efforts were orchestrated to promote a healthy diet and to increase awareness of healthy choices, to increase participants' physical activity during school hours and leisure time, and to reduce screen-time. Schoolteachers were the key-persons to implement the intervention components. The main ones are outlined in table 1 and further described elsewhere.[16]

Anthropometric outcomes
A trained staff person of the same sex as the study participant conducted the anthropometry. Participants wore light clothing or underwear only during these assessments. Height was measured to the nearest 0.1 cm by a wall-mounted measurement tape with the participant standing upright against the wall. Weight was measured to the nearest 0.1 kg by a digital scale/body composition analyser (Tanita TBF-300; Tanita Corp., Illinois, USA). Waist circumference (WC) was measured to the nearest 0.1 cm by a measuring tape between the lower rib and the iliac-crest at the end of a normal expiration. BMI was calculated (kg/m^2). BMI-for-age and sex z-score (BMIz) was calculated by adapting syntaxes for SPSS provided by WHO.[19] The age-specific and gender-specific BMI cut-off values proposed by the International Obesity Task Force were used to categorise the children as being of normal weight or overweight/obese.[20] Only 1.8% of the participants at baseline were obese and thus included with those overweight in the analyses. Waist-to-height ratio (WTHR) was calculated as the ratio of waist (cm) to height (cm).

For ethical reasons, children were asked to self-report their pubertal status by a separate and sex-specific paper questionnaire at the end of the data collection. The questionnaire was based on the Pubertal Category Scores.[21] The children were categorised into five puberty categories which were collapsed to three because of low numbers in the latter two categories (3.5% of the participants in total): prepubertal, early-pubertal, midpubertal/late-pubertal/postpubertal. A reliability study of the anthropometric measures was conducted prior to the survey

Figure 1 Flow diagram of recruitment, randomisation and participation of children in the HEalth in Adolescents study. *Percentage of participants with consent.
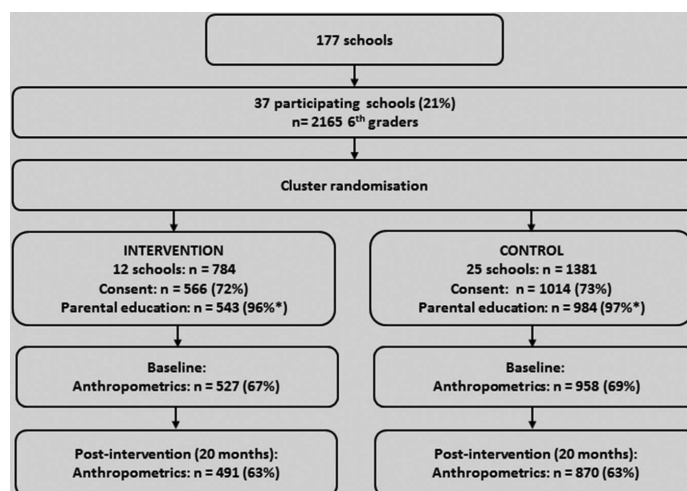
Table 1 The HEIA study: intervention components implemented in the sixth and seventh grades in 12 Norwegian schools in 2007/2008 and 2008/2009

Setting/arena	What	Timing	Purpose
Class (initiated by classroom-teachers)	Lessons with student booklet: 1. Diet and physical activity 2. Meals 3. 5 a day 4. Sugar-rich beverages 5. Your choice	Once a month—6th grade winter/spring	Increase awareness of behaviour-health relationship, recommended intake levels and own intake
	Posters for classrooms: Key messages, A4-size, placed on a larger 'frame-poster' including the HEIA logo	Monthly—throughout the intervention	As a daily reminder of main messages (topic matched fact sheets to parents)
	Fruit and vegetable (FV) break: Cutting equipment per class provided, students brought FV	Once a week–throughout the intervention	Increase FV intake; cut, serve, taste and eat FV with classmates
	Physical activity (PA) break: 10 min of PA conducted in regular classrooms, booklet with ideas and CD provided	Once a week—throughout the intervention	Increase PA; introduce PA also outside of PE and by classroom-teachers
	Sports equipment for recess activities: 1–2 large boxes per school. Examples of content: Frisbees, jump-ropes, elastic bands, hockey-sticks, a variety of balls	Every day—throughout the intervention (some refill in seventh grade)	Increase PA; stimulate PA during recess—especially among those who do not play ball games
	Active commuting campaigns: Register days with active transport to/from school for 3 weeks (5 campaigns)	5×3 weeks: sixth grade: fall, winter and spring seventh grade: fall, winter	Increase PA; stimulate activity
	Pedometer: One class-set per school to be used in PE (SPARK), as tasks at school, as home assignment and active commuting	Seventh grade	Increase awareness about PA level; stimulate activity
	Computer tailored individual advice 1. Fruit 2. Vegetables 3. Physical activity 4. Screen time 5. Sugar sweetened beverages + 1-week action plans for each topic (instruction on what, where and when to do the suggestions for behaviour change)	Seventh grade Fall Fall Winter/spring Winter/spring Winter/spring	Increase awareness of; Recommended intake and PA level Own intake of FV, PA level and hours of screen time Received personal advice about what and how to change
Home/parents	Fact sheets Facts on targeted behaviours. Practical tasks/challenges for leisure time/weekends in seventh grade	Monthly—throughout the intervention, one behaviour per fact sheet	To stimulate parents to evaluate and change the home environment with regard to facilitating or regulating the targeted behaviours
	Brochures/information sheets Teachers were provided info sheets about the FV break that they could use to inform parents about these	Once	To ensure that the fact sheets were read and discussed/applied to the home environment
	Brochures: 'Cutting FV' 'Meals—a value worth fighting for'. Handed out together with related fact sheets	Once	To provide knowledge and inspiration.
School-wide	Kick-off meetings at each school:Teacher manuals presented, practical activities tested, material partially provided	Once a year—sixth and seventh grades (fall), 2–3 h each time	To inform the school management, teachers, school nurse and parent committees about the project and establish/inform the grade level teachers as the 'HEIA team' at school
	Inspirational courses for PE teachers SPARK ideas/principles[18]	Once a year—sixth and seventh grades (fall), 6 h each time	Teacher training for PE teachers; methods/activities to increase activity time, enjoyment and self-efficacy for all students during PE classes
	Resource box for school management Offer to order free toolbox for cutting and selling FV	Optional	Focus on healthy food/drinks offered in school/during school events
	Committee meetings Meetings with school environment groups/parent committees	Optional	Aimed to stimulate easy-to-do changes on the school grounds that could stimulate activity (booklet/ideas provided). Increase awareness of healthy foods and beverages
Leisure time activities (NGO's)*	Information folder and offer to receive a resource box with equipment for cutting and selling FV	Seventh grade (fall)	Create awareness about leisure time activity leaders as role models for dietary habits, to reflect upon availability of food/drinks during practices and events (ie, tournaments, weekend training sessions, etc)

