Targeting change in physical activity and screen time behaviours within the HEalth In Adolescents (HEIA) intervention study: A mediating framework approach
SUMMARY

Background
During the 1990’s and early 2000’s there has been an increase in prevalence of overweight (including obesity) in European children and adolescents. This is a public health challenge as overweight and obesity are associated with adverse psychosocial and physiological health effects, both in youth and adulthood. School-based interventions to promote physical activity, improve dietary and reduce sedentary behaviours have been recommended for weight regulation. However, only modest and mixed effects of obesity prevention initiatives have been seen so far. This may, however, be due to ineffective targeting of potentially mediating variables of the behaviours assumed to influence weight development or insufficient implementation of the interventions.

Aim
The overall goal of the HEalth in Adolescents (HEIA) study was to design, implement and evaluate a comprehensive intervention programme to promote healthy weight development among young adolescents (11 to 13 year-olds). Change in weight development was targeted through change in physical activity, sedentary and dietary behaviours.

This thesis investigates: 1) modifiable correlates of moderate-to-vigorous physical activity (MVPA) at baseline; 2) intervention effect on targeted determinants hypothesized to mediate change in physical activity and screen time behaviours; 3) how adolescents’ reported “dose received” of the intervention was related to change in these determinants, and 4) mediating effects of the targeted determinants on physical activity and screen time behaviour change, as well as main effect on screen time behaviours. In addition, moderation effects of gender, weight status, and parental education status were explored.

Methods
The HEIA study was a group randomized controlled trial (RCT) including 37 schools from seven counties in the south-eastern region of Norway (12 intervention schools and 25 control schools). All the 6th graders in the schools (n=2165) and their parents/legal guardians were invited to participate. Of these, 1580 (73%) returned a parent signed informed consent. Height and weight were measured and physical activity was assessed by accelerometers. Adolescents reported determinants, screen time behaviours and demographic variables in an electronic
questionnaire, while mothers and fathers reported determinants of screen time behaviours in a paper questionnaire and parental education status on the informed consent for the adolescents.

The 20 month HEIA intervention was based on a social-ecological framework and a conceptual study model. Change in overall physical activity was targeted through theoretically informed modifiable factors including environmental opportunities, social support, self-efficacy and enjoyment. TV-viewing and computer/game-use were targeted through parental regulation. The intervention consisted of a mix of individual-, group- and environmental strategies and components.

**Main results**
Baseline findings revealed that being normal weight, self-efficacy, and social support from friends were positively associated with MVPA, while weekend computer/game-use was negatively associated with MVPA. Weight status moderated the association between weekend computer/game-use and physical activity, and more computer/game-use was related to less MVPA among the overweight/obese, but not among the normal weight adolescents. In total the identified correlates explained 14% of the variance in MVPA.

The intervention affected enjoyment, self-efficacy, and social support from parents and teachers, but the effects were small, varied mid-way vs. post-intervention, and both favourable and unfavourable effects were observed. At post-intervention, a beneficial intervention effects on social support from teachers and an unbeneﬁcial effect on self-efficacy were observed in the total sample. Gender did not moderate any effects on the determinants. Weight status moderated the mid-way effect on self-efficacy and post-intervention effect on enjoyment in disfavour of the overweight/obese, while post-intervention effects on social support from teachers and parents varied by parental education status. The proportion of the adolescents who reported that they had been highly exposed to/participated in the physical activity and screen time behaviours components, decreased from 56% at the mid-way to 31% at the post-intervention assessment. There was a positive dose-response association between a high (vs. a low) degree of reported exposure/participation in the intervention and change in most of the determinants.

For the total sample, the intervention produced a borderline significant post-intervention effect on overall physical activity (mean count per minute). Subgroup analyses revealed a
small significant effect in girls and normal weight adolescents, with a tendency for an unfavourable effect among the overweight. There was no effect on the screen time behaviours in the total sample. Gender moderated the effect of weekend computer/game-use in favour of girls. Weight status moderated the effect on weekday TV-viewing and computer/game-use. The follow-up subgroup analyses revealed a favourable intervention effect on weekday TV-viewing among the normal weight.

The effects on physical activity and screen time behaviours were not mediated by any of the targeted determinants. However, change in enjoyment, self-efficacy, social support from friends and perceived environmental opportunities were, independent of the intervention, associated with change in physical activity in the expected direction. In addition, stronger parental regulation of screen time behaviours was found to be associated with change toward less time used on these behaviours.

Implications
The identified correlates at baseline pointed to potential mediators for physical activity change from multiple domains. The moderation result for weight status showed that weekend computer/game-use may be a larger threat to physical activity among overweight than normal weight adolescents.

To avoid unfavourable effects on psychological determinants of physical activity, there may be a need for weight status specific intervention strategies when targeting physical activity change among adolescents. The success of multicomponent initiatives may depend on the dose received of the intervention. Further research should investigate the influence of implementation issues on both determinants and behaviours. During the development and implementation of behavioural change intervention, steps should be taken to ensure a sufficient implementation.

Multiple behaviour intervention can produce effects on physical activity and TV-viewing, but may not reach all equally well. There seems to be a need for developing approaches that will fit overweight as well as normal weight adolescents.

Even though no mediation effects of the targeted determinants were seen, the results support that change in physical activity should be targeted through factors from multiple domains.
Parental regulation of screen time behaviours appears to be an important social influence on TV-viewing and computer/game-use. However, additional determinants and potential mediators of both physical activity and screen time behaviour change should be investigated in future studies.

Key words
Adolescents, physical activity, sedentary behaviour, correlates, determinants, mediators, moderators, social-ecological framework, accelerometers, randomized controlled trial
ACKNOWLEDGEMENT

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Oslo, March 2013
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LIST OF PAPERS

Paper Ia (included for informational purposes only)
Lien N, Bjelland M, Bergh IH, Grydeland M, Anderssen SA, Ommundsen Y, Andersen LF, 
Henriksen HB, Randby JS, Klepp K-I. Design of a 20-month comprehensive, multicomponent 
school-based randomised trial to promote healthy weight development among 11–13 year 

This thesis is based on the following papers:

Paper Ib
Bergh IH, Grydeland M, Bjelland M, Lien N, Andersen LF, Klepp K-I, Anderssen SA, 
Ommundsen Y. Personal and social-environmental correlates of objectively measured 

Paper II
Bergh IH, Bjelland M, Grydeland M, Lien N, Andersen LF, Klepp K-I, Anderssen SA, 
Ommundsen Y. Mid-way and post-intervention effects on potential determinants of physical 

Paper III
Bergh IH, van Stralen MM, Grydeland M, Bjelland M, Lien N, Andersen LF, Anderssen SA, 
Ommundsen Y. Exploring mediators of accelerometer assessed physical activity in young 

Paper IV
Bergh IH, van Stralen MM, Bjelland M, Grydeland M, Lien N, Klepp K-I, Anderssen S, 
Ommundsen Y. Post-intervention effects on screen behaviours and mediating effect of
parental regulation: the Health in Adolescents (HEIA) - a multi-component school-based randomized trial (BMC Public Health, submitted)
## ABBREVIATIONS

<table>
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<th>Abbreviation</th>
<th>Definition</th>
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<tr>
<td>BMI</td>
<td>Body mass index</td>
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<tr>
<td>CI</td>
<td>Confidence intervals</td>
</tr>
<tr>
<td>CVD</td>
<td>Cardiovascular disease</td>
</tr>
<tr>
<td>EBRB</td>
<td>Energy-balance related behaviours</td>
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<tr>
<td>ICC</td>
<td>Intraclass correlation</td>
</tr>
<tr>
<td>IOTF</td>
<td>International Obesity Task Force</td>
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<tr>
<td>PE</td>
<td>Physical education</td>
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<tr>
<td>PDS</td>
<td>Pubertal Development Scale</td>
</tr>
<tr>
<td>MCPM</td>
<td>Mean count per minute (overall/total physical activity)/ CPM (cpm)</td>
</tr>
<tr>
<td>MVPA</td>
<td>Moderate-to-vigorous physical activity</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomized controlled trial</td>
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<tr>
<td>SCT</td>
<td>Social cognitive theory</td>
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<td>SES</td>
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INTRODUCTION

Overweight and obesity is a public health concern among young people as well as adults. The energy we consume and spend, through eating and being either physically active or sedentary, influences weight development. Diet, physical activity and sedentary behaviours are in turn predicted by a set of factors from multiple domains (Glanz & Bishop 2010).

Overweight and obesity in children and adolescents – a cause for action

The World Health Organization describes obesity as a “condition of abnormal or excessive fat accumulation in adipose tissue, to the extent that health may be impaired” (World Health Organization 2000). While the mechanism leading to obesity is not fully understood (Dehghan et al 2005), overweight and obesity develop when there is an imbalance between the energy expenditure and energy intake (Krebs et al 2007). Limited energy expenditure (i.e. less physical activity than necessary) and excessive energy intake are the most important preventable factors underlying overweight and obesity (Biro & Wien 2010). Therefore, when it comes to obesity prevention, physical activity, sedentary- and dietary behaviours are referred to as energy-balance related behaviours (EBRB) (Kremers et al 2006), and act as modifiable factors in the causal path of a healthy weight development (Han et al 2010; Kamath et al 2008).

Childhood overweight and obesity is a growing health concern in virtually all parts of the world for several reasons (Lobstein et al 2004; Wang & Lobstein 2006). The adverse health effects for youth include psychological and social consequences in the form of stigmatisation and discrimination. The biological consequences comprise earlier puberty and menarche in girls, insulin resistance/type 2 diabetes and higher incidence of the metabolic syndrome and risk of developing cardiovascular disease (CVD) (Biro & Wien 2010; Lobstein et al 2004; Park et al 2012). In addition, overweight and obesity track from childhood and adolescence into adulthood and overweight/obese children have increased risk of being overweight adults (Herman et al 2009; Singh et al 2008). Both at the individual and the national levels, obesity can lead to economic consequences (Lobstein et al 2004).

While the prevalence of childhood obesity worldwide has increased greatly during the past three decades, some data suggests that childhood obesity in the USA and some countries in Europe might be levelling off (Han et al 2010; Lien et al 2010). This trend, however, does not
seem to have reached those with lower socio-economic status (SES) to the same extent as those with higher SES (Lissner et al 2010; Stamatakis et al 2010). Nevertheless, prevalence rates in Europe are high and the most recent data based on measured body mass index (BMI) among 10-12 year-olds (from seven countries) shows that 26% of the boys and 22% of the girls were overweight or obese, with obesity being present in 5% and 4% of the boys and girls, respectively (Brug et al 2012). Studies of Norwegian 9-15 year-old children, based on measured height and weight, indicate a prevalence of overweight including obesity between 10-22% (Anderssen et al 2008; Juliussen et al 2010; Kolle et al 2012; Oellingrath et al 2010). In the most recent country representative survey, about 17% of the boys and 21% of the 9 year-old girls, and 16-17% of the 15 year-olds were overweight/obese (Kolle et al 2012). There was a social gradient in both genders in the 9 year-olds and in the 15 year-old boys.

Treatment of overweight/obesity has had limited success (Biro & Wien 2010; Lobstein et al 2004; Oude et al 2009), and prevention of overweight and obesity is agreed upon as being a key strategy and the most cost-effective approach for dealing with the obesity challenge (Dehghan et al 2005; Lobstein et al 2004). Interventions targeting the EBRB have been recommended and implemented to promote a healthy weight development among youth (Brown & Summerbell 2009; Harris et al 2009; Summerbell et al 2005; Van Cauwenberghe et al 2010; Waters et al 2011). However, obesity prevention efforts have to be implemented without facilitating unintended effects such as eating disorders, teasing and/or harassment (Biro & Wien 2010; Lobstein 2004; Summerbell et al 2005), and reactive behaviours such as increased sedentariness.

**Physical activity and screen time behaviours**

**Physical activity**

Physical activity is defined as “any bodily movement that results in energy expenditure above resting level” (Caspersen et al 1985). Physical activity is a behaviour that can be performed on a continuum from minimal to maximal movement (Smith & Biddle 2008). In contrast, physical inactivity implies an absence of physical activity. However, an individual is often described as physically “inactive” if she or he does not meet a specific threshold or level of physical activity even though he/she more correctly should be described as “insufficiently active”. On the other hand, “sedentary behaviour” is a more suitable label for inactivity. It reflects that a range of behaviours can be considered “inactive”. The word sedentary is derived from the Latin verb *sedere*, meaning to sit, and sedentary behaviour refers to any
INTRODUCTION

Waking activity characterised by an energy expenditure equivalent to a sitting or reclined posture which requires minimal energy expenditure (Pate et al 2008). Common sedentary behaviours include TV-viewing, playing video games and computer-use (more specifically termed screen time behaviours), but also a range of other behaviours such as passive commuting; driving a bus or a car, reading and sitting still in a classroom. The terms sedentary behaviour(s) and screen time behaviours will be used interchangeably throughout the thesis, but when using screen time behaviours this will specifically indicate activities in front of screens for recreational purposes.

Some young people show both high levels of physical activity and sedentary behaviours, so physical activity and sedentary behaviour do not need to be two sides of the same coin. The two behaviours also seem to carry independent health risks (Marshall et al 2002; Tremblay et al 2011). Promoting more physical activity and less sedentary behaviour is beneficial for weight development, but is also beneficial for all children whether they are at risk of obesity or not (Lobstein 2004).

Physical activity, sedentary behaviour, and health

Physical activity
Physical activity has an important role in the growth, development and physical health of children and adolescents and is associated with numerous physical and psychological health benefits (Biddle & Asare 2011; Hallal et al 2006; Hills et al 2007; Janssen and Leblanc 2010). Higher levels of physical activity is related to lower levels of obesity, hypertension and CVD risk factors and is beneficial for bone health (Janz et al 2010; Mountjoy et al 2011; Tobias et al 2007). There is a biological carry over effect of physical activity from youth into adulthood, and adults may benefit from childhood physically by reduced risk of CVD and osteoporosis (Boreham and Riddoch 2001).

In addition, physical activity can be beneficial for mental health in youth (Ahn & Fedewa 2011). Physical activity has proven to have a favourable effect on depression, anxiety (Larun et al 2006) and overall self-esteem (Ekeland et al 2005). Physical activity can also improve cognitive performance, academic achievement and classroom behaviours (Fedewa & Ahn 2011).
**Sedentary behaviour**

Sedentary behaviour in children and adolescents is related to health in different ways (Tremblay et al 2011). There seems to be a dose-response relation, independent of physical activity levels, between increased sedentary behaviour, and unfavourable health outcomes. TV-watching has been the most widely studied indicator of sedentary behaviour. In particular, TV-watching above 2 hours per day seems to be associated with unfavourable body composition, reduced fitness, and also lower scores for self-esteem, pro-social behaviours and decreased academic achievement (Tremblay et al 2011). In addition, TV-viewing has been shown to be prospectively associated with increased odds of depression (Primack et al 2009). Both overall sedentary time and sedentary behaviours are associated with other adverse health behaviours such as smoking and socio-cognitive outcomes (Salmon et al 2011).

Several mechanisms may explain how screen time behaviours influence weight development (Salmon et al 2011). Children watching more TV have a higher energy intake of unhealthy food and drinks (Coon & Tucker 2002), while a positive association between unhealthy food advertising and overweight prevalence has been reported (Lobstein & Dibb 2005). It has also been questioned whether screen time behaviours influence energy expenditure by displacing time that otherwise could be used for physical activity (Biddle et al 2004; Vandewater et al 2004). The association between children’s TV-viewing and metabolic risk factors, however, has been found to be independent of objectively measured physical activity (Ekelund et al 2006). This suggests that the relation between TV-viewing and health can possibly be explained more readily by change in energy intake rather than energy expenditure (Salmon et al 2011).

**Adolescence – a key transition age**

Adolescence is a period of rapid physical and psychosocial changes in which young people gain more autonomy and decision making power when it comes to health behaviours (Sherar et al 2010). The last part of primary school (10-11 years of age) seems to be a particularly critical period and a key transition age in terms of physical activity change (Caspersen et al 2000; Jago et al 2010a; Nader et al 2008).

Physical activity levels decline sharply during early adolescence, also in Norway (Kolle et al 2009a; Nader et al 2008; Telama & Yang 2000), while TV-viewing, TV- and electronic games and using the computer are becoming increasingly popular leisure time choices.
Children and adolescents spend a large portion of their waking time in sedentary pursuits (Ruiz et al. 2011; Tremblay et al. 2011), and many young people in the Western world, including Norway, are not sufficiently active according to the recommendations (Ekelund et al. 2011; Kolle et al. 2009a).

In addition, both physical activity, including sport participation, and sedentary behaviours are somewhat stable and track at moderate to low level from childhood/early adolescence to late adolescence/young adulthood (Anderssen et al. 2005; Biddle et al. 2010; Janz et al. 2000; Raudsepp et al. 2008). Physical activity is also found to track from childhood to adulthood (Craigie et al. 2011; Tammelin et al. 2003; Telama 2009).

School-based obesity prevention and parental involvement

The school and family environment are key settings for health promotion initiatives aimed at children and adolescents (Booth & Okely 2005; De Bourdeaudhuij et al. 2011b; Naylor & McKay 2009; Story et al. 2006; Wechsler et al. 2000). School provides a window of opportunity to promote healthy behaviours. Children and adolescents from diverse ethnic and socio-economic backgrounds can be reached through schools, and young people spend a large portion of their waking hours there. Schools also play a formal role in delivering health messages, and health initiatives can be promoted through the school infrastructure, environment, policy and staff (Naylor & McKay 2009). However, academic learning is the primary aim of schools, and in Norway many extra-curricular demands have been placed on schools. Thus, insufficient time and resources, competing priorities and non-supportive environments may be barriers for implementation of health promotion initiatives (Naylor & McKay 2009).

Parental involvement in obesity prevention and EBRB have been recommended (De Meester et al. 2009; Lindsay et al. 2006; van Sluijs et al. 2007), but the evidence for whether children or adolescents benefit most from family involvement in physical activity interventions has been somewhat contradictory (Salmon et al. 2007; Timperio et al. 2004; van Sluijs et al. 2007).

Effect of interventions targeting obesity, physical activity and sedentary behaviour

By the upstart of the HEIA study in 2007, the Cochrane review by Summerbell et al. (2005) showed that diet and exercise interventions so far did not significantly improve BMI. However, some impact on the targeted behaviours was seen.
Regarding behavioural interventions, the review by van Sluijs et al (2007) found multicomponent physical activity interventions including family or community involvement to be promising for adolescents (≥12 years), while some evidence of the effect of environmental interventions was seen among children. Meanwhile, Salmon et al (2007) suggested that the most effective intervention for the youngest children included some focus on physical education (PE), activity breaks and family strategies. In addition they proposed that more motivationally tailored strategies, potentially combined with environmental strategies, could possibly be more effective among older children (≥10 years).

Regarding sedentary behaviour intervention, the review by De Mattia et al (2007) included six population based prevention studies on sedentary behaviour change interventions and weight control. Even though intervention approaches varied, all six reduced sedentary behaviour and improved weight indices were observed. Targeting screen time behaviours was emphasized as a promising approach in obesity prevention.