*Not successfully implemented.
FV, fruits and vegetables; HEIA, HEalth In Adolescents; NGO, non-governmental organisation; PE, physical education.

among 114 children;[16] all tests had a reasonable reproducibility (intra-class correlation (ICC) and Pearson's R 0.76–0.99, p<0.001, except voice change (boys only) ICC 0.36, p<0.006).

Demographic characteristics

On the informed consent, parents reported their educational level. Parental education was categorised into three levels: <12 years (low), 13–16 years (medium) and >16 years (high).

If both parents provided level of education, we included the parent with the highest level of education in our analyses; we otherwise used data provided by either parent.

Data preparation and statistics

To address the clustered effects of schools as the unit of recruitment while children were the unit of analysis, we conducted a Linear Mixed Model Procedure (analyses available upon request). Both Tabachnick and Fidell and Heck et al state that if the ICC is small when quantifying the degree of clustering (<5%), there is no meaningful difference among groups and the data may be analysed at the individual level.[22 23] As only 2% of the variance in BMI and WC was explained by group, we did not adjust for clustering in our analysis.[22 23]

Baseline differences between the intervention and control groups were tested with independent sample t tests and a χ^2 test. Drop-out analyses were done likewise. The effect of the intervention was determined using one-way analysis of covariance (ANCOVA) with the postintervention value for the outcomes as the dependent variables (continuous variables), baseline values of the outcomes as covariates and group (intervention vs control) as the independent variable. The same technique was used for categorical outcomes using logistic regressions. Interaction effects by gender, pubertal status and parental educational level were tested in separate analyses as a second step using two-way ANCOVA/logistic regressions with the interaction terms as covariates. The significance level of the interaction tests was set to p<0.1. Significant interactions were explored by rerunning the analyses stratified by the moderator.

The significance level of the main analyses was set to p<0.05. Data were analysed using the IBM SPSS Statistics V.18 (IBM Corp., New York, New York, USA).

RESULTS

Only 4% of children dropped out of the study and attrition was equal between the intervention (n=17) and control (n=35) groups. Drop-out analyses showed that the participants lost to follow-up (n=52) weighed more (42.8 vs 39.7 kg, p=0.01) and had a higher BMI (19.2 vs 17.9 kg/m², p=0.01) and BMIz (0.55 vs 0.10, p=0.003) than the investigated sample (n=1324). No other differences were detected.

There were no significant differences between the intervention and control groups at baseline with respect to age, gender, weight, height, pubertal status and parental education (table 2), as well as for body composition estimates. Table 2 also shows baseline characteristics by gender for descriptive purposes.

For the total sample, there were no significant intervention effects on any of the body composition measures outlined in table 3, or for weight status: OR 1.6 (95% CI 0.9 to 2.7), p=0.1. Gender was identified as a moderator of the intervention effects on BMI (p=0.02), BMIz (p<0.01), WC (p=0.05) and WTHR (p=0.05). The effect on BMI was also moderated by parental education (p=0.04); similar was the effect on WTHR (p=0.06). No moderating effects of pubertal status were detected (data not shown). After stratification, there was a significant intervention effect on BMI for girls; girls in the intervention group increased less on BMI compared with the control group. No such effect was seen for boys. Similarly, an intervention effect was seen on BMIz for girls but not for boys. For WC and WTHR, there was no significant intervention effect for either gender after stratification (table 3). Furthermore, a beneficial intervention effect on BMI among the participants of parents with high education was found, but no effect was detected among participants of parents with medium or low education. For WTHR, a negative effect was found among participants of parents with low education.

Table 2 Characteristics at baseline for the HEIA study intervention and control groups and by gender

	Control (n=859)	Intervention (n=465)	p Value*	Girls (n=643)	Boys (n=681)
Age (years)	11.2 (0.3)	11.2 (0.3)	0.59	11.2 (0.3)	11.2 (0.3)
Girls (% (n))	48 (409)	50 (234)	0.35		
Weight (kg)	39.8 (7.8)	39.5 (7.6)	0.46	40.2 (7.9)	39.2 (7.6)
Height (cm)	148.5 (6.8)	148.6 (6.7)	0.93	149.0 (7.2)	148.2 (6.4)
Puberty scale score (% (n))			0.38		
Prepubertal	21.5 (174)	19.4 (85)		9.4 (59)	32.2 (200)
Early pubertal	35.9 (291)	33.9 (149)		19.4 (122)	51.1 (318)
Mid-late-postpubertal	42.7 (346)	46.7 (205)		71.2 (447)	16.7 (104)
Parental education (years) (% (n))			0.10		
<12	30.9 (259)	26.7 (120)		29.9 (188)	28.9 (191)
13–16	36.2 (304)	36.7 (165)		33.0 (207)	39.6 (262)
>16	32.9 (276)	36.7 (165)		37.1 (233)	31.5 (208)
BMI (kg/m²)	17.9 (2.6)	17.8 (2.5)	0.29	18.0 (2.6)	17.8 (2.6)
BMI z-score	0.13 (1.08)	0.06 (1.03)	0.29	0.08 (1.01)	0.13 (1.11)
Overweight/obesity† (% (n))	14 (120)	11 (50)	0.10	13 (85)	12 (85)
Waist circumference (cm)	63.3 (6.5)	62.7 (6.1)	0.10	62.2 (6.2)	63.9 (6.5)
Waist-to-height ratio (WTHR)	0.43 (0.04)	0.42 (0.04)	0.06	0.42 (0.04)	0.43 (0.04)

*Differences between intervention and control groups were tested by student t test/χ^2 test.
†As defined by the International Obesity Task Force's cut-offs for overweight/obesity at ages from 10.5 to 12.5 (weight status).
BMI, body mass index; HEIA, HEalth In Adolescents.

Table 3 Intervention effects of the HEIA study on anthropometric outcomes after 20 months; total sample and by gender and parental education

	Control (n=859) Mean (95% CI)	Intervention (n=465) Mean (95% CI)	p Value
BMI, total sample	18.9 (18.8 to 18.9)	18.8 (18.7 to 18.9)	0.501
Gender			
Girls	19.2 (19.1 to 19.3)	19.0 (18.8 to 19.3)	**0.024**
Boys	18.5 (18.4 to 18.6)	18.6 (18.5 to 18.7)	0.306
Parental education			
Low	19.3 (19.1 to 19.4)	19.4 (19.2 to 19.7)	0.189
Medium	18.7 (18.6, 18.8)	18.7 (18.5 to 18.8)	0.742
High	18.6 (18.5 to 18.8)	18.4 (18.2 to 18.6)	**0.027**
BMIz, total sample	−0.01 (−0.04 to 0.02)	−0.04 (−0.09 to 0.00)	0.227
Gender			
Girls	0.03 (−0.01 to 0.08)	−0.8 (−0.14 to −0.02)	**0.003**
Boys	−0.05 (−0.09 to −0.00)	−0.01 (−0.07 to 0.05)	0.322
WC, total sample	66.2 (66.0 to 66.5)	66.4 (66.0 to 66.7)	0.502
Gender			
Girls	66.0 (66.0 to 66.3)	65.7 (65.3 to 66.1)	0.279
Boys	66.4 (66.1 to 67.5)	67.0 (66.5 to 67.5)	0.089
WTHR, total sample	0.416 (0.415 to 0.418)	0.418 (0.415 to 0.420)	0.412
Gender			
Girls	0.414 (0.412 to 0.416)	0.413 (0.416 to 0.421)	0.344
Boys	0.419 (0.416 to 0.421)	0.422 (0.419 to 0.425)	0.089
Parental education			
Low	0.420 (0.417 to 0.423)	0.426 (0.422 to 0.430)	**0.020**
Medium	0.417 (0.414 to 0.419)	0.415 (0.412 to 0.419)	0.484
High	0.413 (0.410 to 0.416)	0.413 (0.410 to 0.416)	0.978

Intervention effects determined by analysis of covariance adjusted for baseline value. BMI, body mass index; BMIz, BMI-for-age z-score; HEIA, HEalth in Adolescents;WC, waist circumference; WTHR, waist-to-height-ratio. Bold signifies p<0.05.

DISCUSSION

The HEIA study had a beneficial effect on BMI and BMIz in girls, but not in boys. A beneficial effect on BMI was seen among participants of parents with higher education. However, a negative intervention effect on WTHR was seen among participants of parents reporting low education.

Effect of the intervention on BMI

One reason for the lack of overall effect on BMI for both boys and girls can be the inadequate dose received of intervention components. Unpublished process evaluation data indicate that the level of implementation of the components decreased from midway to postintervention, thus reducing both the reach and dose received by the participants. Furthermore, since low cost and high applicability of the intervention activities in the public school system were given high priority, this may also have limited the dose received on each of the targeted behaviours. Moreover, the diet and activity behaviours that were promoted in the intervention, separately or in combination, may not have been sufficient to affect estimates of body composition to a greater magnitude.[3] The length of the intervention, being almost two academic years, can be considered relatively long compared with similar school-based interventions.[4][5][24] Sufficiently intense intervention (daily expert-led physical education) and adequate duration (1 year) were two strengths that were pointed out in the successful KISS study, which managed to favourably affect estimates of body composition in first and fifth grade schoolchildren.[24] Additionally, both the control group and the intervention

group in the present study increased their total physical activity significantly during the intervention.[15] This was unexpected as a decline in physical activity with increasing age has repeatedly been documented between the ages 9 and 15.[25–27] We cannot rule out that the control schools have initiated their own health-promoting initiatives, even if allocated to the control arm of the study. For ethical reasons, we made no attempt to prevent this. The lack of overall intervention effects can also be due to the limited potential for change, as the majority of participants in this study were of normal weight at baseline.[5]

Effect of the intervention on secondary objectives

We have previously reported that gender moderated the effect of the HEIA intervention on dietary behaviours, sedentary behaviours and physical activity.[13][14] The effect of the intervention was greater for girls than for boys on most of the outcomes we investigated.

This can have several explanations. Four female researchers developed the intervention and assisted the implementation. The majority of teachers involved in this project were women. Unintentionally, the intervention components may therefore have been better adapted and delivered to girls than to boys. The earlier demonstrated intervention effects on behaviours in girls but not in boys may partly explain why the intervention was effective on BMI and BMIz among girls only.[14][15] It is possible that boys did not change their physical activity level as much as girls because of higher baseline values and, consequently, had a smaller potential for change. Furthermore, the issues addressed in the study may be of greater interest to girls, or girls may be more conscientious regarding the intervention components than boys. We appreciate the results showing that the intervention reached and affected girls. However, we also acknowledge that the intervention failed to affect the same outcomes in boys. Similarly, the American 'Planet Health' study significantly reduced the prevalence of obesity in 12-year-old girls by promotion of physical activity, modification of dietary intake and reduction of sedentary behaviours, but found no effect on boys.[28] On the other hand, another American intervention study targeting environment, policy and social marketing (M-SPAN) showed a significant reduction in BMI in 11-year-old to 13-year-old boys over two school years, but not in girls.[29] A systematic review of school-based interventions that focused on changing dietary intake and physical activity to prevent childhood obesity concluded that such interventions may be more effective for younger children and girls.[30] The authors suggested that children aged 10–14 years may respond differently by genders to different intervention elements.