More recent obesity prevention reviews and meta-analysis show that school-based interventions targeting EBRB can have a favourable effect on body composition at least in the short run (Brown & Summerbell 2009; De Bourdeaudhuij et al 2011b; Gonzalez-Suarez et al 2009; Safron et al 2011). The latest Cochrane review (Waters et al 2011) concludes that the most pronounced effects on BMI are seen among those below 12 years of age. However, not all the individual interventions were effective and some of the variation between the study findings could not be easily explained. While only around 10% of the school-based obesity related interventions have been conducted in Europe, the evidence so far supports that a combination of educational and environmental components focusing on both sides of the energy-balance (healthy eating and physical activity) results in a better effect on adiposity (De Bourdeaudhuij et al 2011b). In addition, increasing evidence from reviews indicates that targeting sedentary behaviour and sedentary time can be effective in the prevention of overweight/obesity among youth (Tremblay et al 2011).

Several of these reviews of obesity prevention studies and behaviour change interventions emphasise that more high quality studies are needed using rigorous design and appropriate sample size. Both previous and more recent reviews highlight that there is also a lack of studies using an objective measure of physical activity and a lack of long term follow up (De Bourdeaudhuij et al 2011b; Kriemler et al 2011; van Sluijs et al 2007). It is not clear what the
most effective strategies and components are in either obesity or in physical activity and sedentary behaviour interventions (Biddle et al 2011; Kamath et al 2008; Kriemler et al 2011; Maniccia et al 2011; Safron et al 2011; van Grieken et al 2012). Hence, the need to investigate factors along the causal pathway of behavioural change is emphasized (Kriemler et al 2011; Safron et al 2011; van Sluijs et al 2007). Process evaluation can also help explain why interventions are successful or not (Saunders et al 2005). Issues related to implementation, adherence and the amount of intervention received should be examined (De Bourdeaudhuij et al 2011b; Harris et al 2009; Kamath et al 2008; Kriemler et al 2011; Safron et al 2011; van Sluijs et al 2007).

In addition, obesity prevention studies seem to have been more effective in girls than boys (De Bourdeaudhuij et al 2011b; Safron et al 2011), especially among those between 10-14 years of age (Brown & Summerbell 2009). Similar gender differences have also been seen in physical activity interventions (Gentile et al 2009; Kriemler et al 2011; Naylor & McKay 2009). Harris et al (2009) point out that possible subgroup effects of physical activity interventions could have been attenuated by only assessing the entire sample, in that e.g. overweight/obese children may not respond equally well to physical activity interventions as do normal weight children. Furthermore, recent meta-analyses show that interventions to reduce screen time have a small but statistically significant effect (Biddle et al 2011; Maniccia et al 2011), but there is a need to investigate whether sedentary behaviour change intervention effects vary by subgroup (Maniccia et al 2011).

Interventions to reduce screen time behaviours have primarily focused on TV-viewing (Maniccia et al 2011; Salmon et al 2011; van Grieken et al 2012), and whether effects differ for time used on TV-viewing or computers is not clear (van Grieken et al 2012). Mannica et al (2011) have pointed out that above half of the sedentary behaviour studies were theory-based, while a range of different intervention strategies has been applied. Still, none of the interventions attempted to change sedentary behaviour through regulation of screen time behaviours. Effects of physical activity interventions are mixed. Several are limited to school-time related effects (De Meester et al 2009), but there is increasing evidence of interventions being able to affect overall physical activity as well (Kriemler et al 2011). However, the recent meta-analysis by Metcalf et al (2012) of controlled trials, including intervention using objective measures of physical activity, highlights that only small effects on children's (≤16 years) overall physical activity are observed. In addition, there is no conclusion on how to
best involve parents in obesity prevention studies (O'Connor et al 2009) and/or whether parental involvement is central to improve effectiveness of school-based interventions (Kriemler et al 2011; Van Lippevelde et al 2012).

**HEalth in Adolescents (HEIA) study**

In order to prevent an adverse health effect of low levels of physical activity and inactivity including obesity, there is a need to understand the factors that influence these behaviours in young adolescents.

This thesis is a part of the HEIA study. The overall goal of the study was to design, implement and evaluate a comprehensive intervention programme to promote healthy weight development among 11 to 13 year-old Norwegians. Change in physical activity, screen time and dietary behaviours were targeted through modifiable influences on these behaviours.

The thesis focuses specifically on intervention effects on and mediating effects of factors hypothesized to operate as mechanisms of change in physical activity, while there is a complementary focus on these issues related to change in screen time behaviours.

**Theoretical background**

**The epidemiological framework**

This research agenda can be put into perspective by relating the purpose of the thesis to the behavioural framework presented by Sallis et al (2000a) (Figure 1). The framework presents a guide to important phases to consider in physical activity and inactivity research. It first emphasizes applying accurate measures of the health behaviours studied, and to establish links between these behaviours and health. Moreover, this framework stresses the importance of searching for predictive factors of health behaviours which can be used to guide development of interventions and health policies. The last phase is defined by the need to translate research findings into practice. The transition between the phases in the framework is considered an interactive process (Biddle & Mutrie 2008).
A problem driven approach

Increasing evidence indicates that health promotion initiatives lacking a theoretical base are less effective than those theoretically based, and that interventions prove more efficient when built on a multiple theoretical background (Glanz & Bishop 2010). In particular, it is argued that interventions are most successful when based on both 1) theories and models of health behaviour change and 2) empirical knowledge about factors related to the behaviour(s) (Brug et al 2005). Furthermore, when developing and testing effectiveness of health promotion programmes, one needs to use a problem-driven approach (Bartholomew et al 2006), in which the starting point is a statement of the problem. The purpose is then to understand the problem and to gain knowledge that can give directions for actions. When using a solution oriented research approach, the main focus is not on theory testing but rather on using models and constructs from existing theories in combination with evidence based knowledge to tackle a specific problem. Thus, when developing theory- and evidence-based health promotion programmes, it is recommended to use a systematic planning approach, Figure 2. Several similar planning models exist, but the HEIA study draws on the model suggested by Brug et al (2005).

Figure 1. Epidemiological Framework, modified from figure in Biddle & Mutrie (2008)
The first step in a systematic planning model is to identify the health problem that needs to be solved. The second step in the planning model is to identify the behavioural risk factors of the health problems. The third step is to investigate factors that exert influence on these behaviours. Based on the investigations in step three, the fourth step is to develop intervention goals, change strategies, and methods for behaviour change with the use of the Intervention mapping protocol (Bartholomew et al 2006). The development of the HEIA intervention benefited from applying this protocol. How it was used is described more thoroughly in the conceptual paper (Paper Ia). The fifth and last step is to integrate the above process into an intervention package that can be implemented and possibly disseminated. When trying to develop effective obesity prevention programmes with chances of having a lasting effect, a fundamental step is to identify the main factors related to EBRB (Bauman et al 2002; Brug et al 2005; Fulton et al 2001; Kremers 2010).

This is done as the third step in this planning model (Figure 2), and is specifically relevant for this thesis. When taking a wider perspective, the purpose of the thesis is to expand the knowledge base of factors and mechanisms related to physical activity and sedentary behaviour change which can benefit future interventions. In line with this, the theoretical
background and empirical findings concerning factors related to physical activity and screen time behaviours at the time of initiating the HEIA-intervention will be presented further. This also leads into the specific research aims of this thesis.

**Social-ecological framework**

The purpose of theories and models of health behaviour change is to describe and explain the processes underlying changes in health related behaviours (Nutbeam & Harris 2004). However, no single factor or set of factors adequately account for why people are physically active or sedentary (Glanz & Bishop 2010). Accordingly, no single theory is likely to embrace all influences on e.g. physical activity and sedentary behaviour (Gorely 2005). The present thesis is based on a social-ecological framework which acknowledges the contribution of personal as well as social- and physical environmental factors in the understanding of physical activity and sedentary behaviours. As such, this framework also invites the use of specific theoretical models embedded in a social-ecological context that help identify important theoretically informed potential determinants for change in these behaviours.

In terms of specific theoretical approaches, several have been oriented towards individual personal factors emphasizing psychological and/or behavioural factors. They have, however, been criticized for not taking into consideration social- and physical environmental factors. This has led to the development of ecological approaches (Sallis et al 2002a; Sallis et al 1998; Spence & Lee 2003). Ecological approaches to behavioural change are currently at the forefront of public health action, and ecological models have become the prominent theoretical framework to understand factors influencing obesity (Swinburn et al 1999) and the complex behaviours such as physical activity and sedentary behaviour (Sallis et al 2002a; Stokols 1992). The ecological perspective of health behaviours has been central to public health concepts since the 19th century (Green et al 1996), and the term “ecology” refers, in a broad sense, to the interrelations between organisms and the environment in which they exist (Kremers 2010).

Within behavioural sciences, an ecological perspective implies a focus on people’s interactions and relationships with their physical and social environments (Sallis et al 2002a). Social-ecological models of behaviour posit that there are multiple levels of influences on behaviours, including psychological and inter-personal, proximal and distal physical environment factors, as well as policy level factors. The model provides guidance for
developing successful programmes through social and physical environments (McLeroy et al 1988; Sallis et al 2002a). This consideration of multiple levels of influences distinguishes ecological models from most other theoretical perspectives (Gorely 2005).

There are several variations in how ecological models are conceptualized, but McLeroy et al (1988) proposed an ecological model for health promotion consisting of the following five levels, in which behaviour is assumed to be either facilitated or constrained by (Figure 3):

1) Intra-personal factors (i.e. individual characteristics including psychological factors, behaviours, skills and the developmental history of the individual)
2) Inter-personal factors (i.e. family processes, peers, work groups)
3) Institutional factors (i.e. kinder gardens, schools, workplaces; social institutions with organisational structure and formal and informal rules and policies)
4) Community factors (i.e. relationship among organizations, institutions)
5) Public policies (regulations, policies and laws)

![Figure 3. Levels of influence on behaviour based on an ecological model for health promotion, from McLeroy et al (1988)](image)

Physical environments are not explicitly specified by McLeroy et al (1988), but are now recognized as central components of an ecological approach as “behavioural settings” (Sallis et al 1998). A behavioural setting can be explained as the physical and social context in which behaviour occurs. Parks, playgrounds, recess areas, schools, classroom and homes are examples of behavioural settings which may influence young people’s physical activity and sedentary behaviours.
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According to Stokols (1992) there are several assumptions in ecological approaches. First, health behaviours are influenced by multiple facets of the physical and social environment. Another point is that the environments themselves are seen as multidimensional and complex. They may have both social and physical components; for example, schools may provide attractive facilities for physical activity and teachers may stimulate pupils to use these. There may also be differences in the actual environment and the individual’s perception of the environment; for example, some children may not perceive a certain playground as attractive even though it was built to be. In addition, ecological approaches posit reciprocal causation in the individual – environment interaction, meaning that the behaviours can both influence and be influenced by the environment (e.g. children who are more active can receive more social support and/or more social support can cause more physical activity). A last point is that the interaction between the individual and the environment can take place at various levels of aggregation (e.g. at the individual level, within the family and the school system).

For children and adolescents the most proximal levels within the social-ecological model are believed to have the most direct influence on youth’s behaviour, including the social-environmental factors and behavioural settings most relevant for young people (e.g. family, school and peer influences and the closest neighbourhood). It is also assumed that the different components of a coordinated and multilevel programme will work synergistically in influencing the targeted behaviours (King et al 2002). For example, one may hypothesise that an environmental modification like building a new bike trail and distributing a brochure to parents about the benefits of letting the child bike/walk to school would increase the child’s active transport more than just providing one of these components. However, ecological models are inherently complex due to the assumption that personal and environmental factors of behaviour are interdependent (Kelly 1990; Spence & Lee 2003). Various factors can also interact across environment (e.g. school facilities and family practices may be influenced by the socio-economic status of an area). As a consequence, the working mechanisms leading to behaviour change by ecological-based interventions may be difficult to investigate.

The social-ecological framework emphasises the need for implementing strategies at multiple levels and in several behavioural settings in order to obtain greater and longer-lasting changes in health behaviours (Sallis et al 1998; Spence & Lee 2003). It specifies different categories/levels of potential social-environmental factors that can be targeted in behavioural interventions, but provides only a general framework for explaining and influencing
behaviours (Gorely 2005). Therefore, taking a social-ecological approach invites the simultaneous use of a broad set of more specific existing theories and models, representing individual factors as well as social-and physical environmental ones. Such theories and models can add specificity and guidance in understanding and predicting influences on behaviours. While several specific theories and models exist to explain EBRB, we took advantage of the social cognitive theory (SCT) (Bandura 1986) and the concept of enjoyment of physical activity based on several theoretical models (Harter 1978; Harter 1981; Nicholls 1989; Scanlan et al 1993).

**Social cognitive theory and the concept of efficacy**

One of the social cognitive models most widely applied is Bandura’s SCT (Bandura 1986). The concepts of SCT are consistent with principles of social-ecological models (Glanz & Bishop 2010). It implies that creating an environment conducive to change is important when promoting favourable changes in health behaviours. As in social-ecological models, the construct of reciprocal determinism is central in SCT. It means that personal, environmental and behavioural factors are mutually influential in predicting behaviour and behavioural change (Bandura 1986).

The personal factors of SCT comprise knowledge, self-efficacy and outcome expectations. According to SCT, beliefs of personal efficacy are the foundation of human motivation and action (Bandura 2004). Self-efficacy can be defined as a person’s perceived ability to overcome challenges and barriers that may influence behaviour (Bandura 2004). An individual must believe (or be efficacious) that he/she has the power to carry out a behaviour, in order for it to happen. For example, a child must be confident that he/she will be able to go out and play, even though there is a computer to play on at home or it is cold outside. Confidence in personal ability to carry out a behaviour (i.e. self-efficacy) also influences the motivation (i.e. the direction, intensity and persistence of a behaviour) (Bandura 1989; Bandura 1997). Accordingly, an individual who has high self-efficacy about physical activity will also perceive fewer barriers to the behaviour and/or be less influenced by them. As a consequence she/he will be more likely to act on the expectations of the anticipated desired outcomes (the outcome expectancies) of being physically active.

Social-environmental factors within SCT such as social support, social restrictions and barriers to behaviour adaption are concerned with how and to what extent others (e.g. parents
and friends) help facilitate and influence an individual’s engagement or disengagement in specific behaviours. Typically, physical and cultural-environmental factors such as physical facilities (e.g. school yards, playgrounds, parks, bike-trails, school policies) are not denied within SCT, but are assumed to influence behaviours indirectly, i.e. they affect behaviours through mediating cognitive factors (Kremers 2010). SCT reflects a dynamic interaction of personal, social and physical-environmental factors that can form the basis for interventions targeting EBRB (Egger & Swinburn 1997; Kremers et al 2006; Swinburn et al 1999).

**The concept of enjoyment**

Enjoyment is a construct included as a component of several major sport motivation theories such as the competence motivation theory (Harter 1978; Harter 1981), the achievement goal theory (Nicholls 1989) and the sport commitment model (Scanlan et al 1993). In addition, enjoyment shares many characteristics related to intrinsic motivation within the self-determination theory (Deci & Ryan 1985) and factors associated with the concepts of “flow” within sport participation (Csikszentmihalyi 1975; Kimiecik & Harris 1996). However, enjoyment may also be derived from extrinsic aspects of participation in physical activity and aspects other than being in a state of flow; for example context related aspects such as recognition from important others and interaction with peers (Scanlan & Lewthwaite 1986). Within youth research there exists disagreement about the definition of enjoyment of participation in physical activity and sport, but many have defined enjoyment as “a positive affective response to sport/physical activity experiences that reflects generalized feelings such as pleasure, liking and fun” (Scanlan et al 1993). This is a relevant definition when referring to the enjoyment of physical activity in this thesis.

**Correlates, determinants, mediators and moderators**

Understanding theoretically informed factors that influence physical activity and sedentary behaviours can aid the development of more effective interventions. Correlates, determinants and mediators are terms used for factors that are related to and/or influence behaviours. Correlates and determinants are often used synonymously. However, correlates refer to reproducible associations but do not support causal inferences (Bauman et al 2002). When referring to a cause and effect relationship, which is important in appraising the evidence on effect from behavioural change interventions, it is recommended that the term determinants should be used. Still, correlation studies are important because such studies can aid in generating hypotheses about causal relationships and point to potential factors that can be targeted in interventions (Bauman et al 2002).
Modifiable determinants of change are called mediators (Baron & Kenny 1986). Mediators are variables that can specify the causal sequence between an intervention and an outcome (e.g. behaviour) (Bauman et al 2002), Figure 4. While referring to the various papers in this thesis, the term correlate will be used when the cross-sectional baseline results are reported and discussed (Paper Ib), while in the other papers either the term determinant or mediator will be used (Paper II-IV).

One of the conditions of mediation is causality, in which it is anticipated that changes in the mediator precede changes in the outcome (Mackinnon et al 2007). Studies including prospective design with a control group are needed to adequately examine mediators (Baron & Kenny 1986). In a mediation analysis, a potential mediating variable is included in a model of an independent (e.g. intervention condition) and an outcome variable. Different statistical approaches have been applied when studying mediation (Baron & Kenny 1986; Kraemer et al 2008; Mackinnon 2008), but principally a mediation analysis consists of three parts (Van Stralen et al 2011):

1. The action theory test, which refers to how the independent variable (e.g. the intervention) affects the mediating variable (path a). For example, the intervention leads to significantly higher self-efficacy for physical activity in the intervention group compared to the control group

2. The conceptual theory tests, which refer to how the mediating variable influences the outcome variable, controlling for the independent variable (path b). For example, change in self-efficacy is significantly associated with change in physical activity, independent of the intervention

Figure 4. Illustration of a mediating approach, modified from Bauman et al (2002)
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3. The mediated effect test, which is a simultaneous test of the action and conceptual theories test, wherein the extent of the mediated effect on the intervention effect on the outcome (e.g. physical activity) is evaluated.

When an association or effect depends on a third variable, this variable is called a moderator. Moderating variables are not part of the causal chain, but they address when or for whom a variable most strongly predicts or causes an outcome (Bauman et al. 2002; Fairchild & Mackinnon 2009). Typical non-modifiable fixed markers like a person’s characteristics (e.g. gender and parental education status) or biological characteristics (e.g. weight status) that can vary with behaviours are relevant to investigate as moderator. Such analyses can point to subgroups of populations in special need of tailored programmes.

It is argued that thorough examination of interventions which include measurement and analyses of theoretically informed determinants/mediators and moderators, is the foundation of evidence based health behaviour change (Glanz & Bishop 2010). According to the mediating framework or model, it is expected that changes in theoretically informed mediators (i.e. psychological, social and physical environmental determinants) will lead to beneficial change in the targeted behaviour(s). Change in a potential mediator variable can be induced by an intervention designed to change the mediator(s) (Baranowski & Jago 2005).

Within the context of obesity prevention programmes, mediators are the intervening causal variables necessary to complete the pathway from the intervention to the change in the risk behaviours (Bauman et al. 2002; Lubans et al. 2012). Mediating variables form the basis of research questions such as “Can enhanced enjoyment of physical activity increase physical activity levels?” and “Will more parental regulation of TV-viewing decrease time spent on this behaviour?” (Mackinnon et al. 2007). Mediation analyses can be used to describe and investigate whether and how interventions induce change in behavioural outcomes through change in the mediators.