The present study demonstrated a beneficial intervention effect on participants having parents with high education, and a negative intervention effect on participants in the lowest parental education group with respect to WTHR. While acknowledging that we failed to positively reach participants of parents with low education, the reason is not readily explainable. In an attempt to explain social differences in fruit and vegetable consumption among Norwegian schoolchildren, Bere et al[31] found that children with lower educated parents had less access to fruits and vegetables than children with higher educated parents, and hypothesised that cost, greater knowledge, health considerations and greater support from family and friends could be the reasons for this difference. The results are in line with earlier findings, which describe a social gradient in the problem of adolescent overweight and obesity,[32–35] and which show that population-based intervention efforts seem to reach

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participants from different socioeconomic backgrounds differently and may contribute to increased health inequalities.[1 36]

In this paper, we chose to include multiple estimates of body composition as called for,[4] although BMI was the main outcome variable in the study. It is noteworthy that relatively closely related outcomes, that is, BMI and WTHR, gave different results regarding intervention effects. All the investigated outcomes are descriptions of body composition and more equal effects could have been expected. The results suggest that there are differences in how the intervention affects these measures. The power analyses were calculated to detect differences between groups for BMI; the other investigated anthropometric outcomes may have required a larger sample size to detect intervention effects.

Regarding effect size, all the significant effect sizes were classified as small. The highest explained variance was only 1.4% in girls' BMIz and WTHR in the lowest parental education group. This means that most of the participants' estimates of body composition development during the trial were explained by other factors, and thus the importance of the intervention effects may be limited. However, obtaining small but beneficial findings such as this can be important for public health if implemented on a larger scale and with a longer duration.

Strengths and limitations

The strengths of the study include the systematic development of the intervention and the study design, which were based on the current recommendations and best practice.[2 29 37] Other strengths were the large number of participants from a narrow age group. Furthermore, the multicomponent intervention lasting 20 months was designed to be feasible to implement within the school system and not financially demanding. Also, the anthropometric measures were objectively assessed, self-reported pubertal maturation was included and parental education was reported by a parent for nearly the full sample.

We acknowledge that our study has limitations. A possible selection bias might be present because a rather large proportion of invited schools declined to take part in the study. Recruiting schools in Norway to extracurricular projects has become a challenging undertaking over the past decade, as curricular and administrative demands on schools have increased substantially. In addition, weighing of children is a controversial issue in Norway and has been debated in the national media repeatedly. However, attrition analyses showed no differences between the participating schools and schools which declined to participate in terms of the number of students in the sixth grade and the overall size.[38] The drop-out analyses showed that participants lost to follow-up had a higher BMI and indicate that we lost participants that we intended to reach. A possible reason for this attrition could be resistance to assessment of anthropometrics in light clothing or underwear only. This was discovered as the main reason for adolescents to refuse participation in the anthropometric measurement in a Dutch school-based weight gain prevention programme.[39] However, the drop-out rate was small and equal in both groups, and no further differences were detected. Also, when investigating the intervention effects of a multicomponent intervention, it is not possible to sort out the effects of the different components. Finally, as the sample was recruited from a limited geographic area, this could reduce the generalisability of our findings. However, the objectively measured height, weight and total physical activity from the participants in this study fall adequately between the measures of 9-year-olds and 15-year -olds in a nationally representative sample.[40]

CONCLUSION

We demonstrated that a 20-month comprehensive multicomponent school-based intervention designed to increase physical activity, reduce sedentary time and stimulate a healthy diet successfully decreased BMI and BMIz among girls, but not boys.

The intervention had a beneficial effect on BMI among children of parents with higher education, but not among children of parents with lower education. Future interventions should be aware of differences in how the intervention affects genders and socioeconomic groups, and should adequately address this issue to eliminate chances of increasing inequalities in health with regard to obesity development.

What this study adds

- ▶ A multicomponent school-based obesity prevention intervention produced significant positive effects on estimates of body composition among participating adolescent girls, but not among the boys.
- ▶ The intervention gave positive results for participants having parents with higher education, while negative effects were seen among those with parents having lower education. The risk that interventions contribute to increase social inequalities in health should be given attention in future intervention studies.

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Denne artikkelen er tatt ut av den elektroniske versjonen av doktoravhandlingen i Brage. Artikkelen er ikke antatt for publisering enda (15.11.2013), og en tilgjengeliggjøring av manuskriptet kan hindre at artikkelen blir antatt.

This paper is removed from the electronic version of this PhD Thesis in Brage. The article is not accepted for publication yet (the 15th of November 2013), and making the manuscript available can prevent the article from being accepted.

Appendix 1

Test retest

Test-retest reliability of anthropometric and behavioral measures in the HEIA study

Table 1 Test-retest reliability of anthropometric measures among 11-year-olds in the HEIA study.

Anthropometry	n	Test (mean)	Retest (mean)	p^a	ICC	Pearson's r[b]
Height (m)	89	151.1	151.2	0.34	1.00	0.99
Waist (cm)	89	59.9	59.8	0.58	0.94	0.94

[a] for paired t-test [b] Pearson's correlation coefficient, all p-values were <.001. Modified from Lien *et al.,* 2010.

Table 2 Test-retest reliability of self-reported pubertal status among 11-year-olds in the HEIA study.

Puberty	n	ICC	Pearson's r[a]	Kappa[a]
Body hair	101	0.77	0.77	0.67
Voice change (boys only)	52	0.36	0.38	0.43
Facial hair (boys only)	51	0.76	0.76	0.75
Breast growth (girls only)	56	0.80	0.80	0.74
Menarche (girls only)	57	0.90	0.90	0.90

[a] All p-values were <.001, except for Pearson's r for voice change for boys which was 0.006. Modified from Lien *et al.,* 2010.