Targeted mediators can also be considered as an intervention outcome in itself (Green 2000). Investigating effects on mediators can identify potential mechanisms of behaviour change and unravel possible reasons for the effectiveness or ineffectiveness of behaviour change (Lewis et al. 2002). Such knowledge may contribute to more effective and economical interventions. It can lead to improved strategies and activities better able to affect mediators, elimination of
factors that are repeatedly not affected by interventions and contribute to build a knowledge base of potential mediators (Baranowski & Jago 2005). There has been a call for investigation of mediators at multiple time points, including both short-term (i.e. weeks) and long-term (i.e. years), and to examine a range of constructs embedded in a social-ecological model (Lewis et al 2002).

Process evaluation and mechanisms of behavioural change
How and to what extent an intervention is being implemented will influence its efficacy (Baranowski & Jago 2005). Failure of interventions in e.g. affecting the mediator(s) may be due not only to wrong strategies, ineffective components and insensitive instruments, but also to insufficient implementation. Process evaluation is used to assess, monitor and document implementation of interventions (Saunders et al 2005). Dose received as perceived by the participants is a key element of process evaluation. Nevertheless, how study participants receive the intervention is rarely examined within school-based interventions (Lytle 2009). In addition, to investigate how process variables (e.g. degree of exposure and participation in an intervention) relate to mediators will indicate whether implementation issues may be related to mechanisms of change (Baranowski & Jago 2005; Thomas 2006).

Moderation and moderated mediation
The effect of an intervention may be moderated by various demographic subgroups, or biological or personality traits; for example, the programme may affect girls better than boys (Bauman et al 2002; Fairchild & Mackinnon 2009; Kremers et al 2007). There is still a lack of insight into what interventions work for whom (Kremers et al 2007; Yildirim et al 2011). Due to the complex nature of the EBRB, it has also been highlighted that a search for moderators of the determinants of such behaviours is needed (Baranowski et al 2003; Bauman et al 2002; Kremers et al 2006). It is also possible to examine whether the mechanisms by which a programme is hypothesized to impact the behaviour are the same or not across different subgroups of participants, by investigation of moderated mediation effects (Fairchild & Mackinnon 2009). When one investigates mediation and moderation effects together (Fairchild & Mackinnon 2009; Mackinnon 2008), one can e.g. explore whether adolescents’ gender or weigh status may moderate a potential mediation mechanism (e.g. a possible mediation process of self-efficacy or enjoyment due to an intervention may differ in girls and boys).
Empirical evidence for correlates, determinants, moderators and mediators

In the following existing empirical evidence of theoretically informed modifiable and non-modifiable correlates, determinants and mediators at the time of developing and initiating the HEIA intervention are presented. In accordance with social-ecological models, correlates are typically identified within five different domains (Biddle & Whitehead 2005; Sallis et al 2000b; van der Horst et al 2007):

1) Demographic and biological factors (e.g. gender, BMI, parental education)
2) Psychological factors (e.g. self-efficacy and enjoyment for physical activity)
3) Behavioural (e.g. parental physical activity and screen time viewing)
4) Social (e.g. social support, social restrictions)
5) Physical-environmental factors (e.g. environmental opportunities in the school yard, number of TVs at home)

A distinction is made between “children” (less than 13 years of age) and “adolescents” (13 to 18 years) in most reviews of factors related to physical activity or sedentary behaviour, and these terms are used when referring to the empirical findings. However, when referring later to the participants in the HEIA study in this thesis (11 years at baseline and 13 years at post-intervention), the term adolescents is used. This is in line with the term for age categorization used by the World Health Organization (1986).

Modifiable influences on physical activity and screen time behaviours

Most young people seem to have time for both physical activity and screen time behaviours, and in general they seem to be uncorrelated and different behaviours (Biddle et al 2004). Hence, they also have a unique set of predicting factors (Marshall et al 2002; Owen et al 2000).

Among the modifiable biological correlates it was not clear whether anthropometric measures such as BMI were associated with physical activity in children or adolescents (Sallis et al 2000b; van der Horst et al 2007). Bodyweight, however, was consistently positively correlated with sedentary behaviour (TV-viewing) in a review among youth between 2 to 18 years of age (Gorely et al 2004).

With regard to physical activity, higher levels of self-efficacy of physical activity (Biddle & Whitehead 2005; van der Horst et al 2007), enjoyment of physical activity (Biddle &
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Whitehead 2005), social support from significant others (Biddle & Whitehead 2005; Ferreira et al 2006; Gustafson and Rhodes 2006; Sallis et al 2000b; van der Horst et al 2007) and environmental opportunities for physical activity (Davison & Lawson 2006; Ferreira et al 2006; Sallis et al 2000b) were consistently associated with higher levels of physical activity. Sallis et al (2000b) found that TV-viewing after school and on weekends was associated with less physical activity in adolescents, while physical activity was not related to TV-viewing in the review by Gorely et al (2004). However, it has been shown that sedentary behaviour can compete with physical activity for some, while for others these two behaviours can coexist (Marshall et al 2002). In general, however, the evidence for a displacement mechanism, assuming that more time spent on screen time behaviours (primarily TV-viewing) is related to less physical activity, was inconsistent (Sallis et al 2000b; van der Horst et al 2007).

In line with social-ecological approaches, the quality of the social-environment within a behavioural setting may influence behaviours. Findings indicate that young people who experience positive perceptions of their neighbourhood in terms of social relations are more physically active (Hume et al 2009). The school is, in the same way as the neighbourhood, a key setting for developing social networks. We expected the social environment within the school-setting to be a factor possibly related to EBRB, and that aspects linked to social relations could possibly be influenced by the intervention. Therefore, we made use of a “social inclusion” measure (Hume et al 2009), but modified it to capture social aspects related to the school-setting.

Only a few consistent modifiable correlates of screen time behaviours were identified at the time of developing the HEIA intervention (Gorely et al 2004). Nevertheless, several factors in the family environment were highlighted as potential influences on children’s TV-viewing, such as parenting practices, family characteristics, family television viewing practices and access to televisions (Hardy et al 2006).

Regarding mediation evidence, by 2007 nineteen studies published between 1985 and 2006 had investigated effects of strategies to promote children’s physical activity on potential mediators (Salmon et al 2009). Psychological constructs were most often studied. Four of the eight studies including self-efficacy and two of the six studies including enjoyment reported positive changes in these constructs. However, none of the reviewed studies reported whether changes in these constructs mediated changes in physical activity. Only three intervention
studies had carried out a full mediation analysis of physical activity change, and these only among adolescent girls above 14 years of age (Dishman et al 2004; Dishman et al 2005; Dunton et al 2007). Self-efficacy and enjoyment partly mediated physical activity change in the American LEAP-intervention (Dishman et al 2004; Dishman et al 2005). On the other hand, the intervention by Dunton et al (2007) among sedentary Iranians did not impact self-efficacy, enjoyment or social support, and did not mediate physical activity change either. Studies investigating potential mediation of sedentary behaviour change were lacking in 2007.

**Non modifiable influences on physical activity and screen time behaviours**

Regarding demographic, non-modifiable correlates, physical activity was consistently found to vary with gender. Boys were in general more active than girls, while adolescent boys seemed to engage in more screen time behaviours than girls (Sallis et al 2000b; van der Horst et al 2007). How SES is operationalized varies (i.e. educational, occupational, income and neighbourhood-related measures), but there was no evidence for SES being related to physical activity in either children or adolescents in the review by Sallis et al (2000b). However, higher educational level in mothers was seen to be associated with more physical activity in children (Ferreira et al 2006). There seemed to be a reverse cross-sectional association between parental education and sedentary behaviours among youth (Gorely et al 2004; van der Horst et al 2007).

**Need for additional studies**

The literature showed that there was a lack of European studies, and modifiable correlates of physical activity seemed to differ for children and adolescents. This indicated a special need for identifying correlates of physical activity for those in the key transition age.

Recommendation for future research included: 1) to investigate potential environmental correlates of physical activity and correlates of insufficient physical activity and sedentary behaviour, 2) to investigate whether other sedentary behaviours besides TV-viewing were related to physical activity, 3) to aim for more longitudinal and controlled intervention studies, 4) to use objective measures of physical activity and sedentariness, and 5) to investigate potential mediators of behaviour change.

In particular, there is a need for further research to gain more knowledge about mechanisms of physical activity and screen time behaviour change in youth. Identification of both mediators and moderators of behaviour change in behavioural research has the potential to
move the field forward, as it adds knowledge about which strategies and components of an intervention may influence behaviour change and what works for whom.

**Aims and research questions**

The main aims of this thesis are fourfold: 1) to investigate a set of theoretically informed modifiable factors and their relationship to physical activity in Norwegian 11 year-old adolescents; 2) to examine whether these factors mediated intervention effects on physical activity and screen time behaviour change, and 3) to explore potential moderators of the intervention effects.

The following four research questions were put forward in this thesis related to Papers Ib-IV. Paper Ia is included in this thesis to present details on the overall design, sampling and materials, but no specific research questions are related to this paper.

Research question 1 (Paper Ib):

a. To what extent did the potential biological, psychological, behavioural, and social-environmental correlates genuinely account for variation in physical activity among pre-adolescent Norwegian children?

b. Did weight status moderate the role of these potential biological, psychological, behavioural, and social-environmental correlates?

Research question 2 (Paper II):

a. Did the HEIA intervention affect potential psychological, social and physical-environmental determinants of physical activity and screen time behaviours at mid-way and post-intervention?

b. Did gender, weight status and parental education status moderate these mid-way and post-intervention effects?

c. Was degree of exposure to and participation in the intervention related to change in the determinants mid-way and post-intervention?

Research question 3 (Paper III):

a. Did potential psychological, social and physical-environmental determinants mediate intervention effects on physical activity?

b. Did gender and weight status moderate mediated effects?
Research question 4 (Paper IV):

a. Did the intervention affect screen time behaviours (TV-viewing and computer/game-use) post-intervention?

b. Did parental regulation of TV-viewing and computer/game-use mediate the intervention effects on the set of screen time behaviours?

c. Did gender and weight status moderate mediated effects?
MATERIALS AND METHODS

Overall design, sample and data collection

The HEIA study was a 20 month, school-based group RCT to promote a healthy weight development in 11 to 13 year-olds. Schools were identified from the Directorate of Education’s website and recruited from towns/municipalities in seven counties in the south-eastern part of Norway, Figure 5.

Figure 5. The seven counties (in grey) from south-eastern Norway from which schools were recruited to the HEIA study

For logistic reasons schools had to have at least 40 pupils enrolled in 6th grade to be recruited. Out of 177 eligible schools, 37 accepted the invitation and 12 schools were randomly assigned by simple draw to the intervention group and 25 to the control group. Neither schools nor investigators were blinded for condition. All 6th graders (n=2165) in the attending schools and their parents/legal guardians were invited to participate. Of these, 1580 (73%) returned a parental signed informed consent form for the adolescents. At baseline, 1528 (71%) adolescents filled in the main questionnaire. Of these, 1511 participated at the 8 month mid-way assessment and 1463 participated at the 20 month post-intervention. A total of 1418 (93%) adolescents participated both at baseline and post-intervention, and of these 1384 (91%) also provided mid-way data. All the adolescents in the intervention schools took part in the intervention, while only those with consent took part in the data collection. Figure 6 shows the recruitment process and participants in each paper.
Figure 6. Flow chart of recruitment process, number of schools, adolescents and parents included in Papers Ib-IV, by control and intervention condition and in total.
Three data collections were administered. The baseline assessment was conducted in September 2007, the mid-way assessment in May 2008 and the post-intervention assessment in May 2009. At baseline and post-intervention the adolescents answered an internet-based questionnaire, trained project staff measured adolescents’ anthropometry, and the adolescents filled in a gender specific paper questionnaire about puberty development. The parents (both mothers and fathers) answered paper-questionnaires, delivered home to the parents by the adolescents. At the mid-way assessment the adolescents answered an abbreviated version of the electronic questionnaire. These parts of the data-collection were administered over approximately four weeks at each assessment. In addition, the adolescents’ physical activity was assessed by accelerometers over a three month period at baseline (September through November) and post-intervention (March to mid-May). All members of research staff were trained and measurements were conducted according to standard procedure. The conceptual article of the HEIA study (Paper Ia) presents further details on the overall design, sampling, methods, instruments, all behaviours and determinants, and intervention components.

In spring 2007, prior to the baseline data collection, a separate test-retest study was conducted at four different schools among 10-11 year-old adolescents (n=114) and parents (mothers n=43 and fathers n=35) from the same sampling area as the main study.

**Measurements**

This section will provide information on the specific variables that were used in this thesis (Papers Ib-IV). The main variables collected by questionnaires are shown in Appendix 1.

**Demographic variables**

The adolescents reported their gender and age in the electronic questionnaire. Parental education level was used as an indicator of SES. The parents self-reported their years of education in five categories on the informed consent form for the adolescents (Appendix 2), which were categorized into three levels: 12 years or less (“high school”), between 13 and 16 years (≤ 3 years with university/college) and more than 16 years (university/college > 3 years). The data from the parents with the longest education was used in the analyses, or else the one available.
MATERIALS AND METHODS

**Anthropometric and puberty variables**

The procedures for the anthropometry and puberty assessment are described in Paper Ia. The height and weight measures were used to calculate BMI, and the age and gender specific BMI cut-off values proposed by the International Obesity Task Force (IOTF) (Cole et al 2000) were used to dichotomise the adolescents as normal weight or overweight/obese. When reporting and discussing the results for the overweight/obese group further in this thesis, this will be referred to as the overweight group because only a small proportion in the samples were obese (between 1.5-1.9% depending on the sample).

The Pubertal Development Scale (PDS) based on the Pubertal Category Score as defined by Carskadon and Acebo (1993) was used to determine pubertal status, assessed in a self-reported gender specific, one-page paper questionnaire. PDS for boys included body hair growth, voice and facial hair. For girls the scale included hair growth, breast development and menarche. The baseline puberty status was categorized into three groups; pre-, early-, or mid/late/post pubertal.

The intraclass correlation (ICC) was used for assessing test-retest reliability. In the conceptual paper for the HEIA study (Paper Ia) Pearson’s correlation coefficient (r) was used to assess test-retest reliability for height, puberty and the screen time behaviours, but was later assessed using the ICC.

**Psychological, social and physical-environmental variables**

The measures included theoretically derived constructs to capture modifiable psychological, social and physical-environmental influences on physical activity and sedentary behaviours in young people (Bandura 1986; Harter 1978) which have shown evidence of validity in previous studies (Hardy et al 2006; Hume et al 2009; Ommundsen et al 2008; Sallis & Saelens 2000).

The adolescents reported seven psychological, social and physical-environmental measures related to physical activity, and two social-environmental measures related to screen time behaviours. The psychological constructs were: Enjoyment of physical activity (Brustad 1993) and self-efficacy related to barriers for physical activity (Motl et al 2000), both assessed by five items. The social-environmental constructs of physical activity were: Perceived social support from parents, assessed by five items, perceived social support from friends (Sallis et
al 1999) and perceived social support from teachers taken from a pilot study within the European Youth Heart Study (Riddoch et al 2005), both assessed by three items. To capture the quality of relationship with peers at school both within and outside the classroom (degree of closeness and willingness to ask for/provide help when necessary), a construct labelled perceived social inclusion at school was assessed using six items. This measure was adapted and based on a social capital measure (related to people in my area/neighbourhood) developed by Hume et al (2009). As explained in the introduction, we expected this measure to be positively related to EBRB during school-hours. The physical-environmental construct was: Perceived environmental opportunities to be physically active at school and during leisure time, assessed by four items (Sallis et al 1999), including one added item to capture the availability of equipment to stimulate playing games/being physically active in the school yard.

The social-environmental constructs of screen time behaviours were: perceived parental regulation of TV-viewing and perceived parental regulation of computer/game-use assessed by four items (Hardy et al 2006). The parents (both mothers and fathers) reported two social-environmental measures related to the adolescents’ screen time behaviour. The constructs were: parental regulation of TV-viewing assessed by six items and parental regulation of computer/game-use based on Hardy et al (2006) assessed by four items. The measure of parental regulation of computer/game-use assessed by both adolescents and parents was derived from the measures of regulation of TV-viewing.

The participants were asked to rate the items in these measures on a five-point Likert scale coded 1 (“totally disagree”) to 5 (“totally agree”) with a neutral midpoint (neither agree nor disagree). The only exception was the social support measures. They were phrased “almost never or never”, “one or two times a week”, “three to four times a week”, “almost every day” and “every day”. The mean score of the items for each measure was computed at the assessed time-points, including participants with a response rate of 70% or greater on the respective items in each measure (van Sluijs et al 2005). The range for the values of composite scores was from 1.00 - 5.00. The wording of the items in the measures is shown in Appendix 1. Enjoyment, self-efficacy and social support, except for social support from friends, were assessed at all three time-points, while the other constructs were measured at baseline and post-intervention.
The internal consistency reliability was assessed by Cronbach’s alpha (α) in the specific study sample at all time-points. An α-value of above 0.60 was considered acceptable (Sim & Wright 2000a). In order to obtain acceptable α-values for enjoyment, and regulation of TV-viewing and computer/game-use reported by both the adolescents and parents, one item in each of these scales was omitted when the composite scores were computed (Appendix 3). The following criteria based on Landis and Koch (1977) were used to interpret the test-retest reliability (ICC): ≤0.40 “poor” agreement, 0.41-0.60 “moderate” agreement, 0.61-0.80 “good” agreement, ≥ 0.81 “excellent” agreement (Jago et al 2009; Singh et al 2011).

All the determinant measures showed acceptable α-values at all time-points and moderate, good or excellent test-retest reliability (ICC) reported in the specific papers (Ib-IV), also shown in Appendix 3 together with the number of items used in the composite scores.

**Physical activity**

Accelerometers are small lightweight monitors which measure acceleration of the body or different parts of the body in one, two or three dimensions for a specified, predefined time period (epoch) (Ekelund et al 2011). The accelerometer Actigraph models 7164 and GT1M (Actigraph, Pensacola, FL, USA) were used to assess free living physical activity at baseline and post-intervention in the vertical plane (uniaxial). For practical reasons we used two types of accelerometers in the HEIA study.

In Paper Ib the practical and logistic administration of the accelerometer assessment is described in more detail, including the delivery and collection of the instrument to the adolescents through the school and how to place the accelerometers on the body. The adolescents were asked to wear the accelerometers for five consecutive days, and were set to start recording at 6 am the day after the adolescents received them. The epoch length (sample interval rate; the amount of time over which activity counts are integrated and recorded) was set to 10 seconds because children’s physical activity is shown to be spontaneous and the intensity varies in short bouts (Baquet et al 2007; Sirard & Pate 2001). Two weekdays and two weekend days were recorded. The stored activity counts were downloaded to a computer and the customised software programmes “CSA-analyzer” (http://csa.svenssonport.dk) and “Propero” (University of Southern Denmark, Odense, Denmark) were used for accelerometer data reduction and preparation. In the analyses of accelerometer data, only daytime activity was recorded (06:00-24:00 hours). Sequences of twenty minutes or more of consecutive zero
counts were interpreted as representing non-wear time and were excluded for each individual’s recording (Esliger et al 2005). A recording was considered to be valid when three days were assessed (including one weekend day) with at least eight hours (480 minutes) of activity recorded per day, a criteria used by others (Ekelund et al 2004; Kolle et al 2009b).

At baseline and post-intervention 1439/1396 were present and willing to wear an accelerometer, respectively, and 1129 (79%)/892 (64%) obtained valid accelerometer data according to the pre-defined criteria (Figure 6). Reasons for exclusion were not achieving at least three days of recording (baseline n=247; post-intervention n=378), not wearing the accelerometer (baseline n=40; post-intervention n=121) and instrument malfunction (baseline n=23; post-intervention n=5).