Table 3 Test-retest reliability of self-reported intake of sugar-sweetened beverages among 11-year-olds in the HEIA study.

Dietary behaviors	n	Pearson's r[a]
Soft drinks (w/sugar):		
total intake week days (frequency x amount)	96	0.46
total intake weekend (frequency x amount)	109	0.67
Squash/fruit drinks (w/sugar):		
total intake week days (frequency x amount)	86	0.78
total intake weekend (frequency x amount)	108	0.68

Source of questionnaire: Ungkost 2000, Øverby and Andersen, 2002. [a] All p-values were <.001. Modified from Lien *et al*., 2010.

Table 2 Test-retest reliability of self-reported screen time among 11-year-olds in the HEIA study

Screen time	n	Pearson's r[a]
TV/DVD week day (hours)	108	0.64
TV/DVD weekend day (hours)	109	0.64
Computer/games week day (hours)	105	0.56
Computer/games week end day (hours)	108	0.72

Source of questionnaire (modified): Personal and Environmental Associations with Children's Health (PEACH), Page *et al.,* 2010 and Health Behaviour in School-Aged Children Study (HBSC), Currie et al, 2002.
[a] All p-values were <.001. Modified from Lien *et al.,* 2010.

Appendix 2

Alternative analysis - Paper I

Paper I – Alternative analysis replacing ST and MVPA with MCPM:

Table 1 Factors associated with being overweight/obese [a] in a group of 11-year-old Norwegian adolescents (n=1103).

		Crude			Adjusted		
		OR	95%CI	*p*	OR	95%CI	*p*
Parental edu.	≤12 y	1			1		
	13-16 y	0.62	0.40, 0.96	**0.03**	0.58	0.37, 0.92	**0.022**
	>16 y	0.47	0.29, 0.75	**0.002**	0.53	0.33, 0.87	**0.012**
SSB (dl/week)		1.00	0.98, 1.02	0.93			
Sum snacks (times/week)		0.97	0.92, 1.03	0.30			
Breakfast daily (yes/no)		2.00	1.17, 3.40	**0.01**	1.77	1.01, 3.09	**0.046**
TV (hrs/day)		1.53	1.28, 1.82	**<0.001**	1.40	1.14, 1.71	**0.001**
Computer game (hrs/day)		1.43	1.18, 1.74	**<0.001**	1.19	0.95, 1.48	0.14
MCPM		1.00	0.998, 1.000	**0.013**	1.00	0.997, 1.000	**0.034**

[a] Age and gender specific cutoffs for overweight/obesity at age from 10.5 to 12.5 as defined by International Obesity Task Force (Cole et al., 2000b). Numbers are adjusted for gender and puberty. MCPM=mean count pr minute (total physical activity).

Appendix 3

Clustering effects

Clustering effects in the HEIA study (Intra-Class Correlation, ICC)

Clustering effects due to schools being the unit of recruitment for the main variables included in the thesis (behaviours and determinants), by the Linear Mixed Model procedure in SPSS, version 16.

Table 1 Intra-class correlations for anthropometry, pre-test (n = 1481)

Anthropometry	p	ICC	Unexplained variance at school level (%)
BMI	0.05	0.02	2
Waist	0.03	0.02	2

Table 2 Intra-class correlations for behaviours, pre-test (n = 1519)

Behaviors	p	ICC	Unexplained variance at school level (%)
SSB, week day	0.01	0.03	3
SSB, weekend day	0.01	0.03	3
TV/DVD, week day	0.03	0.02	2
TV/DVD, weekend day	0.05	0.01	1
Computer/game-use, week day	0.03	0.01	1
Computer/game-use, weekend day	0.03	0.02	2
Accelerometer assessed physical activity*	<0.01	0.11	11

* n=1129

Appendix 4

Letter of approval from the Regional Committees for Medical Research Ethics

and

the Norwegian Social Science Data Services

UNIVERSITETET I OSLO

DET MEDISINSKE FAKULTET

Prosjektkoordinator dr.philos. Nanna Lien
Institutt for medisinske basalfag
Universitetet i Oslo
Pb. 1046 Blindern

Regional komité for medisinsk forskningsetikk
Sør- Norge (REK Sør)
Postboks 1130 Blindern
NO-0318 Oslo

Telefon: 228 50 670
Telefaks: 228 44 661
E-post: juliannk@medisin.uio.no
Nettadresse: www.etikkom.no

Dato: 16.03.07
Deres ref.:
Vår ref.: S-07034b

S-07034b Pilotundersøkelse av målemetoder og spørreskjema til intervensjonsundersøkelsen "Promoting health weight among school children" [2.2007.115]

Vi viser til møte som fant sted 15. mars 2007 med prosjektleder Nanna Lien, prosjektmedarbeider førsteamanuensis Sigmund Alfred Anderssen, komitéleder Tor Norseth og nestleder Ulrich Abildgaard og komitésekretær. Møtets siktemål var å få redegjort for ulike sider ved prosjektet og å drøfte komiteens merknader i brev av 02.03.07.

Komiteen ved leder og nestleder er av den oppfatning at komiteens hovedinnvendinger ble tilfredsstillende besvart og imøtekommet av Lien og Anderssen.

Komiteen har ingen øvrige merknader til prosjektet og tilrår at det gjennomføres.

Vi ønsker lykke til med prosjektet!