The average number of minutes that the participants wore the accelerometer and the number of activity counts per minute were calculated. Mean count per minute (MCPM) is a measure of the overall “total” volume of physical activity a person engages in. Various types of validity studies, including the “gold standard measurement” doubly labelled water, have demonstrated the Actigraph to provide valid assessment of physical activity in children and adolescents (Ekelund et al 2001; Trost 2007). MCPM was used as the outcome variable in Paper IV.

Regarding health effects of physical activity, the ideal amount and type of physical activity probably depend on the type of health outcome in question (Andersen et al 2006; Ekelund et al 2012; Strong et al 2005). Given the overall purpose of a healthy weight development in the HEIA study, the strategy was to increase overall physical activity including also efforts to increase MVPA. MVPA was calculated using a cut-off point ≥ 2000 counts/min, which has been applied in other studies (Ekelund et al 2004; Kolle et al 2009a; Steele et al 2009). This threshold is approximately equivalent to a walking pace of 4 km/h in youth (3 metabolic equivalents) (Trost et al 1998). There is no consensus about which intensity thresholds are the most appropriate for defining MVPA and whether the thresholds are age specific in children and adolescents, but it is recommended to present an intensity threshold for MVPA in the range of 2000 and 3500 counts per minute (Ekelund et al 2011). Values were calculated for percentage of daily monitored time spent in MVPA to account for variation in time spent wearing the monitors (Morgan et al 2008; Nilsson et al 2009). Percentage daily MVPA (% daily MVPA) was the dependent variable in Paper Ib.
The comparability of the newer model of Actigraph (the GTIM) which came in 2005 with the older model (7164) is still being examined (Cain et al 2012). For MVPA there are studies which show they are comparable (Corder et al 2007; John et al 2010; Kozey et al 2010), but MCPM measured by model 7164 and GT1M has shown to differ (Corder et al 2007; Ried-Larsen et al 2012). Therefore, a free-living validation study of the monitors used in the HEIA study was conducted (Grydeland et al, submitted). 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 is in line with recommendations stated by Corder et al (2007) and findings from Ried-Larsen et al (2012). As the outcome variable in Paper III was MCPM, we adjusted for accelerometer types using the correction factor, but not in Paper Ib in which MVPA was the dependent variable.

**Screen time behaviours**

To assess the level of screen time behaviours, two questions modified from the PEACH study were used (Page et al 2010). The adolescents were asked how many hours they spent watching TV (including DVDs) and using a computer, playing TV-games or playing other electronic games on a regular day. The questions were asked separately for week and weekend days in line with the HBSC study (Torsheim et al 2010).

The questions assessing hours of TV-viewing (including DVDs) were assessed on a six-point scale ranging from 0.5 hours to 5 hours, and the questions assessing hours spent on the computer/game-use on a six-point scale ranging from 0 hours to 4 hours. The test-retest results (ICC) for the screen time behaviours are reported in Appendix 4, all showing acceptable to good values.

Table 1 gives an overview of the main self-reported variables used in this thesis and their role in the various papers.
## MATERIALS AND METHODS

### Table 1. Overview of the main variables and their role in Papers Ib, II, III and IV

<table>
<thead>
<tr>
<th>Category/Variable</th>
<th>Paper Ib</th>
<th>Paper II</th>
<th>Paper III</th>
<th>Paper IV</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Time-point</strong></td>
<td>Baseline</td>
<td>Mid-way</td>
<td>Post-Intervention</td>
<td>Post-Intervention</td>
</tr>
<tr>
<td><strong>Behavioural:</strong></td>
<td>Investigated as</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moderate and Vigorous PA (MVPA)</td>
<td>OC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overall PA: Mean count per minute (MCPM)</td>
<td>OC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TV-viewing weekday</td>
<td>OC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TV-viewing weekend</td>
<td>X</td>
<td>OC</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer/game-use weekday</td>
<td>OC</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer/game-use weekend</td>
<td>X</td>
<td>OC</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Demographical:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td>Co</td>
<td>Mod</td>
<td>Mod</td>
<td>Co/Mod Med</td>
</tr>
<tr>
<td>Parental education level</td>
<td>Co</td>
<td>Mod</td>
<td>Mod</td>
<td>Co/Mod Med</td>
</tr>
<tr>
<td><strong>Biological:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight status</td>
<td>X</td>
<td>Mod</td>
<td>Mod</td>
<td>Co/Mod Med</td>
</tr>
<tr>
<td>Puberty level</td>
<td>Co</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Psychological:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enjoyment of PA</td>
<td>X</td>
<td>OC</td>
<td>OC</td>
<td>Med</td>
</tr>
<tr>
<td>Self-efficacy of PA</td>
<td>X</td>
<td>OC</td>
<td>OC</td>
<td>Med</td>
</tr>
<tr>
<td><strong>Social-environmental:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social support for PA from parents</td>
<td>X</td>
<td>OC</td>
<td>OC</td>
<td>Med</td>
</tr>
<tr>
<td>Social support for PA from teachers</td>
<td>X</td>
<td>OC</td>
<td>OC</td>
<td>Med</td>
</tr>
<tr>
<td>Social support for PA from friends</td>
<td>X</td>
<td>OC</td>
<td>OC</td>
<td>Med</td>
</tr>
<tr>
<td>Parental regulation of TV-viewing</td>
<td>X</td>
<td>OC</td>
<td>OC</td>
<td>Med</td>
</tr>
<tr>
<td>Parental regulation of computer/game-use</td>
<td>X</td>
<td>OC</td>
<td>OC</td>
<td>Med</td>
</tr>
<tr>
<td>Social inclusion at school</td>
<td>X</td>
<td>OC</td>
<td>OC</td>
<td></td>
</tr>
<tr>
<td><strong>Physical-environmental:</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Environmental opportunities for PA</td>
<td>X</td>
<td>OC</td>
<td>Med</td>
<td></td>
</tr>
</tbody>
</table>

PA=Physical activity; OC=Outcome (dependent); X=Correlate (independent/predictor); Co=Covariate (adjusted for); Mod=Moderator; Mod Med (Moderator of mediation)
Process evaluation questions
In the process evaluation, three elements were prioritised in the evaluation among the adolescents: 1) “Reach”, defined as a participation/exposure rate and/or how many within the targeted population received/participated in each of the intervention components, 2) “Dose received” (e.g. amount/degree of exposure): a description and quantification of how much of the intervention was received by the targeted population, and 3) “Dose received”, related to satisfaction: a description and rating of the participants’ liking of the intervention components (Saunders et al 2005).

In the electronic questionnaire, the adolescents were asked about the degree of exposure to or participation in the physical activity and screen time components of the intervention by six questions at the mid-way assessment and seven questions at the post-intervention assessment. The response categories were yes (1) or no (0), while four of the questions had three or more response categories and were dichotomised into yes/no (Table I, in Paper II). A composite score for the adolescents’ perceived total intervention dose received at mid-way and post-intervention was calculated by adding and averaging the respective process questions, giving scores ranging from 0.00 to 1.00, where 0.00 indicated minimum and 1.00 indicated a maximum degree of exposure/participation in the intervention components. By inspecting the distribution of the scores, a score equal or above 0.75 (75%) was set to represent a “high” dose received, and a score lower than 0.75 represented a “low” dose received of the intervention. These dichotomised composite scores were used for analytical purposes in Paper II.

The intervention
The development of the HEIA intervention was based on the recommendations from the Cochrane review on interventions preventing obesity in children (Summerbell et al 2005), and guided by the conceptual model of the HEIA study and the Intervention mapping methodology (Bartholomew et al 2006) as described in Paper Ia. The targeted determinants of physical activity and screen time behaviours were selected based on theoretical models and existing empirical evidence presented in the introduction of this thesis and in Paper Ia. In addition, formative evaluations using focus groups with adolescents and parents were conducted to explore the target group views on the behaviours (dietary, physical activity and screen time behaviours), settings (e.g. schools, homes, leisure time, week vs. weekend days)
and potential strategies, activities, and forms of communication. A more detailed description of the development of all parts of the intervention is presented in Paper Ia.

Each school year the intervention was initiated by a kick-off meeting with the involved teachers. The purpose of these meetings was to ensure that the whole team of teachers knew the rationale, was familiar with the various intervention components and was motivated to implement the components and support the pupils with regard to involvement in the intervention components. During the school year the teachers received external support in the form of short, monthly e-mail reminders from the HEIA study group. The control schools followed the regular Norwegian school curriculum including PE classes (2 X 45 min/week). They were not restricted with respect to initiating own physical activity, sedentary- or dietary behaviour activities.

A graphical “flower” was designed to present an overview of the intervention components. It was used when presenting the main content and setting of the intervention for the teachers, adolescents and parents (Appendix 5). The intention with the “flower” was to illustrate that the main focus of the intervention was to promote a healthy diet and physical activity in the adolescents by involving different settings and facilitators (primarily school/teachers and family/parents). Healthy weight development was supposed to be a consequence of the intervention and was not meant to be focused on during the intervention. Hence, it was put underground and explained as the “root” of the study.

The intervention consisted of a mix of individual, group and environmental strategies and components, meant to generate synergy effects on targeted determinants and behaviours. Multiple efforts were made to promote participants’ overall physical activity throughout 6th and 7th grade. In the second part of the intervention (in 7th grade), a few components targeting screen time behaviours were included as well. An overview of the physical activity and screen time behaviour components of the interventions, time of implementation, and the targeted determinants is listed in Table 2. It illustrates how the various intervention components were directed towards change in multiple determinants.
**Table 2.** Physical activity and screen time behaviour intervention components, time of implementation, and the targeted determinants in the HEIA study

<table>
<thead>
<tr>
<th>Intervention components</th>
<th>Timeline</th>
<th>Determinants for PA</th>
<th>Determinants for SB</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>Personal</td>
<td>Social-environmental</td>
</tr>
<tr>
<td>Kick-off meeting for teachers</td>
<td>2-2.5 hours Nov</td>
<td>2-2.5 hours Sept</td>
<td></td>
</tr>
<tr>
<td>4 lessons during classroom-time (part of one lesson focused on PA, other on diet)</td>
<td>Nov-Dec</td>
<td></td>
<td>X</td>
</tr>
<tr>
<td>Active commuting-to-school campaigns and active living/daily PA campaigns</td>
<td>2 campaigns, winter &amp; spring: focus on active commuting to and from school</td>
<td>2 campaigns/ &quot;pedometer-challenges&quot;; focus on active commuting and active living/daily PA; fall &amp; winter</td>
<td>X</td>
</tr>
<tr>
<td>PA breaks during classroom hours</td>
<td>Once a week (5-10 min), folder with ideas provided</td>
<td>Once a week (5-10 min), CD with exercises and music provided</td>
<td>X</td>
</tr>
<tr>
<td>Posters to raise awareness about the HEIA-project</td>
<td>1 on PA, 1 used in the active commuting campaign</td>
<td>1 on SB, 1 related to active commuting campaign/ &quot;pedometer-challenges&quot;</td>
<td></td>
</tr>
</tbody>
</table>
### Table 2. (continued)

<table>
<thead>
<tr>
<th>Activity box</th>
<th>In use Nov-June, throughout project</th>
<th>In use Sept-April, throughout project</th>
<th>X</th>
<th>X</th>
<th>(X)</th>
<th>X</th>
<th>X</th>
<th>(X)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Inspirational course for teachers promoting ideas for PE-lessons (including some equipment) based on SPARK program*</td>
<td>1 day course for teachers Feb; try out 6 lessons March-May</td>
<td>1 day course for teachers Oct &amp; Nov; try out one lesson per month Oct-April</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Computer-tailoring program, including one session on PA and one on SB</td>
<td>1 session on PA and one on SB; Jan-April</td>
<td></td>
<td>X</td>
<td>(X)</td>
<td>X</td>
<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Fact sheets to parents</td>
<td>3 x PA</td>
<td>2 x PA, 1 x SB; including child-parent homework</td>
<td></td>
<td>X</td>
<td>X</td>
<td>X</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

PA= Physical activity; SB=Screen time behaviour

(X): The components did not directly target these determinants, but when delivered they were intended to facilitate support and positive social interaction among participants hypothesised to influence these determinants

*Based on the SPARK program (Sallis et al 1997)
When developing the intervention we emphasised components that were supposed to be: 1) geared toward the developmental level of the participants, and 2) equally appealing to girls and boys. The first part of the intervention in 6th grade included low threshold physical activity components that were meant to create a sense of efficacy and enjoyment and increase the opportunities to be physically active during school hours. In addition, most of the physical activity components were based on interactions with classmates so as to facilitate social support and inclusion.

Most of the 6th grade physical activity components were continued through 7th grade, while some components were modified somewhat to create new interest and challenges. The computer-tailoring programme with four sessions was implemented in 7th grade only. One of these sessions was concerned with physical activity, another with screen time behaviours, and two with dietary behaviours. Through an internet-based program, the adolescents answered questions about their engagement in the respective behaviours, each in a 15 min session. Immediately, afterwards they printed out a personalized letter which informed them on whether they needed to try to change their physical activity level or the time they used in front of screens. The letter included personally tailored advice and suggestions on how to change.

The family component included fact sheets distributed to the parents via the adolescents. The very first sheet was meant to inform about the aim and content of the intervention. In 6th grade three of the fact sheets concerned physical activity issues. They were supposed to increase parents’ awareness of physical activity levels in Norwegian children, increase knowledge of the recommendations and health benefits of physical activity and stimulate parental support for adolescents’ physical activity during leisure time and weekends. In 7th grade, three of the fact sheets included physical activity and screen time behaviour issues. The purpose of the first was to inspire parents to stimulate their adolescents to spend time outdoors, while the second was to encourage parental regulation of the adolescents’ TV-viewing and computer/game-use, and the third was meant to encourage parents to motivate their offspring to be active after the end of primary school. The 7th grade fact sheets included homework assignments that the adolescents and parents were meant to complete together.

**Ethics**

The Regional Committee for Medical Research Ethics and the Norwegian Social Science Data Service approved the study (Appendix 6). Parents gave written consent for their
adolescents’ participation before taking part in the study (Appendix 2). All participants were informed about their right to withdraw from any part of the data collection at any time.

The control schools received an abbreviated intervention package with information about all the intervention components and copies of all the printed intervention material after the post-intervention data collection. They were not offered kick-off meetings or PE-inspirational courses for teachers, and only received a list (not the actual equipment) of the sport/game equipment that could be used during recess.

**Sample size and power calculation**

As described in Paper Ia, power calculations were based on detecting changes in the primary (BMI) and secondary outcomes (the behaviours; intake of fruit and vegetables, soft drinks and overall physical activity (MCPM)) in the HEIA study. For MCPM we based the power analysis on being able to detect a difference of 62 cpm between the control and intervention groups. This estimate was based on a nationally representative population study among 9 and 15 year-olds (Kolle et al 2009a). A power analysis to examine whether we had sufficient participants to enable mediation analyses was not conducted. However, others have calculated that when applying the product of coefficient test, one needs a sample between 490-660 participants (Cerin et al 2009; Fritz & Mackinnon 2007). The mediation analyses in Paper III included 700 adolescents and in Paper IV 1418 adolescents, 835 mothers and 668 fathers (Figure 6). Hence, the mediation analyses in these samples should hold sufficient power.

**Statistical analyses**

Data were analysed using SPSS version 15 and 18 IBM SPSS (IBM Corp., Somers, New York, USA).

Aside of internal reliability analyses of the determinants by Cronbach alpha (α) and test-rest reliability analyses by ICC of determinant and screen time behaviour (p. 28; 30), baseline values by frequency n (%) or mean (SD) for all included variables were presented in all papers. Independent t-test and chi-square test were used to test for: 1) baseline differences between the control and intervention groups, 2) differences between those lost and those retained in the analyses, and 3) differences between control and intervention groups among those lost to the analyses.
The adolescents were recruited and randomized by schools. Due to this clustering of schools, the within and between variance in schools for the dependent/outcome variables was investigated by running a so-called “empty or null” model with no predictors (no intercept model) in Linear Mixed Model (Hox 2002; Tabachnick & Fidell 2007). How much of the unexplained variance is due to the school level (level 2), and how much is due to the individual factor (level 1) in the dependent can be expressed through an ICC, calculated based on the results from the empty model.

The unexplained variance at the school level was below 5% for the outcome variables (determinants) in Paper II, except for social support from teachers as described in the paper, and in Paper IV (screen time behaviours). Further analyses were therefore done without adjusting for the school effect in these papers (Heck et al 2010). In Papers Ib and III the variance between schools was higher (around 11%) for the outcome variables (MVPA and MCPM), and therefore the analyses were carried out using Linear Mixed Models to account for the clustering effect.

Paper Ib included hierarchical regression analyses in Linear Mixed Models using four blocks. Paper II included investigation of intervention effect by Analysis of covariance (ANCOVA analyses). In Papers II, III and IV the effect analyses were based on post-intervention values of the outcome variables adjusted for the baseline values (Twisk & Proper 2004). The effect analyses, including the mediation analyses, were run in samples which had complete data at baseline and post-intervention (without imputations). The sample size in Paper III was lower than in Papers II and IV due to more missing and invalid data for accelerometer measured physical activity than for the outcomes measured by the adolescents’ questionnaire (Figure 6).

In Papers III and IV main, mediating and moderated mediation effects were assessed by the product-of-coefficient test based on linear regression (Cerin & Mackinnon 2009; Mackinnon et al 2007). In Paper III this was done in Linear Mixed Models to account for the clustering effect. The product-of-coefficient test consists of: 1) estimating the main effect of the intervention on the behaviour (c-coefficient), 2) estimating the effect of the intervention on changes in the potential mediator (a-coefficient), 3) estimating the independent effect of changes in the potential mediator on change in the behaviour adjusted for the intervention condition (b-coefficient), and (4) computing the product of the two coefficients (a*b),
representing the mediated effect, Figure 7. To calculate mediation effects, the Sobel test was used in Paper III (Sobel 1982) and bootstrapping in Paper IV (Efron & Tibshirani 1993).

**Figure 7.** Conceptual model of mediation

In Papers III and IV moderated mediation was investigated by running separate mediation analyses for each moderator (girls vs. boys and normal weight vs. overweight/obese). Then the product-of-coefficient (ab-coefficient) of both groups was compared. There is a significant moderation of the mediated effect if the ab-coefficient in each group are significantly different from each other, Figure 8. To test differences in ab-coefficients between the subgroups for statistical significance, the difference was divided by the pooled standard error (e.g. $s_{\text{pooled}} = \sqrt{s^2_{ab, boys} + s^2_{ab, girls}}$) (Fairchild & Mackinnon 2009).

**Figure 8.** Conceptual model of moderated mediation
A detailed description of the analyses of the data is presented in the method section in the individual papers. Significance levels were set at p<0.05, except for the interaction analyses in Paper II and Paper IV where it was set at p<0.10 (Stone-Romero & Liakhovitski 2002; Yildirim et al 2011), reflecting the acceptance of a 5- or 10% probability of type I errors.
SUMMARY OF RESULTS

This chapter presents the main results related to the four questions in the individual papers. The reader is referred to the papers at the back of the thesis for more details on the results.

Appendix 7 shows the baseline characteristics of the participants based on the sample in Papers II and IV (n=1418; Figure 6). The sample consisted of 48% girls and 52% boys and the participants was 11.2 (0.27) years old on average.

**Paper Ib**


The purpose of Paper Ib was to investigate the association between eleven modifiable, potential behavioural, psychological, social and physical-environmental factors and accelerometer assessed MVPA expressed as % daily MVPA. In addition we examined whether weight status moderated the associations.

The sample consisted of participants with valid accelerometer data at baseline (n=1129), Figure 6. The adolescents spent 8.6 (3.0)% of the time in MVPA. The girls engaged in less MVPA than the boys (7.8 (2.4)% vs. 9.5 (3.2)%), and 12.8% of the adolescents were overweight/obese.

Independent of gender and parental education status, the normal weight adolescents engaged in more MVPA than the overweight. Beyond weight status, self-efficacy was positively associated with MVPA and weekend computer/game-use was negatively associated with MVPA. In addition, social support from friends was positively associated with MVPA.

Weight status moderated the association between weekend computer/game-use and MVPA, reflecting that more computer/game-use on weekends was associated with lower MVPA among the overweight, but not among the normal weight adolescents. Biological,
SUMMARY OF RESULTS

psychological and social-environmental correlates were all shown to account for added variance, altogether explaining 14% of the variance in MVPA.

Paper II

The main aim of Paper II was to investigate intervention effects on potential determinants mid-way and post-intervention. We also examined whether gender, weight status and parental education status moderated the effects on the determinants. In addition, we explored whether degree of exposure to and participation in the intervention were related to change in the determinants.

The sample consisted of the adolescents with questionnaire data from both the baseline and post-intervention assessments (n=1418), Figure 6.

At mid-way the intervention had a favourable effect on enjoyment, self-efficacy (borderline significant) and social support from teachers in the total sample. Gender and parental education status did not moderate any effect on the determinants mid-way, but weight status moderated the intervention effect on self-efficacy. The follow-up subgroup analyses showed enhanced self-efficacy among the normal weight, while there was a tendency for an unfavourable effect among the overweight.

The favourable mid-way intervention effect on teacher support for physical activity was sustained post-intervention, while there was an unfavourable effect for self-efficacy in the total sample. Gender did not moderate any effects on the determinants post-intervention. Weight status moderated the post-intervention effect on enjoyment with subgroup analyses showing an unfavourable effect among the overweight, whereas no effect was seen among the normal weight. In addition, parental education status moderated the intervention effect on social support from teachers and parents. Concerning teacher support, the subgroup analyses showed a favourable intervention effect on teacher support among the adolescents with low
and high parental education status, while there was no effect among those with a medium parental education status. In addition, there was an unfavourable post-intervention effect on parental support among adolescents with medium parental education status, whereas no effect was seen among those with low and high parental education status. No intervention effects were observed on social support from friends or on the parental regulation of screen time behaviours.

At the mid-way assessment 56% of the adolescents reported a high intervention “dose received”, while this decreased to 31% at the post-intervention assessment. The “dose received” of the intervention was related to change in the determinants. At the mid-way assessment, favourable changes in enjoyment, self-efficacy and perceived social support from teachers were observed among those reporting that they had received a high vs. a low intervention dose. In the same manner, changes in enjoyment, social support from friends, perceived environmental opportunities and social inclusion at school were related to the dose received at the post-intervention assessment.

**Paper III**


The main aim of Paper III was to explore whether change in psychological, social and physical-environmental factors mediated intervention effects on physical activity post-intervention. In addition, we explored whether gender and weight status moderated mediated intervention effects.

The sample consisted of those with valid accelerometer data at both baseline and post-intervention (n=700), Figure 6.

None of the hypothesized mediators (self-efficacy, enjoyment, social support from parents, teachers and friends and perceived environmental opportunities) mediated the borderline effect on overall physical activity (MCPM) or the effects observed among girls and the normal weight adolescents (Paper III, Table 2) (Grydeland et al 2013a).
The moderated mediation analyses revealed that the intervention did have a positive effect on social support from teachers among girls and normal weight adolescents. However, change in social support did not predict change in MCPM. Hence, social support did not mediate physical activity change. While enjoyment, self-efficacy, social support from friends and environmental opportunities were not affected by the intervention (path a), these factors were associated with change in physical activity in the expected direction (path b), but with some variations across the subgroups. Social support from parents was not affected by the intervention nor was it associated with change in MCPM.

In addition, as part of the moderated mediation analyses, unfavourable intervention effects on enjoyment and self-efficacy were found among the overweight adolescents (path a). However, no mediation or suppressor (inconsistent mediation) effects were observed of enjoyment or self-efficacy in either the overweight adolescents or the normal weight. Still, weight status moderated the mediated effects of enjoyment on physical activity change.

**Paper IV**


The purpose of Paper IV was to examine post-intervention effects on weekday and weekend TV-viewing and computer/game-use, and whether effects on the screen time behaviours were mediated by change in parental regulation reported by the adolescents and their parents. In addition we examined whether gender and weight status moderated main and mediated effects.

The sample consisted of the adolescents with questionnaire data from both the baseline and post-intervention assessment (n=1418), and the mothers and fathers of these adolescents with questionnaire data from both baseline and post-intervention (mothers: n=835; father: n=668) Figure 6.
SUMMARY OF RESULTS

No main intervention effects on the screen time behaviours were found. However, gender moderated the effect on weekend computer/game-use while weight status moderated the effect on weekday TV-viewing and computer/game-use. The follow-up subgroup analyses revealed a tendency for an effect on weekend computer/game-use among girls, but not among boys. For weekday TV-viewing there was a small effect among the normal weight. There were no sub-group effects by weight status for weekday computer/game-use, but for both weekday TV-viewing and computer/game-use the analyses revealed larger effect estimates (c-coefficients), however non-significant, but in an unexpected direction among the overweight compared to the normal weight.

Parental regulation did not mediate change in the screen behaviours. However, stronger parental regulation was associated with less TV-viewing and computer/game-use (path b), with effects being conditional on adolescents’ versus parental reports.

Neither gender nor weight status moderated any mediation effects of parental regulation, with the exception of a moderated mediation effect of weight status by mothers’ regulation on weekday TV-viewing.
DISCUSSION

Methodological considerations
An RCT is the “gold standard” for obtaining evidence when evaluating cause-effect relationship and efficacy of interventions, but the weaknesses include possible threats to external validity and contamination (Sanson-Fisher et al 2007). In the following some aspects related to these issues will be discussed.

Generalizability
Schools in the HEIA study were recruited from the 3-4 largest towns/municipalities in 7 counties surrounding the county of Oslo. They represent something in between rural and urban schools, which is quite common in Norway because there are many small municipalities in Norway and only few large cities besides the capital. Seventeen out of 37 schools were recruited from Akershus County which surrounds the capital. The socio-economic status may in general be somewhat higher in Akershus compared to the other six counties, which probably can be explained by a concentration of institutions for higher education and corresponding job opportunities in this area. In addition, national objectively physical activity data collected in 2006 show that the 9 and 15 year-olds in Akershus had some of the highest values for overall physical activity (MCPM) compared to other counties (Anderssen et al 2008). Since 46% of the schools were from Akershus, this may have caused a bias in our sample. However, due to the larger size with more inhabitants, more schools were eligible for recruitment from this county, and its relative distribution of schools in the sample does seem to reflect the population’s distribution of eligible schools in general. In addition, the distribution of control and intervention schools from this county also goes along with the 2:1 ratio of control vs. intervention schools.

However, the 37 schools which accepted participation reflect a low (21%) response rate. During the recruitment process many schools probably declined to participate because of possible concerns of an added workload. There have been several curricular changes in the Norwegian primary schools the last decades. This has increased demands on both management and teachers and may have made them more reluctant to become involved in research studies. Due to ethical restrictions, reasons for non-participation were not asked for, but 35% (n=50) of the schools who refused participation informed us they did so because they
were already involved in other initiatives. However, there were no differences in number of pupils in 6th grade and overall size of the schools between participating schools and those who did not accept the invitation (Gebremariam et al 2012).

Parental consent was obtained for 1580 (73%) of the 2165 adolescents in the participating schools (Figure 6). The Norwegian Social Science Data Service allowed contacting those who did not respond to the written invitation by phone. This may have reduced the bias which has been found to be associated with an active written parental consent (Klepp 1995). However, the response rate was somewhat lower than expected based on previous Norwegian school-based dietary interventions (Bere & Klepp 2004; Yngve et al 2005). Others have found that parents of overweight school-age children or children at risk for overweight have been significantly less likely to accept participation in studies (Mellor et al 2008), and weighing of children has also been continuously debated in the Norwegian national media. Hence, inclusion of a sensitive topic such as obtaining body measures of the adolescents may have caused a selection bias. On the other hand, the BMI prevalence data for the 11 year-olds in the HEIA study are comparable and fall between national data for 9 and 15 year-olds assessed in 2005/2006 (Anderssen et al 2008), indicating representativeness. Regarding the physical activity data, a substantial proportion of the adolescents did not achieve valid accelerometer data at baseline or post-intervention, Figure 6 (Paper III, discussed later). However, comparing the HEIA study baseline sample to nationally representative figures assessed both in 2005/2006 and 2011, the MCPM values of the participants in the HEIA study at baseline (age 11 year) fall between the values of the 9 and 15-year-olds from these national surveys (Kolle et al 2009a; Kolle et al 2012). This may indicate representativeness of the data.

Parents filled out data about their own education level on the consent sheet. Therefore, parental education level was collected from nearly all (1476; 97%) of the 1528 adolescents who filled out the questionnaire at baseline. However, the representativeness of the parental education level used to define the adolescents’ SES may be questioned. The parental education background for the adolescents (low: ≤ 12 year, medium: 13-16 years, and high: >16 years) is quite evenly distributed within the HEIA study (Paper II, III and IV). However, it has previously been shown that the proportion of adolescents with high parental education status is twice as high when compared to national data from Statistics Norway based on data from 30-49 year-old adults (Bjelland 2011). The proportion with lowest parental education status in the HEIA study is about half compared to national data. This may partly be explained...
DISCUSSION

by a somewhat higher proportion of adults with higher education in Akershus County compared to the national level (Bjelland 2011). In addition, we also used the education level from the parent with the longest education (or else the one available) when defining the adolescents’ parental education status. This may probably also be a reason for why there is a quite large proportion of adolescents with higher parental education status in the HEIA study.

In Paper IV, there was a higher proportion of parents within the highest education category answering the parental questionnaire (mother n=835; fathers n= 668; Figure 6) compared to the distribution of the parental educational status in the total sample (adolescents n=1418, Figure 6). Among the mothers, the distribution of high and low education level was 38% vs. 37%, while it was 40% vs. 22% among the fathers (data not shown), compared to 34% vs. 29% among the adolescents. Thus, the subsample of participating parents seems to represent a skewed one towards those with a slightly higher parental education status.

In conclusion, the generalizability of our findings may be hampered by some selection biases, but findings for the adolescents may still be fairly representative for the semi-urban areas surrounding the largest cities in the south-eastern region of Norway. However, the relevance of the findings from the parental subsample may be limited to a more selected group of parents within this region, and points to the problem of how to best involve parents (O'Connor et al 2009; Van Lippevelde et al 2012).

Contamination

When recruiting schools, we got the impression that those schools who accepted the invitation may have been especially interested in the topic and were thus more motivated to participate in the study than those who refused. High media publicity about both physical activity and dietary issues in general, and attention related to a project launched by the Directorate of Health and the Department of Education in 2004 called “School meals and physical activity during the school day” involving many schools, could have caused an increased focus and motivation/or pressure to act among schools. Several schools expressed a strong interest in being an intervention school. This could possibly have lead to contamination by the control schools trying to compensate for not being selected to the intervention group and initiating their own diet and or physical activities/programmes. This can cause a “form of project contamination” (Shadish et al 2002b; Ward et al 2007). The descriptive values of the physical activity level in the HEIA-study participants show an unexpected increase in both the control
and intervention group from baseline to post-intervention (Paper III, Table 2). This may indicate that both the control and intervention groups have been involved in initiatives to promote physical activity. However, the unexpected increase is also likely due to seasonal differences between fall (baseline data collection) and spring (post-intervention collection).

**Internal validity**
Randomization reduces the probability that other factors than the intervention can explain the effect (Shadish et al 2002a). However, the quality of the assessment and the assessment tools may be potential threats to the internal validity.

**Quality of assessment**
Although blinding in behavioural research is not always possible or convenient, blinding intervention providers and participants will reduce biases (Rothman 2002). Still, in physical activity intervention among youth blinding is in general not regarded a useful criteria to identify studies with risk for high or low bias (Dobbins et al 2009). Blinding of data collection staff in the HEIA would probably have been possible, but would have required more human resources which was not possible within the budget. However, to reduce the possibility of bias, staff were carefully trained to follow the protocols for all parts of the data collections.

An RCT is the gold standard to evaluate cause and effect, because the groups are assumed to be similar apart from random variation. Therefore, intention to treat analyses is advocated. This means that study participants should be studied within the group to which they were allocated regardless of whether they received the intervention as allocated. However, a full application of the intention to treat is possible only when complete outcome data are available for all randomized subjects (Hollis & Campbell 1999). In this thesis intention to treat analysis was not conducted, because we were not able to collect data from all those who were not present on the day of the various data collections. We did not impute values for missing data or cases who withdrew, because this can be problematic and bias the outcome (Montori & Guyatt 2001).

The alternative to the intention to treat is usually to analyse data “per protocol” (Montori & Guyatt 2001; Sim & Wright 2000b). In Papers II, III and IV we did the analyses on participants who provided data at both baseline and post-intervention. However, attrition analyses were conducted in all the papers to detect potential selection biases (Shadish et al 2002c).
Selection biases can be identified when those included in the analyses are different than those not included. The retention rate in Papers II and IV was high (93%) between baseline and post-intervention (1418 out of 1528 adolescents participated at both time-points, Figure 6). However, the attrition analyses did reveal a few selection effects between those included in the analyses and those not. Most importantly, a higher proportion of overweight participants was lost to post-intervention. This means that some of the tendencies observed for the overweight group may represent an underestimation. Interestingly, lower values for perceived social inclusion at school were also seen in these “drop-outs” (Paper II). This result compares with findings revealing overweight/obese to be socially excluded by peers at school (Stankov et al 2012).

In the analyses including accelerometer assessed physical activity data (Paper Ib and Paper III), a larger proportion of the sample was lost to the analyses. This was due to difficulties collecting valid accelerometer measures from participants at baseline (Paper Ib). The problem was even more salient in Paper III when the same individuals needed a valid measure at both time-points to be included in the analyses. In Paper III, more boy and higher values for physical activity and for several of the potential mediators were found among those lost to post-intervention. However, this did not cause a significant difference in the gender distribution in the included study sample. In addition, both gender and baseline values of the potential mediators were adjusted for in the relevant analyses (Paper III). Thus, the lower retention rate among boys probably does not represent an influential bias.

Among those lost to post-intervention across Papers II, III and IV, the only significant difference when comparing intervention vs. control was for physical activity (Paper III). MCPM was lower in the intervention group vs. control. However, despite the randomization, a similar difference between the groups for MCPM was also detected among those with valid physical activity data at baseline (n=1129) and at both time-points in Paper III (n=700). Hence, the observed difference may be random. In theory this could mean a greater potential for detecting an intervention effect for physical activity, but this should be eliminated by the adjustment for baseline values on the outcome in the analyses.
Quality of instruments
The determinants, the screen time behaviours and the process questions were all self-reported, while physical activity, height and weight were objectively assessed. Self-reported, self-administered questionnaires are the most practical and cost-effective method for assessing data in larger groups (Sallis & Saelens 2000). However, self-reported questionnaires, especially in children, have limitations due to recall and social desirability biases which can reduce their reliability and validity (Ekelund et al 2011; Sallis & Saelens 2000).

Test-retest study and paper format vs. computer format
In the test-retest study, paper and pencil questionnaires were used while an electronic questionnaire was used to measure determinants and screen behaviours among the adolescents in the main surveys. Internal consistency ($\alpha$) of psychosocial construct measures related to adolescents’ health behaviours has been found to be higher when measured with computer format compared to paper format, while test-retest result reliability estimates did not differ significantly between formats (Hagler et al 2005; Norman et al 2005). In addition, using paper format questions about feelings/affective states has been found to be more affected by social desirability responses than in computer formats, while format did not seem to affect adolescents’ responses on health and lifestyle behaviours (Vereecken & Maes 2006). Thus, by using an electronic questionnaire for the self-reported measures in the HEIA study, we may have reduced a potential social desirability bias in the assessment of the determinants and possibly improved the internal consistency ($\alpha$). In addition, by using a computer format one can increase validity of the assessments by avoiding problems associated with the paper format, such as double answers, unreadable responses, feelings of not being anonymous and stigmatisation of those with writing disabilities (Rew et al 2004).

Assessment of correlates/determinants/mediators
Even though we did observe acceptable or better test-retest reliability (ICC) and internal consistency ($\alpha$) values for the determinants, uncertainties still exist as to the responsiveness of such measures in detecting change (Brown et al 2009). However, all the potential mediator measures were theoretically based and developed for children, and the validity is therefore assumed to be better than measures originally developed for adults (Brown et al 2009).

Assessment of screen time behaviours
To recall screen time behaviours accurately is a complex task for young people. In addition, they may answer according to social expectations and norms both when it comes to
behaviours and potential mediators (Jago et al 2007). Hence, it could well be that the screen time behaviours in the HEIA study are underreported due to the social desirability influence.

However, a recent review found that self-report measures of screen behaviours seem to provide reliable estimates of screen time (Lubans et al 2011). Acceptable to excellent test-retest results (ICC) for the screen time behaviours were reported in the HEIA-study as well (Appendix 4, Paper Ib and IV). Similar questions are widely used, but validity is largely untested (Lubans et al 2011). There exists no real suitable objective method to assess screen time behaviour in large scale studies. Objective measures of TV-viewing have, however, been used in some small scale studies, but these methods (e.g. observation) do involve errors such as difficulties in coding and variation in inter-rater variability (Bryant et al 2007).

**Perceived intervention dose received**

The process questions were asked to the intervention participants retrospectively after the end of 6th (mid-way) and 7th grade (post-intervention), which may have increased the possibility for recall bias (Sallis & Saelens 2000). Alternatively, objective process evaluation could have been used, but due to the large number of schools and adolescents this was not possible in the HEIA study within the existing budget.

In addition, adolescents’ reports of the “dose received” of the intervention may differ from teachers’ reports of the dose implemented. However, the participants’ own reports may be as important when it comes to the impact of process data on the effect of the intervention. Some of the adolescents may, for example, not have been present at school (due to sick leave or vacation) the day(s) of the implementation of certain components, or the implementation fidelity may have been low for some components. In Paper II the determinants were measured at the individual level, and therefore it can be argued that the adolescents’ perception of participation/exposure to the components of the intervention was the most interesting process data to use.

**Accelerometer measured physical activity**

Self-reports do not provide accurate estimates of overall physical activity and time in MVPA (Ekelund et al 2011; Sallis & Saelens 2000). Accelerometers provide many advantages over self-report in youth (Sirard & Pate 2001). It is now the most commonly used method to measure free-living physical activity (Riddoch et al 2007). The weaknesses of accelerometers include inability to measure water-activities, cycling, skiing/skating, carrying loads, inclines
and upper-body movements (Ekelund et al 2011). To ask the HEIA participants to keep logs of such activities could have made it possible to estimate and impute activity levels (Ward et al 2005). However, we reasoned that logs would also be prone to errors and would have put a burden on the participants, possibly decreasing their willingness to wear the accelerometers. Therefore, the reported physical activity levels may represent an underestimation of physical activity levels.