Med vennlig hilsen

Tor Norseth
Leder

Julianne Krohn-Hansen
Sekretær

Kopi:
Stipendiat Mona Bjelland, Avdeling for ernæringsvitenskap, Pb. 1046 Blindern, Universitetet i Oslo
Stipendiat May Grydeland, Norges idrettshøgskole, Pb.4014 Ullevål stadion, 0806 Oslo

Norsk samfunnsvitenskapelig datatjeneste AS
NORWEGIAN SOCIAL SCIENCE DATA SERVICES

Nanna Lien
Avdeling for ernæringsvitenskap
Institutt for medisinske basalfag
Universitetet i Oslo
Postboks 1046 Blindern
0316 OSLO

Vår dato: 05.03.2007   Vår ref 16073/KS   Deres dato·   Deres ref:

TILRÅDING AV BEHANDLING AV PERSONOPPLYSNINGER

Vi viser til melding om behandling av personopplysninger, mottatt 09.01.2007. All nødvendig informasjon om prosjektet forelå i sin helhet 26.02.2007. Meldingen gjelder prosjektet:

16073	*Pilotundersøkelse av målemetoder og spørreskjema til intervensjonsundersøkelsen Promoting healthy weight among school children*
Behandlingsansvarlig	*Universitetet i Oslo, ved institusjonens øverste leder*
Daglig ansvarlig	*Nanna Lien*

Personvernombudet har vurdert prosjektet, og finner at behandlingen av personopplysninger vil være regulert av § 7-27 i personopplysningsforskriften. Personvernombudet tilrår at prosjektet gjennomføres.
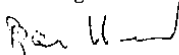
Personvernombudets tilråding forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, eventuelle kommentarer samt personopplysningsloven/-helseregisterloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.
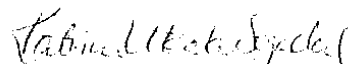
Det gjøres oppmerksom på at det skal gis ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernombudets vurdering. Endringsmeldinger gis via et eget skjema, http://www.nsd.uib.no/personvern/endringsskjema. Det skal også gis melding etter tre år dersom prosjektet fortsatt pågår. Meldinger skal skje skriftlig til ombudet.

Personvernombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://www.nsd.uib.no/personvern/database/

Personvernombudet vil ved prosjektets avslutning, 31.12.2007 rette en henvendelse angående status for behandlingen av personopplysninger.

Vennlig hilsen

Bjørn Henrichsen   Katrine Utaaker Segadal

Kontaktperson: Katrine Utaaker Segadal tlf: 55 58 35 42

Vedlegg: Prosjektvurdering

Personvernombudet for forskning, NSD

I prosjektet vil det bli registrert sensitive opplysninger om helseforhold, jf. personopplysningsloven § 2 nr. 8 c).

Prosjektslutt er angitt til 31.12.07. Senest ved prosjektslutt vil datamaterialet være anonymisert, det vil si at verken direkte eller indirekte personidentifiserende opplysninger lenger foreligger i datamaterialet. Koblingsnøkkelen slettes, og indirekte personidentifiserende opplysninger slettes eller grovkategoriseres på en slik måte at ingen enkeltpersoner kan gjenkjennes i materialet.

Ombudet har mottatt reviderte informasjonsskriv (26.02.07) og finner disse tilfredsstillende.

Kopi av tilråding fra Regional komité for medisinsk forskningsetikk bes ettersendt.

Appendix 5

Study information and consent form

UNIVERSITETET I OSLO
DET MEDISINSKE FAKULTET

Orientering til foresatte

Institutt for medisinske basalfag
Avdeling for ernæringsvitenskap
Postboks 1046, Blindern
0316 Oslo

Besøksadresse
Domus Medica
Sognsvannsveien 9

Telefon: 948 91 416
Telefaks: 22 85 15 31
E-post: heia@medisin.uio.no
Nettadresse: www.med.uio.no/imb

Dato: Oslo, august 2007
Deres ref.:
Vår ref.:

Skolen der barnet ditt er elev, har takket ja til å delta i prosjektet "HEIA- mat og aktivitet for god helse". Prosjektet har som mål å fremme gode kostvaner og økt fysisk aktivitet for å oppnå en sunn vektutvikling blant skolebarn, og er et samarbeid mellom Norges idrettshøgskole og Avdeling for ernæringsvitenskap ved Universitetet i Oslo. Vi ønsker med dette å orientere om prosjektet, samt forespørre foresatte og elev om samtykke til deltakelse.

Forskning har vist at det er en klar sammenheng mellom levevaner og vekt i ung alder og risiko for sykdom senere i livet. Gode kostvaner og fysisk aktivitet reduserer risikoen for en rekke kroniske sykdommer. Skoleelever er en viktig gruppe for forebyggende og helsefremmende tiltak ettersom de levevaner en tilegner seg i denne perioden av livet har en tendens til å vedvare.

Totalt har 37 skoler i Akershus, Buskerud, Hedmark, Oppland, Telemark, Vestfold og Østfold sagt ja til å delta. Samtykke til deltakelse i prosjektet innebærer for 6. klassingen tre datainnsamlinger med fokus på kostvaner og fysisk aktivitet, og for foresatte to datainnsamlinger.

Det vil i løpet av prosjektperioden gjennomføres tre datainnsamlinger i skoletiden (høsten 2007, våren 2008 og våren 2009). For elevene innebærer datainnsamlingene:

- å besvare et elektronisk spørreskjema (en skoletime) på alle tre tidspunkt

- veiing og måling samme skoledag som spørreskjemaet besvares, gjelder høsten 2007 og våren 2009

- objektiv måling av fysisk aktivitet via aktivitetsmåler, gjelder høsten 2007 og våren 2009

Spørreskjemaet omhandler sukkerholdige drikker, frukt, grønnsaker, fysisk aktivitet, stillesittende aktiviteter, kroppsbilde/slanking, samt faktorer som påvirker dette. Spørreskjemaet inneholder i tillegg noen spørsmål om foresatte (fødeland, inntak av brus/saft/grønnsaker, opplevd støtte/oppmuntring og restriksjoner). I etterkant av utfyllingen av spørreskjemaet ønsker vi å måle elevenes høyde, vekt, kroppssammensetning, midje- og hofteomkrets. Den enkelte elev skal i tillegg fylle ut et papirskjema om pubertetsutvikling når han/hun veies og måles. Aktivitetsregistrering gjøres ved hjelp av en liten aktivitetsmåler som elevene skal bære på hoften i 5 dager. Måleren er festet i et belte. Når aktivitetsregistreringen skal gjennomføres vil elevene få en demonstrasjon av bruk i skoletiden og en skriftlig instruks med hjem til foresatte. Aktivitetsmåleren leveres ut og returneres via kontaktlærer.