Technical challenges related to using Actigraph accelerometers indicate a lack of consensus on the methods used to collect, process and score accelerometer outputs (Cain et al 2012). Studies vary to a large extent regarding several important decision points such as non-wear time, wear time, valid days and epoch length. A 20 min string of zero count definition for non-wear time is argued to be most appropriate for youth (Esliger et al 2005). We used a quite low criteria to define a “valid day” of recording, but the 8 hour criteria is among the most commonly used (Ekelund et al 2011). All the same, the average wear time was about 12-13 hours (Papers Ib and III). Due to the limitations of the storage capacity of the Actigraph model 7164 when using 10 second epoch, we were not able to collect more than 4 days of accelerometer data, but longer protocols are advocated (Cain et al 2012).

The use of cut-points to define threshold for various intensities is widely debated (Cain et al 2012; Ekelund et al 2011). Many suggest that the MVPA threshold lies between 3000 and 3600 counts per minute (cpm) (Mattocks et al 2007; Puyau et al 2002; Treuth et al 2004). However, the 2000 cpm European Youth Heart Study cut-point we use is among the most commonly used in youth, also in the most recent studies (Ekelund et al 2011). Setting appropriate epoch length is important for the estimation of MVPA, particularly in children and young adolescents because their physical intensity level can vary frequently. Too long epochs in youth studies may result in an underestimation of vigorous physical activity levels which are included in the estimation of MVPA (Baquet et al 2007; McClain et al 2008). In general, the definition criteria and reporting standard for accelerometer use applied in the HEIA study seem to be in accordance with “best practice” (Cain et al 2012; Ekelund et al 2011).

In addition, studies using objective measure of physical activity are called for in mediation analyses in youth (Lubans et al 2008). However, objective measures do not inform about the types of activities and contexts in which the adolescents engage in, and context and type of
activities can be useful to guide and target strategies in the development of interventions (Jago et al 2010b; Jago et al 2011b). Hence, to investigate mediation of type and context, specific physical activity change in addition to or in combination with objectively assessed physical activity, can be useful to inform interventions (Lubans et al 2008).

**Weight and height data**

Three staff teams with four members each were used to carry out the main data collections. Two persons administered the survey, and one male and one female conducted the anthropometric measures. The same females were used throughout the study, while we had to use several males. Theoretically this could have increased inter-observer measurement errors, but staff training, as used in the HEIA study, can limit these types of errors (Himes 2009).

There exists a variety of reference data sets for BMI in childhood (Flegal et al 2006), all with some limitation which can affect prevalence estimates. However, the IOTF cut-off to define overweight/obesity has been recommended as they allow for comparisons across populations (Cole et al 2000; Sweeting 2007).

**Power calculations**

The power calculation for detecting an intervention effect on physical activity was based on a larger n than we achieved. However, the calculations may have been overestimated since limited population level data from effect studies using accelerometers within this age-group are available to make good estimations of expected effect. Still, particularly in Paper III, the moderated mediation analyses by gender and weight status may suffer from less than optimal power.

**Statistical analyses**

**Assessing reliability**

Using correlation coefficients for continuous data to assess test-retest reliability is considered inappropriate, as correlations are measures of associations, not agreement (Bland & Altman 1986; Booth et al 1996). In contrast, ICCs examine scores within individuals and calculate the degree of consistency between two scores provided by the same individual for the same variable (Sim & Wright 2000a). Therefore, ICC was used to investigate test-retest study in this thesis. Most of the test-retest results reported by Pearson’ r in Paper Ia have been re-analysed using ICC, and only minor differences have been found (Bjelland 2011).
DISCUSSION

Adjustment for clustering effect
When the no-intercept model and ICC reveal that the unexplained variance in a behaviour (outcome/dependent) caused by e.g. attending different school is below 5%, the analyses may be conducted without taking the clustering into account (Heck et al 2010). This was the case in Paper II and IV. However, running these analyses without adjusting for a clustering effect may have increased the probability of making a type I error. It may also be questioned why the analyses in Paper I b and III were adjusted by school but not class. However, after the revision of the Norwegian Education Act 2003 pupils in the Norwegian primary and secondary education are no longer organised by classes, but in larger and smaller groups varying by subjects. Adjusting for a possible class effect has therefore not been relevant.

Test of interaction effects and subgroup analyses
By doing subgroup analyses one can compare effects of interventions across different population groups. To explore what works for whom, may consequently lead to better targeted interventions which can reduce health inequities between poorer and better-off individuals within a population (Petticrew et al 2012). However, subgroup specific analyses require data to be subdivided into smaller data sets, each with reduced power, and such analyses can produce spurious results (Brookes et al 2001). Thus, finding a significant result in one group and not in another does not mean that there is a real difference between groups (Petticrew et al 2012). The HEIA study was not powered to detect subgroup analyses for either gender- or weight status groups. However, generally when significant interaction effects in moderation analyses are observed, further explorations within the relevant subgroups are justified (Yildirim et al 2011). This analytic procedure was used in Papers II and IV. However, in Paper III we justified the subgroup analyses for the main and mediated effects based on previous findings from the HEIA study. These studies revealed: a) significant interactions of weight status on determinants of physical activity in the larger sample (Paper II), b) gender effects and moderation effect of weight status for dietary- and screen time behaviours at the mid-way evaluation (Bjelland et al 2011), and in addition c) both gender and weight status are found to be relevant effect modifiers in EBRB intervention (Yildirim et al 2011). When planning the intervention we kept gender in mind by trying to develop components that we hypothesised as being equally appealing to both genders. Given that we did not intend to specifically target particular subgroups, we did not pay specific attention to potential distinctive needs among the overweight participants. However, because the subgroup analyses in Paper III were not based on preceding significant interaction results, the
subgroup findings should be interpreted with particular caution. Still, such stratified analyses can shed some light on differences in effectiveness that may warrant further investigation in future interventions (De Bourdeaudhuij et al 2011a).

Assessing mediation

The product-of-coefficients test to analyse mediation has been recommended because it can establish mediation even in the absence of a significant effect between the intervention and outcome, and it is able/suitable for detecting mediation in smaller samples (Cerin et al 2006; Mackinnon et al 2000). There are three main reasons why there can be a mediation effect even in the absence of a significant intervention effect on the outcome (Cerin & Mackinnon 2009), as discussed in detail by Cerin et al (2009). First, the effect of the mediator on the outcome may depend on the values of an independent variable (interaction effect) (Cerin & Mackinnon 2009; Kraemer et al 2002). The second reason is that the effect of an independent variable on the outcome can be explained by multiple competing mechanisms that are of opposite direction and which may cancel each other out and possible suppression effects (inconsistent mediation) (Mackinnon et al 2000; Shrout and Bolger 2002). Suppression effects, based on unexpected results from a-path analyses, have been seen for self-efficacy and perceived barriers in both dietary and physical activity interventions in youth (Haerens et al 2007; Haerens et al 2008). Such results have been explained by either the use of wrong strategies to affect the mediators or by a possible intervention by measurement effect, whereby the intervention can affect the intervention participants’ interpretations of the items of the construct in question. A third reason for doing mediation analyses, even though there is no significant relation between the independent variable and the outcome, is low power. This argument is of particular relevance when the outcome is temporally or causally distal (Shrout & Bolger 2002). In addition, it is argued that results of mediation analyses should be reported even in the absence of any significant findings, since they have the potential to extend our understanding of behaviour change (Brown et al 2013; Cerin & Mackinnon 2009).

Reporting issues

Due to the space restriction in journals, it is often difficult to report all parts and details of the intervention in specific articles. However, articles elaborating on the design, the development and the details of the intervention may be especially useful for providing information about large, multicomponent, multi-behaviour interventions (De Meester et al 2009). Therefore, the conceptual paper (Ia) is included for informational purposes in this thesis.
Discussion of the results

**Research question 1 (Paper Ib)**

a. To what extent did the potential biological, psychological, behavioural, and social-environmental correlates genuinely account for variation in physical activity among pre-adolescent Norwegian children?

b. Did weight status moderate the role of these potential biological, psychological, behavioural, and social-environmental correlates?

The results revealed that MVPA in these 11 year-old adolescents was associated with weight status. Being overweight was related to lower levels of MVPA. Previously, overweight adolescents have been found to engage in less intense physical activity than their normal weight counterparts (De Bourdeaudhuij et al 2005). Recent country representative survey data from Norway also show that overweight 9 year-old boys are less active, and that fewer 6 and 9 year-old overweight children meet the physical activity recommendations compared to the normal weight (Kolle et al 2012). The evidence from the prospective literature is inconsistent. Some studies show that physical activity influences weight status (Must & Tybor 2005; Riddoch et al 2009), whereas others find that adiposity influences physical activity (Ekelund et al 2008; Metcalf et al 2011). Therefore, the role of physical activity as a key determinant of body fat levels in individuals and populations has been questioned (Bauman et al 2012).

Self-efficacy was positively related to MVPA. The finding confirms that self-efficacy is an important predictor of physical activity among youth. Reviews show that self-efficacy is one of the most consistent determinants and mediators of physical activity change (Bauman et al 2012; Lubans et al 2008; Van Stralen et al 2011). In addition, self-efficacy may both mediate and moderate relations between social-environmental factors and physical activity among adolescents (Dishman et al 2009; Motl et al 2005). Self-efficacy also seems to track from childhood to early adolescence (Gebremariam et al 2012). Hence, efforts to increase self-efficacy in physical interventions in young adolescents seem important.

Parental regulation is identified as a consistent correlate of screen time behaviour (Cillero & Jago 2010; Pate et al 2011). In light of a possible displacement mechanism between screen time behaviours and physical activity, one could assume that parental regulation of screen time behaviours would be positively related to physical activity, but there was no relation between the measures of parental regulation of screen time measures and MVPA. Indirectly,
the result indicates that screen time behaviours and physical activity are two distinct behaviours with their own set of correlates (Biddle et al 2004).

On the other hand, the association between computer/game-use on weekends and MVPA indicates that screen time behaviours may displace physical activity on weekends. Weekend TV-viewing is previously found to be consistently related to physical activity in children (Sallis et al 2000b). However, since weight status moderated the association between weekend computer/game-use and MVPA, a possible displacement mechanism may be more relevant for overweight than for normal weight adolescents. On the other hand, a study from European and North American countries has shown a stronger negative association between physical activity and screen-based sedentary behaviours among adolescents in countries where physical activity level was relatively lower (Melkevik et al 2010). In light of such a finding, physical inactivity may not be a consequence of adolescents spending too much time on screen-based behaviours, but rather that more inactive adolescents have more time to spend on these behaviours. This may also be the case for the overweight adolescents in this study as they engaged in less MVPA at baseline than the overweight (Paper Ib). It has previously been shown that there is no need for specific tailoring on psychosocial correlates for overweight adolescents compared with normal weight adolescents for physical activity change (De Bourdeaudhuij et al 2005). Still, emerging evidence shows that overweight and obese adolescents experience barriers likely to be exacerbated by their weight status and also more barriers to physical activity than their normal weight peers (Stankov et al 2012). Hence, it may be necessary to pay more attention to the needs of overweight adolescents in the formative phase of EBRB interventions.

Parental involvement through a combination of methods such as transport, encouragement and modelling has been shown to be associated with organised physical activity in 6-11 year-old children in an in-depth review of parental influence on physical activity (Edwardson & Gorely 2010). Parent also played an important role in MVPA through direct involvement. However, the cross-sectional data from the HEIA study indicates that social support from friends may hold a stronger potential to mediate change in physical activity than support from both parents and teachers. Theories on social development express that peer support increases in the transition from childhood to young adulthood (Kuperscmidt & Dodge 2004). Hence, the intervention could possibly have benefited from targeting social support from friends more directly. It has also been advocated that parents’, siblings’ and peers’ influences on physical
activity at different developmental stages should be examined further (Edwardson & Gorely 2010).

Due to the cross-sectional design in Paper Ib, the findings are limited to hypothesis generation related to potential cause and effect relationships. It has also been pointed out in recent reviews of prospective evidence that not all established correlates seem to qualify as determinants of physical activity among children and adolescents (Craggs et al 2011). Hence, longitudinal and controlled intervention studies are needed.

The results from Paper Ib support that change in physical activity in youth is related to factors from multiple domains, and that the identified factors hold potential as mediators of physical activity change regardless of gender and socio-economic background. However, gender and parental education status did explain approximately half of the variance in this study. Among the modifiable factors, the psychological and behavioural factors (self-efficacy and computer/game-use on weekends) contributed to most of the added explained variance, while social support from friends was the only social-physical environmental factor that explained added variance. However, entering the social- and physical environmental variables in the last block also typically reduced their probability to add to the variance. In addition, the influence of environmental variables may also depend on factors from other domains (e.g. the influence of the use of neighbourhood or school facilities for physical activity may depend on and interact with degree of self-efficacy and/or social support from friends). This is also in line with how social-ecological models posit that factors at different levels are interdependent and may interact with each other in influencing behaviour (Stokols 1992).

To our knowledge this is the first paper to investigate modifiable correlates in young Norwegian adolescents using objectively assessed physical activity. The relatively low explained variance observed in this study, also commonly seen in studies using objective measures of physical activity, compared to those using self-report, may be due to shared method variance between correlates and self-reported measures of physical activity (Dishman 1994; Podsakoff et al 2003). Using self-report of physical activity may overestimate associations (Sallis et al 2002b), while using accelerometer assessed physical activity may mean that types of physical activity not considered by the adolescents when reporting on correlates will lower the association. However, the low variance may also indicate that other factors than those investigated may contribute to explained variance. For example, self-
regulation and goal setting and/or other environmental factors related to school, family or leisure time context may be worthwhile to investigate in further studies (Perry et al 2012).

The descriptives revealed relatively high baseline values for the correlates, except for social support for physical activity. This may indicate a limited potential for change in these factors. At the same time these young adolescents spent a modest amount of their time in MVPA (8.6%). However, on average they met the recommendation of a minimum of 60 min or more of daily MVPA, while boys showed slightly higher levels of both MVPA and overall physical activity (MCPM) than girls (Table 2, Paper Ib). The data support the fact that Norwegian children become less physically active in the transition into adolescence, and that early adolescence is a critical age period. Both MVPA and overall physical activity in these 11 year-olds seem to be closer to physical activity levels for 15 year-olds than for 9 year-olds seen in previous and recent national surveys (Kolle et al 2009a; Kolle et al 2012). Thirteen percent of the 11 year-olds were overweight/obese, and this is within the range of previous Norwegian data (Anderssen et al 2008; Juliusson et al 2010; Kolle et al 2012; Oellingrath et al 2010). It is, however, lower than the prevalence of 16-17% overweight/obese found among the 15 year-olds in the most recent national survey (Kolle et al 2012).

**Research question 2 (Paper II)**

a. Did the HEIA intervention affect potential psychological, social and physical environmental determinants of physical activity and screen time behaviours mid-way and post-intervention?

b. Did gender, weight status and parental education status moderate these mid-way and post-intervention effects?

c. Was degree of exposure and participation in the intervention related to change in the determinants mid-way and post-intervention?

In the following, the findings obtained in the total sample and the follow-up subgroup analyses based on the detected moderation effects will be discussed.

**Effects on psychological determinants and moderation effects by weight status**

The mid-way moderating effect of weight status and the follow-up subgroup analyses for self-efficacy revealed that the favourable (borderline) effect on self-efficacy seen in the total sample was only observed among the normal weight. Among the overweight there was a tendency for an unbefocal effect on self-efficacy (Figure 2a and Table 5, Paper II). Hence, with regard to mid-way effects on self-efficacy, the normal weight and overweight seemed to respond differently to the intervention. Findings are in parallel to those in Paper Ib, showing
that the overweight were less physically active (MVPA) than the normal weight at baseline. One cannot rule out that the intervention more rapidly elicited a perceived “pressure” among the overweight than the normal weight towards being more physically active. This may have led to lowered self-efficacy to be active among the overweight mid-way, by challenging their capacity to self-regulate when faced with barriers. Whereas overweight participants may have felt they ought to increase their physical activity level and even tried to enhance activity, at the same time they may have perceived it to be more difficult than expected. This could be due to lack of capacity for self-regulation when more sedentary options are at hand, and/or not finding appealing physical activity alternatives when perceiving encouragement and expectations from parents or teachers to be more active. Whether this in turn led to lowered encouragement and expectations on the parents and teacher side is not known. This would if so, reflect a vicious circle regarding physical activity change among the overweight. It would also be in line with SCT and the social-ecological model which posits that the relationship between social influence, self-efficacy and behaviour is reciprocal (Bandura 1986; Gorely 2005).

The favourable mid-way effect on self-efficacy among the normal weight may reflect that these adolescents felt they were meeting the expectations of the intervention quite well, causing their enhanced self-efficacy. Furthermore, teachers and/or parents may have been less concerned about their physical activity level in the beginning of the intervention. Nevertheless, an unfavourable effect on self-efficacy was seen in all post-intervention. Hence, as the intervention went along, a similar response to self-efficacy as put forward to explain the mid-way effect on self-efficacy among the overweight, may have occurred in all the participants. Indeed, similar unexpected effects on self-efficacy have been seen both in physical activity and dietary intervention in youth (Haerens et al 2007; Haerens et al 2008; Lytle et al 2009).

With regard to enjoyment, the small favourable mid-way effect in the total sample may reflect a positive response to the physical activity components of the intervention. These emphasized novel, low-threshold activities and provided the participants with some new and fun equipment. However, one may speculate whether the mid-way trend for lower self-efficacy among the overweight group may have mediated the unfavourable post-intervention effect on enjoyment among the overweight (Figure 2b and Table 5, Paper II), as a feeling of self-
efficacy may be a prerequisite for the experience of enjoyment (Hu et al. 2007; Lyu & Gill 2013; Scanlan & Lewthwaite 1986).

Alternatively, the unfavourable post-intervention effect on enjoyment among the overweight may be due to stigmatisation. It has been assumed that targeting obesity prevention to all pupils, regardless of weight status, will prevent negative consequences of stigmatisation of overweight and obese children (Dobbins et al. 2009). On the other hand, it is also argued that possible stigmatisation will occur when possible unfit and/or overweight pupils have to engage in various forms of physical activity together with their peers, because this may make them prone to ridicule. Overweight/obese adolescents are also found to be commonly victimized by peers and experience lower self-esteem (Neumark-Sztainer et al. 1998; Strauss 2000; Strauss & Pollack 2003). Even though the HEIA intervention was not tailored to any specific needs of overweight participants, the intervention included low-threshold activities and active living components that were supposed to appeal to all. In addition, all the intervention components focused on the targeted behaviours, and not on body and/or weight issues. All the same, the overweight pupils may have felt like they were forced to engage in school-based physical activity initiatives against their will (Stankov et al. 2012). This feeling may, in particular, be likely to occur when activities are presented as an initiative within a context of obesity prevention. Overweight adolescents have also been found to perceive a greater number of barriers to sport participation (Deforche et al. 2005). They also seem to experience many specific barriers to physical activity within the school setting (Stankov et al. 2012). This may result in negative perception of physical activity in general (Dobbins et al. 2009), and could have made the overweight adolescents respond with a form of reactance (Brehm 1966). This sort of reactance can possibly have a negative influence on determinants like enjoyment, and consequently also physical activity.

In line with this reasoning, there was a tendency for an unfavourable post-intervention effect in physical activity (MCPM) among the overweight (Grydeland et al. 2013a), also reported in Paper III (Table 2). However, probably due to the small group size of overweight, this effect was not significant. Together, the results suggest that the intervention did not meet with the needs of the overweight adolescents.
**Effects on social-environmental variables and moderation effects by parental education status**

Intervention effects on social and physical environmental determinants have not been extensively examined, but existing evidence shows that interventions among youth appear to be less successful in affecting social support compared with psychological measures such as self-efficacy and enjoyment (Brown et al 2013; Salmon et al 2009; Van Stralen et al 2011).

However, social support from teachers was favourably affected by the HEIA intervention in the total sample at both assessment points, and also in Paper III in which the analyses were adjusted for the clustering effect. Hence, it seems to be a robust finding. The follow-up subgroup analyses based on the parental education level indicated that teacher support may be a type of social influence able to affect both those with low and high SES. This is an encouraging result, as higher levels of social support have been found to be consistently associated with smaller declines in physical activity among adolescents (Craggs et al 2011). However, subgroup analyses on the effect on physical activity indicated that there was an intervention effect on mcpm only among those with medium SES background (Grydeland et al 2013a).

A review of European school-based interventions shows that “a whole school” approach applying environmental strategies has been able to affect pupils within both low and high SES groups (De Bourdeaudhuij et al 2011a). Possibly, teacher support may have a role in explaining such results. Teachers have the ability to reach every child regardless of parental education status, and teacher support may act synergistically with environmental oriented interventions. This line of reasoning is also in accordance with social-ecological models (Stokols 1992). In addition, a recent systematic review of reviews has shown that school-based physical activity interventions have primarily affected physical activity during school hours (Kriemler et al 2011). The effect on teacher support points to support from teachers as one possible mediator of physical activity change which may contribute to explaining the above mentioned findings regarding both SES and within school effects from physical activity interventions. However, few have investigated social support for physical activity from teachers, and the evidence for a mediating role of social support for physical activity change among youth is limited (Van Stralen et al 2011). Still, the role of teacher support in EBRB intervention seems warranted to investigate further.
DISCUSSION

Regarding parental influence, findings from qualitative studies have revealed that fact sheets may be a useful tool to reach parents (Borra et al 2003; Kaplan et al 2006). However, sending material home does not appear to be an effective strategy for physical activity change in youth (O’Connor et al 2009). This may explain why the intervention did not favourably affect parental support for physical activity or parental regulation of TV-viewing and computer/game-use. Previous data show that about 66% of the parents in the intervention group participated at mid-way (Bjelland et al 2011). Among those about 30% reported receiving a low-dose of the fact sheet. Hence, it seems difficult to reach all parents by distributing information via the adolescents. Aside from this, it is difficult to interpret why the intervention produced an unfavourable effect on parental support among the adolescents with medium parental education status.

Weight status moderated the effect on psychological determinants (self-efficacy mid-way and enjoyment post-intervention), while parental education status moderated the effect on social-environmental determinants (teacher support and parental support post-intervention). It may be that weight status being an intra-personal factor interacts more directly with other intra-personal/psychological factors like self-efficacy and enjoyment. These are determinants which may be more closely related to perception of one’s own abilities and/or feelings. Parental education, on the other hand, can be classified as a type of inter-personal (social-environmental) factor and is thus possibly less related to adolescents’ self-perception regarding physical activity. Hence, parental education status may be a more important moderator of other inter-personal variables like social support. It is somewhat surprising that gender did not moderate any effects on the determinants since gender is identified as the most consistent effect modifier of EBRB (Yildirim et al 2011).

Perceived intervention dose received and its relation to change in the determinants
Factors related to exposure and adherence to the intervention, have not been widely described. This makes it impossible to investigate the impact of process evaluation data on outcomes (van Sluijs et al 2007). However, the results in Paper II support the importance of investigating process indicators of change (Baranowski & Jago 2005). A “high dose” vs. a “low dose” received of the intervention was significantly related to higher scores on enjoyment, self-efficacy and perceived social support from teachers mid-way, and post-intervention for enjoyment, social support from friends, perceived environmental opportunities and social inclusion at school. The findings regarding social inclusion may
indicate that a high degree of exposure to and participation in the intervention may help facilitate young people’s sense of connectedness to school. If so, this would seem to be a positive side effect of the intervention.

The descriptives also revealed a substantial decline in the proportion of the adolescents reporting a high intervention “dose received” from the mid-way assessment (56%) to post-intervention (31%). This could explain why fewer effects on the determinants were seen post-intervention compared to mid-way. It could possibly also explain why the effects observed on the determinants as well as for physical activity (Grydeland et al 2013a) and screen time behaviours both mid-way (Bjelland et al 2011) and post-intervention (Paper IV) in general were small. However, looking at the proportion of adolescents reporting a moderate to low “intervention dose received” score based on the composite score, a higher proportion reported that they had participated/been exposed to several of the individual components of intervention both mid-way and post-intervention (Table I, Paper II). This indicates that school/teachers have been somewhat selective in which components they have implemented, and each schools/teachers have probably not completed all components. This may have reduced the impact of the intervention since the intervention was supposed to be implemented as a package, in order for the various components to act synergistically. However, this sort of problematic selectiveness may be especially relevant in longer, multi-components interventions like the HEIA intervention (Thomas 2006).

The varied and somewhat diverse effects on the determinants for physical activity at the mid-way vs. post-intervention assessment underscore the importance of assessing determinants both during and after an intervention (Lewis et al 2002), especially in interventions of longer duration like the current one. However, to reduce the total assessment burden on the participants, a shorter version of the questionnaire was used mid-way, and only four of the determinants were assessed mid-way. In addition, the results highlight the need to study potential moderator effects on potential mediators of EBRB. Such effect modifiers are rarely examined but can add knowledge about mechanisms of behaviour change. The results revealed that effect on determinants may vary by weight status and parental education status. This indicates that these are relevant effect moderators of determinants as well as for the behaviour (Kremers et al 2007; Yildirim et al 2011).
Furthermore, the analyses of intervention dose received (high vs. low) indicate a positive dose-response association between degree of exposure/participation in the intervention and the effect on the determinants. Hence, further research should continue to investigate how implementation fidelity indicators influence both determinants and outcomes in EBRB interventions and how to improve implementation fidelity.

In addition, the descriptive results of the determinants indicate a general trend for a decline in the determinants, especially from mid-way to post-intervention. This trend matches the general decline in physical activity level seen in Norwegian adolescents between age 9 to 15 (Kolle et al 2009a; Kolle et al 2012). In terms of the favourable intervention effects, the results reflect a smaller reduction in the determinants in the intervention compared to the control group.

Research questions 3 (Paper III) and 4 (Paper IV)

In the following section research questions 3 and 4 will be discussed together.

Research question 3 (Paper III)

a. Did potential psychological, social and physical-environmental determinants mediate intervention effects on physical activity?

b. Did gender and weight status moderate mediated effects?

Research question 4 (Paper IV)

a. Did the intervention affect screen time behaviours (TV-viewing and computer/game-use) post-intervention?

b. Did parental regulation of TV-viewing and computer/game-use mediate the intervention effects on the set of screen time behaviours?

c. Did gender and weight status moderate mediated effects?

Possible explanation for the lack of mediation effects

The results from Papers III and IV showed that the lack of mediation findings were in general due to limited post-intervention effects on the hypothesised mediators. In Paper III, social support from teacher was the only mediator favourably affected by the intervention (in all and in girls). Teacher support, however, was not related to change in overall physical activity (MCPM). Therefore, no significant mediation effect of teacher support on MCPM was found. However, it may be that teacher support is context specific and has a larger potential for
influencing physical activity during the school day. Regarding screen time behaviours, the intervention did not affect parental regulation of these behaviours, neither when reported by the adolescents nor the parents (Paper IV). Several explanations may be raised for the lack of mediation findings. These include wrong strategies, targeting of wrong mediators, insufficient implementation and/or insensitive measures.

It could be that we implemented a wrong type of intervention and/or used ineffective strategies. However, the dose-response association between the exposure/participation in the intervention and change in several of the potential physical activity mediators (Paper II) strongly indicate that a weak implementation may be an important factor in explaining why the targeted mediators were only modestly affected. The non-effect on parental regulation of screen time behaviours (Paper IV) may be due to both 1) relatively low proportion of participating parents (Figure 6), 2) the relatively low dose received as it seems as many parents did not receive all the fact sheets (Bjelland et al 2011), 3) the limited dose planned for as only one of the fact sheets in the intervention did target parental regulation, and 4) the type of mode applied as written material deliver to the home does not appear to be a very effective strategy to reach parents (O'Connor et al 2009). In light of the relatively high baseline values of the regulation measures, slightly higher when reported by the parents vs. the adolescents (Table 3, Paper IV), the parents may have felt there was no real need to strengthen their regulation of their adolescents screen time behaviours either. Hence, a possible ceiling effect may have influenced the potential to affect these measures.

In addition, the level of responsiveness in mediator measures to detect intervention effects is not well known (Brown et al 2009), and how well the mediator measures correspond to the assessment of the behaviours may also influence the sensitivity to detect change. We did measure all the mediators using a general frame of reference, and the physical activity mediator measures were meant to match the targeted type of physical activity (overall physical activity). Also, before filling out the questionnaire, all the participants were orally informed by the project staff to ensure a common understanding of what was meant by “physical activity”. The screen time behaviours were assessed separately for a general weekday or weekend day, but the regulation of the screen time behaviour measures did not differ between weekday and weekend. In addition, the phrasing of the mediator measures did not exactly match the context in which the intervention components were initiated (primarily school and family). However, phrasing and matching the mediators more specifically to the
targeted context would necessarily have extended the length of the questionnaires. This could have caused a threat to the overall validity of the questionnaire (Kremers et al 2005). Another issue to consider is whether the intervention components and strategies matched the determinants they were meant to target. An intervention by measurement effect can also possibly explain why we did observe few effects on the potential mediators. Such an effect can occur if an intervention affects the response to the items, making it less likely to detect an effect (Cerin & Mackinnon 2009; Podsakoff et al 2003).

Even when there are no effects on the mediators (a-path analyses), it is important to carry out the next step in the mediation analysis, the b-path analysis (Figure 7). This analysis reveals whether change in the potential mediator, independent of the intervention, is associated with change in the behaviour in the expected direction. Hence, the results are informative for future interventions (Van Stralen et al 2011). The results in Papers III and IV revealed that changes in constructs from all the investigated domains were related to change in physical activity (MCPM) in the expected direction, including self-efficacy, enjoyment, social support from friends and perceived environmental opportunities (in girls only) (Paper III). In addition, stronger parental regulation of both TV-viewing and computer/game-use were associated with less TV-viewing and computer/game-use, respectively (Paper IV). This was more so, however, when reported by the parents than the adolescents themselves, and more so on weekdays compared to weekends. Overall, the results support that factors from psychological and social- and physical environmental domains hold potential as mediators in future interventions targeting change in physical activity and screen time behaviours in youth.

It should be underscored that in many RCTs, the hypothesised mediators are usually being assessed at the same time as the behavioural outcomes (Chin A Paw et al 2008). Even though the current analyses were assessing change by using post-intervention values adjusted for baseline values, the applied mediating approach was statistically correlational in nature. Hence, a reverse causality between the identified determinants and change in the respective behaviours cannot be ruled out, which is in line with the concept of reciprocity in SCT (Bandura 1986).
DISCUSSION

*Moderated main effects and moderated mediation effects by gender and weight status on physical activity and screen time behaviours*

Regarding girls’ physical activity, existing evidence consistently shows lower levels in girls compared to boys (Sallis et al 2000b; van der Horst et al 2007), and this was observed at baseline in the HEIA study as well (Paper Ib). Hence, it may be that the intervention effect on MCPM among girls (Paper III) could be a consequence of their greater potential for change (Grydeland et al 2013a). However, at baseline the normal weight adolescents had higher level of MCPM than the overweight adolescents (Paper Ib), so this argument does not hold for explaining the observed effects on MCPM among the normal weight. The moderated mediation analyses in Paper III were not based on preceding significant interaction effects of gender or weight status. Hence, the subgroup results for MCPM (Paper III) should be interpreted with more caution than the subgroup effects for screen time behaviours in Paper IV (n=1418, Figure 6), in which the stratified analyses were based on preceding significant interaction results of gender and weight status (Petticrew et al 2012). Nevertheless, Paper III which included only 700 participants compared to 1418 in Paper IV (Figure 6) showed interaction of weight status on physical activity (MCPM) that approached significance (p=.16) (Grydeland et al 2013a). In addition, a small beneficial effect on BMI among girls (Grydeland et al 2013b), possibly mediated by the effect on MCPM in girls, has been observed. Whether the intervention has affected the targeted dietary behaviours and how these potential dietary effects may contribute to explain effects on BMI remains unanswered.

Previous school-based physical activity interventions have been most successful in affecting school-related physical activity (De Bourdeaudhuij et al 2011b; Dobbins et al 2009; Kriemler et al 2011), but some studies have shown effect on overall physical activity as well (Kriemler et al 2011). The HEIA study also affected overall accelerometer assessed physical activity among the girls and normal weight adolescents (Grydeland et al 2013a). The observed effects, however, were modest at best, but correspond with findings in the most recent review showing only small effects from interventions using objectively assessed physical activity (Metcalf et al 2012). Controversy exists regarding parental involvement and/or which strategies may be most effective (De Meester et al 2009; Kriemler et al 2011; O’Connor et al 2009; Van Lippevelde et al 2012). However, including a family component may be important for mediating change in physical activity outside school (Salmon et al 2007). It could be that the parental fact sheets targeting physical activity factors in the HEIA study may have contributed to the overall effects on physical activity, because the “dose” of these fact sheets
was more substantial (3 fact sheets in 6th grade and 3 in 7th grade) than for the screen time behaviours.

Even though a small physical activity effect among girls was observed (Paper III) (Grydeland et al 2013a), Paper II revealed that gender did not moderate any effects on the determinants (the potential mediators). Gender did not moderate any mediation effects of the mediators in Paper III either. Together these results indicate that the working mechanism of physical activity change did not differ by gender. This is also in line with prospective evidence from a review on determinants of physical activity. Cragg et al (2011) found that gender was not associated with change in physical activity in young adolescents (10-13 year-olds). Hence, this age period may provide a window of opportunity to reach both genders by the same strategies. Girls are, however, generally less active than boys, therefore it may be fruitful to pay special attention to how to attract girls by making intervention components equally appealing to girls as to boys.

Weight status moderated the intervention effects on self-efficacy and enjoyment with the post-intervention results revealing unfavourable and unexpected effects on enjoyment among the overweight, Paper II. A similar result for enjoyment among the overweight group was also seen in the a-path analyses in Paper III, as well as unfavourable effect on self-efficacy. In addition, weight status moderated the mediation effect of enjoyment on physical activity (Table 5; Paper III). However, limited power in the stratified mediation analyses with a low n was a particular problem for the overweight group (Control=67; Intervention=26), and no mediation effects were seen. While the moderated mediation results are difficult to interpret, they may indicate that the working mechanism of enjoyment on physical activity differed between normal weight and overweight adolescents. It is likely that the unexpected post-intervention effects on enjoyment (Paper II and III) and on self-efficacy (Paper III), together with the moderated mediation findings by weight status for enjoyment on physical activity, may have contributed to the tendency for an unfavourable effect on MCPM among the overweight, (Paper III, Table 2) and (Grydeland et al 2013a). Even though this was a non-significant result, the effect estimate was the largest among all groups (c= -96.1, Confidence Interval (CI) = - 211.3; 19.0, p=.12). Overall the results from both Paper II and III indicate: 1) that the intervention seemed to work differently for physical activity change among normal weight vs. overweight adolescents, and 2) that differences in how the intervention affected enjoyment and self-efficacy in these groups may explain this.
Regarding the screen time behaviours, weight status moderated effect on weekday TV-viewing and a small intervention effect on weekday TV-viewing among the normal weight was observed (Paper IV). In addition, moderation effect in favour of the normal weight was revealed for weekday computer/game-use and in favour of girls for weekend computer/game-use. These results are partly in line with previous mid-way results showing effects on screen time behaviours among girls but not boys, and moderation effects of weight status on boys’ weekday TV-viewing and computer/game-use (Bjelland et al 2011). At the mid-way assessment there was also a near significant unfavourable intervention effect on TV-viewing and computer/game-use among the overweight boys. Cross-sectional evidence shows that boys engage in more screen time behaviours than girls (Sallis et al 2000b; van der Horst et al 2007), while longitudinal evidence shows that higher BMI is associated with increase in time used on screen time behaviours (Uijtdewilligen et al 2011). Therefore, it may be that boys and overweight adolescents in this age group (11-13 years) are more attracted to spending time in front of screens in their leisure time compared to girls and the normal weight. This may also possibly explain why the intervention was unsuccessful in affecting screen time behaviours among these groups. For the gender results in particular, this line of reasoning is supported by supplementary qualitative findings showing that boys but not girls view screen time as a barrier to physical activity (Protudjer et al 2010).

Even though there was a small intervention effect on weekday TV-viewing among the normal weight (Paper IV), the largest effect estimate, however non-significant, showed a tendency for an unbeneificial effect with more weekday TV-viewing among the overweight (c = 0.22, CI= -0.17; 0.62, p=.26, Table 2 in Paper IV). There was also a sign for a similar unbeneificial c-path result for weekday computer/game-use among the overweight (c = 0.27, CI= -0.10; 0.62, p=.15, Table 2 in Paper IV). This is worrying, as a significant increase in the energy-balance due to increase in energy intake has been observed in young children (8-12 years) when screen time behaviours were increased (Epstein et al 2002). Seen together with the tendency for an unfavourable effect on MCPM among the overweight group (Paper III), the result indicates that overweight adolescents may possibly displace physical activity with screen time behaviours. It may be that overweight adolescents feel they lack alternatives to screen time behaviours and/or are turned off physical activity (Stankov et al 2012). This points to difficulty in reaching already overweight adolescents in interventions aimed to prevent obesity (Simon et al 2008). The result is also a particular cause of concern since the
overweight adolescents were less active than the normal weight at the beginning of the intervention (Paper Ib), and also because both sedentary behaviours and physical activity track from childhood to adolescence (Raudsepp et al. 2008), possibly even more so for sedentary behaviours than physical activity (Biddle et al. 2010). Hence, already overweight adolescents may need specifically tailored initiatives to promote physical activity and reduce sedentary behaviours.

Furthermore, the favourable intervention effect on TV-viewing among the normal weight could possibly be explained by a displacement of TV-viewing with physical activity, since beneficial post-intervention effects for MCPM (Paper III) and on overall sedentary time assessed by accelerometers were observed among the normal weight (Grydeland et al. 2013). In addition, weight status moderated the mediation of mothers’ regulation on weekday TV-viewing (Table 5, Paper IV). This indicates that the mechanism of change of maternal regulation differed among the normal weight and overweight adolescents. However, there were no intervention effects on the mothers’ report of parental regulation measures. Hence, there were no mediation effects of mothers’ regulation in any of the groups. This makes the moderated mediation result more difficult to interpret. Possibly, maternal regulation may be a more influential determinant for controlling TV-viewing among the overweight than in the normal weight (seen by the larger b-coefficient in b-path analyses; Table 5, paper IV). Hence, it may be helpful to enhance the understanding of the importance of restricting screen time behaviours in parents of overweight adolescents or those at risk for being overweight in particular. At the same time, it seems sensible to provide parents with strategies to help these youngsters make use of more physically active alternatives to screen time behaviours.