Department of Nutrition
Faculty of Medicine
University of Oslo

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Prosjektet er meldt til Regional komité for medisinsk forskningsetikk og Norsk samfunnsvitenskapelig datatjeneste AS, og støttes økonomisk av Norges forskningsråd, Norges idrettshøgskole og Direktør Throne Holsts Fond for ernæringsforskning.

- Vi håper du/dere vil delta i datainnsamlingene og ber om at det vedlagte skjemaet fylles ut, signeres av foresatt(e) og elev, og returneres i konvolutten til kontaktlærer via eleven.

- Dersom verken elev eller foresatt(e) ønsker å delta, ber vi om at konvolutten returneres tom.

- I de tilfeller hvor det ikke er gitt tilbakemelding via konvolutten innen en uke etter utdeling på skolen, vil foresatte bli kontaktet per telefon. Dersom du/dere ikke ønsker å bli kontaktet ber vi om at det snarest gis beskjed til kontaktlærer.

Det vil ikke virke inn på forholdet til skolen dersom foresatt(e) og/eller eleven velger å ikke delta. Dersom det er elever som ikke skal delta vil de få et alternativt opplegg fra skolens side når datainnsamlingene gjennomføres. Spørreskjemaet til eleven kan sendes for gjennomsyn i forkant av datainnsamlingene om ønskelig.

Kontakt en av våre prosjektmedarbeidere dersom du har spørsmål eller ønsker mer informasjon om prosjektet, tlf: 948 91 416, faks: 22 85 15 31 eller e-post: heia@medisin.uio.no

Med vennlig hilsen

Nanna Lien   Mona Bjelland   Ingunn Holden Bergh   May Grydeland
Prosjektkoordinator   Stipendiat   Stipendiat   Stipendiat

SAMTYKKEERKLÆRING FOR "HEIA-PROSJEKTET" – DEL 1 (DEL 2: Se baksiden)

Jeg/vi har mottatt og lest informasjonen om datainnsamlingene. Deltakelsen er frivillig og vi kan til enhver tid trekke oss uten å måtte oppgi noen grunn. Det er en forutsetning for vår deltakelse at all informasjon vi gir behandles strengt konfidensielt. Hvis vi trekker oss fra undersøkelsen kan vi kreve at alle persondata blir slettet.

Jeg/vi samtykker til at mitt/vårt barn KAN DELTA:

_____
Elevens navn (blokkbokstaver)

_____   _____
Skole   Klasse/gruppe

_____ _____ _____
Sted   Dato   Underskrift foresatt(e)

Foresatte 1: Jeg samtykker til å delta

_____ _____ _____
Sted   Dato   Underskrift foresatt

Hvilken relasjon har du til barnet som blir med i undersøkelsen?
□ Jeg er moren til barnet
□ Jeg er faren til barnet
□ Jeg er stemoren til barnet
□ Jeg er stefaren til barnet
□ Jeg er barnets kvinnelige foresatte
□ Jeg er barnets mannlige foresatte

Hva er din høyeste fullførte utdanning?
□   Mindre enn 7 års utdanning
□   Folkeskole/grunnskole/ungdomsskole (7-9 år)
□   Gymnas/yrkesskole e.l. (inntil 12 år)
□   Universitet-/høyskoleutdanning (inntil 4 år)
□   Universitet-/høyskoleutdanning (mer enn 4 år)

Foresatte 2: Jeg samtykker til å delta

_____ _____ _____
Sted   Dato   Underskrift foresatt

Hvilken relasjon har du til barnet som blir med i undersøkelsen?
□ Jeg er moren til barnet
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Snu arket!

SAMTYKKEERKLÆRING – DEL 2

SAMTYKKE TIL Å MOTTA E-POST FRA HEIA-PROSJEKTET (MAKS. 1 GANG PER MÅNED)

Prosjektgruppen ønsker å prøve ut direkte kommunikasjon til foresatte via e-post, derfor etterspørres e-post adresse. E-postene vil inneholde informasjon om kosthold og aktivitet/inaktivitet, samt informasjon om HEIA-prosjektet.

Foresatt 1:

Jeg gir samtykke til bruk av min egen e-post adresse:

_____
Skriv e-post adresse til foresatte 1

Foresatt 2:

Jeg gir samtykke til bruk av min egen e-post adresse:

_____
Skriv e-post adresse til foresatte 2

Dette samtykkeskjemaet returneres til kontaktlærer i konvolutten snarest.

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Med vennlig hilsen

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Prosjektkoordinator	Stipendiat	Stipendiat	Stipendiat

SAMTYKKEERKLÆRING FOR "HEIA-PROSJEKTET"

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_____ _____   _____
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□ Jeg er barnets mannlige foresatte	

Foresatte 2: Jeg samtykker til å delta

_____ _____   _____
Sted   Dato   Underskrift foresatt

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Dette samtykkeskjemaet returneres til kontaktlærer i konvolutten snarest.

Appendix 6

Questionnaire (selected items only)

Selected survey items from the electronic child questionnaire (in Norwegian)
(relevant survey items only)

HEIA - mat og aktivitet for god helse

Spørreskjema om kosthold og fysisk aktivitet

Takk for at du hjelper oss med å svare på disse spørsmålene om kosthold og fysisk aktivitet.

Det er frivillig å svare på disse spørsmålene, og alle svarene du gir er hemmelige. Ingen på skolen din, eller andre du kjenner, får vite hva du har svart.

Spørsmål som er markert med stjerne (*) er obligatoriske og må besvares før du kan gå videre.

Husk å sjekke at alle spørsmålene på siden er besvart før du går videre - når du klikker i ringen ved det svaret du ønsker, skal det komme opp en svart prikk.

Lykke til!
Ditt svar vil være anonymt
(QuestBack ivaretar din anonymitet)

Skriv skolens navn *

Skriv ID-nummeret ditt *

Hvilket år er du født? *

○ 1994
○ 1995
○ 1996
○ 1997
○ Annet år: [   ]

I hvilken måned har du fødselsdag? *

○ Januar
○ Februar
○ Mars
○ April
○ Mai
○ Juni
○ Juli
○ August
○ September
○ Oktober
○ November
○ Desember
☒ [#4713]

Er du jente eller gutt? *

○ Jente
○ Gutt

Intake of sugar-sweetened beverages (soft drinks and fruit drinks), weekday and weekend

På de neste sidene kommer det noen spørsmål om hva du drikker på HVERDAGER.

Senere spør vi om hva du drikker i HELGEN.

❌ [#4713]

På HVERDAGER (mandag til fredag):
Hvor ofte drikker du vanligvis følgende typer drikke?

Sett ett kryss for hver linje

	Aldri/ sjeldent	1 dag	2 dager	3 dager	4 dager	Hver hverdag
Brus, med sukker (f.eks. Cola, Solo)	○	○	○	○	○	○
Brus, uten sukker (f.eks. Cola light, Pepsi Max)	○	○	○	○	○	○
Saft, med sukker (f.eks. husholdningssaft, appelsinsaft)	○	○	○	○	○	○
Saft, uten sukker (kunstig søtet)	○	○	○	○	○	○

Ruting til:

Når du drikker brus MED sukker på hverdager, hvor MYE pleier du å drikke?
(1/2 liter = 3 glass)

○ 1 glass
○ 2 glass
○ 3 glass
○ 4 glass eller mer

2

Når du drikker saft MED sukker på hverdager, hvor MYE pleier du å drikke?
(1/2 liter = 3 glass)

○ 1 glass
○ 2 glass
○ 3 glass
○ 4 glass eller mer

På de neste sidene spør vi om hva du drikker i HELGEN.

I HELGEN:
Hvor mye drikker du vanligvis av følgende drikker? (1/2 liter = 3 glass)
Legg sammen det du drikker lørdag og søndag, og sett ett kryss for hver type drikke.

Sett ett kryss for hver linje

	Aldri eller sjeldent	1 glass	2 glass	3 glass	4 glass	5 glass	6 glass	7 glass eller mer
Brus, med sukker (f.eks. Cola, Solo)	○	○	○	○	○	○	○	○
Brus, uten sukker (f.eks. Cola light, Pepsi Max)	○	○	○	○	○	○	○	○
Saft, med sukker (f.eks. husholdningssaft, appelsinsaft)	○	○	○	○	○	○	○	○
Saft, uten sukker (kunstig søtet)	○	○	○	○	○	○	○	○

MÅLTIDER

Hvor ofte spiser du FROKOST?

- ○ Aldri
- ○ Sjeldnere enn 1 gang i uken
- ○ 1 gang i uken
- ○ 2 ganger i uken
- ○ 3 ganger i uken
- ○ 4 ganger i uken
- ○ 5 ganger i uken
- ○ 6 ganger i uken
- ○ Hver dag

Hvor ofte spiser du vanligvis SJOKOLADE/GODTERI?

◎ Aldri/sjeldent
◎ Mindre enn 1 gang i uken
◎ 1-2 ganger pr uke
◎ 3-4 ganger pr uke
◎ 5-6 ganger pr uke
◎ 1 gang pr dag
◎ 2 ganger eller mer pr dag

Hvor ofte spiser du vanligvis SALT SNACKS (f.eks. potetgull, popkorn og lignende)

◎ Aldri/sjeldent
◎ Mindre enn 1 gang i uken
◎ 1-2 ganger pr uke
◎ 3-4 ganger pr uke
◎ 5-6 ganger pr uke
◎ 1 gang pr dag
◎ 2 ganger eller mer pr dag

Hvor ofte spiser du vanligvis SØTE KJEKS?

◎ Aldri/sjeldent
◎ Mindre enn 1 gang i uken
◎ 1-2 ganger pr uke
◎ 3-4 ganger pr uke
◎ 5-6 ganger pr uke
◎ 1 gang pr dag
◎ 2 ganger eller mer pr dag

Hvor ofte spiser du vanligvis BOLLER, SKOLEBRØD, MUFFINS og lignende?

◎ Aldri/sjeldent
◎ Mindre enn 1 gang i uken
◎ 1-2 ganger pr uke
◎ 3-4 ganger pr uke
◎ 5-6 ganger pr uke
◎ 1 gang pr dag
◎ 2 ganger eller mer pr dag

Screen time: TV/DVD and computer/electronic games

NOEN SPØRSMÅL OM TV/DVD

Hvor mange timer ser du vanligvis på TV og/eller DVD på en vanlig HVERDAG?

- ○ Ca. 5 timer eller mer
- ○ Ca. 4 timer
- ○ Ca. 3 timer
- ○ Ca. 2 timer
- ○ Ca. 1 time
- ○ Ca. en halv time eller mindre

Hvor mange timer ser du vanligvis på TV og/eller DVD på en vanlig HELGEDAG eller FRIDAG?

- ○ Ca. 5 timer eller mer
- ○ Ca. 4 timer
- ○ Ca. 3 timer
- ○ Ca. 2 timer
- ○ Ca. 1 time
- ○ Ca. en halv time eller mindre
- ☒ [#4713]

NOEN SPØRSMÅL OM TV-OG DATASPILL
(For eksempel surfing på Internett, MSN, Gameboy, Nintendo, Playstation)

Hvor mange timer bruker du vanligvis til data, TV-spill eller andre elektroniske spill på en vanlig HVERDAG?

- ○ Ca. 4 timer eller mer
- ○ Ca. 3 timer
- ○ Ca. 2 timer
- ○ Ca. 1 time
- ○ Ca. en halv time eller mindre
- ○ Ikke noe tid

Hvor mange timer bruker du vanligvis til data, TV-spill eller andre elektroniske spill på en vanlig HELGEDAG eller FRIDAG?

- ○ Ca. 4 timer eller mer
- ○ Ca. 3 timer
- ○ Ca. 2 timer
- ○ Ca. 1 time
- ○ Ca. en halv time eller mindre
- ○ Ikke noe tid