Comparing findings of correlates and determinants

In Paper Ib correlates of physical activity at baseline were studied, and in Paper III many of the same factors were inspected as determinants (b-path analyses). Even though MVPA (Paper Ib) and MCPM (Paper III) differ somewhat with respect to the type of activity they reflect, they should be relevant to compare as outcomes. Self-efficacy was identified as a correlate of MVPA in Paper Ib, and Paper III showed that a positive change in self-efficacy was related to positive changes in MCPM. As self-efficacy is identified as a consistent determinant and mediator of physical activity change in both young people and adults (Bauman et al. 2012; Lubans et al. 2008; Van Stralen et al. 2011), the unfavourable post-intervention effects on self-efficacy in Paper II (in the total sample) and Paper III (among the
overweight group only) is worrying. A possible reason for such a response is already discussed. To counteract such an effect on self-efficacy, the HEIA intervention could perhaps have benefited from including intervention activities emphasising behavioural skills like goal setting and self-monitoring (Perry et al 2012). One may hypothesise that such strategies will be increasingly efficient as the participants transfer from childhood to adolescence and progress in their cognitive development. A recent review of physical activity and intervening variables in adolescents also showed that ten of 13 interventions relying on behavioural skills strategies produced an effect on physical activity (Perry et al 2012). Kamath et al (2008) also found that intervention effectiveness regarding enhancement of physical activity, sedentary behaviours and healthy eating was associated with use of multiple cognitive components such as e.g. goal setting, problem solving, relapse prevention and inclusion of reinforcement.

Interestingly, social support from neither parents nor teachers was identified as a correlate of MVPA (Paper Ib) and change in these factors was not associated with change in MCPM either (Paper III). Hence, the results from this thesis indicate that social support from teachers and parents is irrelevant in changing the behaviour. In addition, no strong evidence of a mediating role for social support has been found among youth (Lubans et al 2008; Van Stralen et al 2011). However, teacher support may be more strongly related to physical activity within the school context and less relevant to overall physical activity. Regarding parental support, our result based on longitudinal is in line with the review by Cragg et al (2011), in which there was no evidence for parental support being a determinant among children (10-13 years). However, more longitudinal evidence has been called for (Edwardson & Gorely 2010). It may be that social influence increases with age as social influence in general has been identified as a consistent correlate (Sallis et al 2000b; van der Horst et al 2007) and a determinant of physical activity in adolescents (14-18 years) (Craggs et al 2011). Hence, the mediating potential for social support influences may also be stronger with increasing age.

Since peer support may be increasingly important in the transition from childhood to young adulthood (Kuperschmidt & Dodge 2004), the HEIA intervention could possibly have benefited from targeting social support from friends more directly. Most of the intervention components (active commuting to school campaigns, physical activity breaks during classroom hours, the “Activity box” during recess and also the computer-tailoring programme) were meant to facilitate positive social interactions which could promote support
from friends for physical activity among the participants (as indicated in Table 2). Still, no direct strategies were applied to facilitate friends’ support. Lytle (2009) has in her commentary article on “Where do we go next”, strongly argued that school-based interventions may benefit from including peer-leader approaches and placing stronger focus on working with the participants’ social networks (Valente et al. 2003). Such strategies may be useful to consider in future interventions. However, interventions targeting social support from friends do not yet provide very strong evidence for a mediating potential of friends’ support (Brown et al. 2013; Lubans et al. 2008; Perry et al. 2012; Van Stralen et al. 2011).

Evidence from longitudinal data pointing to modifiable determinants of screen time behaviours in youth is lacking (Uijtdewilligen et al. 2011). However, the results for parental regulation from the HEIA study (Paper IV) do show that parental regulation, independent of the intervention, is related to change in screen time behaviours. Future interventions should therefore continue to target change in parental regulation. Parental effort to restrict adolescents’ behaviours, however, may not work equally well for all. Kremer (2010) has discussed that the child’s personality, in particular the child’s openness to parental socialisation, will moderate the impact of parenting practices. Some personality structures will be more likely to be resistant to parental advice and restrictions. Hence, personality variation may impact the adolescents’ perception of and response to restrictive social influence. In addition, parenting style may influence screen time behaviours (Jago et al. 2011a), and in accordance with self-determination theory giving advice in an autonomy supporting manner may prove effective (Fortier et al. 2012). Still, giving restrictive advice may be especially challenging in young adolescents going through puberty, since this phase is recognized by a need to oppose and liberate oneself from parental influences. There may also be a need to apply other strategies in combination with parental regulation as it seems that the variety and number of strategies included in family based interventions influence the effectiveness (Golley et al. 2011).

Even though no mediation effects of the targeted factors for MCPM and screen time behaviour change were observed, all the targeted factors for change in physical activity and screen time behaviours, except for parental and teacher support for physical activity, were identified as determinants of the respective behaviours. Hence, the results from Papers Ib, III and IV do support that intervention in young adolescents may benefit from using a social-ecological approach targeting factors from both the social and physical-environmental domain.
in addition to psychological factors (Perry et al 2012). Paper II provided evidence that it is possible to affect several of these determinants in young adolescents, but the results seem to be dependent on intervention dose received, and it should be kept in mind that the intervention did not work equally well for all.

Regarding the differential intervention effect seen by weight status (Papers II, III and IV), it may be necessary to focus on how to enhance both self-efficacy and enjoyment of physical activity among overweight adolescents in particular, and search for strategies and attractive alternatives to screen time behaviours for these adolescents.

It also seems important to continue to search for other modifiable factors that can be targeted for change in physical activity and screen time behaviours in youth. For example, behavioural skills seem promising in physical activity interventions (Perry et al 2012). Screen time behaviours may be a behaviour more strongly driven by habits than cognitions. Habits tend to form at an early age, and the role of breaking screen time behaviour habits may be particularly important for young adolescents. Habits can be prompted by situational and environmental cues (Aarts et al 1997). Hence, home environmental factors such as reducing the availability of number of TV sets and computers in the home and parents’ own TV-viewing may also hold potential to mediate change in screen time behaviours (He et al 2009; Pate et al 2011). In addition, it is advocated to publish insignificant mediation findings as it will contribute to add knowledge about mechanisms of physical activity change (Cerin & Mackinnon 2009; Brown et al 2013) and prevent possible publication bias from physical activity interventions (Perry et al 2012).

Taken together, effects observed were modest at best, both on determinants and physical activity and screen time behaviours. However, small effects on the determinants and the respective behaviours common in large parts of the adolescent population, such as physical activity and screen time behaviours, may result in beneficial changes in health status at the population level (Biddle et al 2011; Maniccia et al 2011). In addition, results show that physical activity and screen time behaviour intervention may not reach all equally well.
CONCLUSION

Among these adolescents in the HEIA study recruited from the south-eastern part of Norway:

- The cross-sectional data at baseline showed, independent of gender and parental education background, that being normal weight, having higher levels of self-efficacy and feeling more social support from friends were associated with higher levels of MVPA. More weekend computer/game-use was related to lower levels of MVPA. Weight status moderated the association between weekend computer/game-use and physical activity, reflecting that more computer/game-use on weekends was associated with less MVPA among the overweight/obese, but not among the normal weight. In total 14% of the variance in MVPA was explained.

- The intervention affected change in both personal and social-environmental determinants. The effects were modest, and both expected and unexpected effects were observed. The effects also varied at mid-way and post-intervention. For example, at mid-way there was a beneficial effect on enjoyment while at post-intervention there was an unfavourable effect on self-efficacy in the total sample. In addition, moderating effects of weight status and parental education status were revealed. The effects on self-efficacy and enjoyment varied by weight status, while the effect on social support from teachers and parents varied by parental education status. Furthermore, there was a positive dose-response association between the degree of perceived exposure/participation in the intervention and the effect on several of the determinants at both assessment points. The proportion of adolescents reporting a high degree of exposure to/participation in the intervention decreased from 56% at the mid-way assessment to 31% post-intervention.

- A borderline significant post-intervention effect on overall physical activity was observed, and a small effect in girls and normal weight adolescents, while there was a tendency for an unfavourable effect among the overweight. There was no effect on the screen time behaviours in the total sample. Moderation effects of gender and weight status in favour of the girls for weekend computer/game use and in favour of the normal weight adolescents for weekday computer/game-use and TV-viewing were
seen. The follow-up subgroup analyses revealed a favourable intervention effect on weekday TV-viewing among the normal weight.

- The post-intervention effects on physical activity (MCPM) and weekday TV-viewing were not explained by change in any of the targeted mediators of physical activity or screen time behaviours. This was mainly due to the limited effect of the intervention on the potential mediators post-intervention.

- No mediation effects of the targeted determinants due to the intervention were observed. Still, change in personal, social and physical-environmental factors (enjoyment, self-efficacy, social support from friends and perceived environmental opportunities), independent of the intervention, were associated with change in physical activity in the expected direction. In addition, social influence in the form of higher parental regulation of screen time behaviours was found to be related to less TV-viewing and computer/game-use, but was conditional on adolescent vs. parental reports.
IMPLICATIONS FOR PRACTICE

The baseline results indicate that overweight 11 year-olds Norwegians engage in less MVPA than normal weight adolescents at the same age. Parents, teachers and health educators should be aware of this and 1) try to prevent adiposity in children and 2) make sure to encourage already overweight adolescents to engage in physical activity. Both initiatives to promote a healthy weight development and enhance physical activity will probably benefit from starting at an earlier age. Nevertheless, efforts to enhance self-efficacy and social support from friends and reduce computer/game-use, particularly on weekends, may prove to positively influence physical activity levels of moderate-to-vigorous intensity in all young adolescents. Spending time on computers and gaming may be a larger threat to engagement in MVPA for overweight than normal weight adolescents, particularly on weekends. Hence, overweight adolescents may need to be offered opportunities for physical activity and ways of being physically active that are more appealing than computer/game-use.

Initiatives to change physical activity and screen time behaviours may work differently for normal weight and overweight adolescents. For overweight adolescents, teachers, parents and health professionals may have to apply specifically tailored strategies to enhance both self-efficacy and enjoyment of physical activity. In addition, the effect of interventions and/or programmes seems to be influenced by the implementation fidelity. Thus, having thorough plans, making sure all parts of a project will be implemented and received as intended, is likely to enhance the effectiveness.

Efforts trying to promote more physical activity and less time in front of screens should target change in factors related to physical activity and screen time behaviours from multiple domains. Physical activity initiatives will probably benefit from strategies to enhance self-efficacy, enjoyment, social support and increase opportunities to be physically active. Both mothers and fathers should be encouraged to regulate and restrict their offspring’s screen time behaviours on weekends as well as weekdays. Still, additional strategies will probably be necessary to influence adolescents’ screen time behaviours. Moreover, specific efforts to affect overweight adolescents’ screen time behaviours may be needed.
To improve the chances of reaching everyone equally well, programmes to increase physical activity, regulate screen time behaviours and promote a healthy weight development will probably benefit from starting at an earlier age and include both children and their parents.
SUGGESTIONS FOR FUTURE RESEARCH

The results from this thesis suggest that the following issues should be considered in future research aimed at understanding mechanisms of change in physical activity and screen time behaviours among young adolescents:

- Guided by a theoretical framework, search for additional modifiable factors than those investigated in this thesis that may predict physical activity and screen time behaviour change.

Continue to study:

- Whether adiposity predicts physical activity or vice versa using longitudinal designs.
- Whether screen time behaviours may displace physical activity (and if this differs on weekdays and weekends).
- Whether interventions affect targeted psychological and social-environmental determinants.
- Mediating role of both social and physical-environmental factors, as well as psychological ones using both objective and self-reported measures of the behaviours.
- The role of teacher support on change in children’s and adolescents’ school-based physical activity.
- Mediating pathways between intra-personal factors and social-environmental factors by using appropriate statistical methods.
- Moderating effects of gender, weight status and SES in mediation processes and on effects on behaviours to explore “for whom” intervention works or not and to reveal potential adverse effects of interventions.
- Use mixed methods to further investigate if and why overweight/obese adolescents may react unfavourably to physical activity and screen time behaviour interventions and how this can be counteracted.

In the planning and development of intervention studies:

- Include issues related to weight status, SES and gender in the formative evaluation of obesity and EBRB prevention studies to be able to tailor the intervention to potential specific needs in these groups.
SUGGESTIONS FOR FUTURE RESEARCH

- Plan for a thorough process evaluation with multiple process indicators both during and at the end of the implementation phase to assess how implementation issues may be related to change in determinants and behaviours.

- Develop strategies to ensure a strong implementation in school-based intervention through both qualitative and quantitative research methods.
REFERENCES


Bandura, A. 1997. Self-efficacy: the exercise of control, New York, Freeman


REFERENCES


Biddle, S. & Mutrie, N. 2008, "Introduction and rationale: why you should take your dog for a walk even if you don't have one!," In Psychology of physical activity: determinants, well-being and interventions, 2nd ed., London: Routledge, pp. 1-31


REFERENCES


Csikszentmihalyi, M. 1975, Beyond Boredom and Anxiety, San Francisco: Jossey-Bass


90
REFERENCES


REFERENCES


REFERENCES


Jago, R., Baranowski, T., Baranowski, J.C., Cullen, K.W., & Thompson, D.J. 2007. Social desirability is associated with some physical activity, psychosocial variables and sedentary behavior but not self-reported physical activity among adolescent males. Health Educ Res, 22, (3) 438-449


REFERENCES


REFERENCES


Lindsay, A.C., Sussner, K.M., Kim, J., & Gortmaker, S. 2006. The role of parents in preventing childhood obesity. *Future Child*, 16, (1) 169-186


Mackinnon, D.P. 2008. Introduction to Statistical Mediation Analysis, Hove; East Sussex: Lawrence Erbaum Associates, Taylor & Francis Group


REFERENCES


REFERENCES


101

REFERENCES


REFERENCES


REFERENCES


Thomas, H. 2006. Obesity prevention programs for children and youth: why are their results so modest? Health Educ Res, 21, (6) 783-795


Torsheim, T., Eriksson, L., Schnohr, C.W., Hansen, F., Bjarnason, T., & Valimaa, R. 2010. Screen-based activities and physical complaints among adolescents from the Nordic countries. BMC Public Health, 10, 324


REFERENCES


REFERENCES


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Personal and social-environmental correlates of objectively measured physical activity in Norwegian pre-adolescent children

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Physical activity decreases dramatically from childhood to adolescence (Nader et al., 2008). Low levels of physical activity among youth are associated with an increase in obesity and associated chronic diseases (Daniels et al., 2005; Anderson & Butcher, 2006). Inactivity in childhood and adolescence also seems to track into early adulthood (Andersen et al., 2005) and might hinder the development of an enduring physically active lifestyle in this period of life.

Physical activity in children is influenced by factors from multiple domains (Sallis et al., 2000), and research aimed at identifying correlates should be conceptualized within an ecological framework (Stokols et al., 1996). However, some of the inconsistent findings concerning correlates of children’s physical activity may be due to the measurement method of physical activity (Sallis et al., 2000; van der Horst et al., 2007). Compared with self-reported, objectively measured physical activity provides a more valid measure of overall physical activity in children.

There is no conclusive evidence for an association between body composition measures and children’s physical activity in reviews (Sallis et al., 2000; van der Horst et al., 2007), but some studies with accelerometer-assessed physical activity have shown that a higher body mass index (BMI) and percent body fat is associated with less physical activity (Adkins et al., 2004; Dencker et al., 2008). In studies examining correlates using objective measures of physical activity, self-efficacy has been identified as a psychological correlate in children (Trost et al., 1999; Strauss et al., 2001; Dishman et al., 2009). However for behavioral correlates, studies show conflicting results for TV-viewing (Strauss et al., 2001; Nilsson et al., 2009). Within the social-environmental domain, both perceived parental and peer support have been found to be related to physical activity in children (Strauss et al., 2001; Duncan et al., 2005), while others found no association between peer support and physical activity (Prochaska et al., 2002).

In order to reduce the decline in physical activity among youth, it is important to identify modifiable correlates of physical activity in the pre-adolescent age. Identifying correlates with potential to mediate physical activity change in pre-adolescent children seem especially critical, because it coincides with the rapid decrease in physical activity levels (Nader et al., 2008). In light of the increase in the use of computers...
and other electronic games, studies examining whether other sedentary behaviors, besides TV-watching, are related to children’s physical activity have been called for (van der Horst et al., 2007). Furthermore, it would also be of interest to examine whether perceived parental regulation of TV-viewing and computer/game-use are correlates of children’s physical activity. Studies investigating the role of perceived support from teachers and perceived social inclusion among peers related to the school context to children’s objectively measured physical activity are lacking. Children. Second, correlates of physical activity may be culturally specific, and to our knowledge, there exist no studies examining a wide range of correlates with an objective measure of physical activity in Norwegian children. Lastly, to identify possible moderation effect of weight status on the association between psychological and behavioral and social-environmental correlates, and physical activity among children is important, as it might help to inform the design of interventions to target subgroups appropriately (Bauman et al., 2002).

The current study adds to existing research by simultaneously examining an extended set of modifiable correlates of children’s objectively measured physical activity from multiple domains. Furthermore, the large sample consists of children within a narrow age-range in a critical period of physical activity change. The aims of the study were twofold: First, to examine modifiable biological, psychological and behavioral, and social-environmental correlates of objectively measured physical activity in a large population-based sample of Norwegian pre-adolescent children. Second, to investigate whether weight status (normal weight vs overweight/obese) moderates the association between the remaining correlates and physical activity. The following hypothesis was set forth: correlates within the biological, psychological and behavioral, and social-environmental domains genuinely account for variation in objectively measured physical activity.

Methods
Study design and sample
The study is based on baseline data from sixth graders (11-year-olds) participating in the HEalth In Adolescents (HEIA) study—a 2-year, school-based randomized-controlled intervention to promote healthy weight development. A total of 37 schools out of 177 schools from the three to fourth largest towns/municipalities in seven counties surrounding the county of Oslo (south-eastern region of Norway) agreed to participate. The schools were to have a minimum of 40 enrolled pupils in grade 6 in order to be invited. All the sixth graders (n = 2165) in the recruited schools were invited to participate. Parental consent was obtained for 73% (n = 1589) of the children, and 96% of the recruited participants (n = 1528) filled out the main questionnaire. Of these, 1439 were present and willing to wear accelerometers on the day these were handed out. This study is based on 1129 of the children (71% of those who gave consent), 570 girls and 559 boys, who answered a questionnaire and provided valid accelerometer data. The study was approved by the Regional Committee for Medical Research Ethics and the Norwegian Social Science Data Service.

Data collection and processing
The data collection consisted of two parts running on separate days. Part 1: an internet-based questionnaire and measurement of anthropometry, and Part 2: an accelerometry assessment. The administration of the questionnaire and anthropometric measurement occurred during 4 weeks in September 2007 and was conducted by four research teams of four people each. Each team visited one school per day. The accelerometry assessment of physical activity was administered from September through November 2007 by a separate research team of one or two research assistants, and visited up to four schools per day. All research staff were trained and all procedures and measurements were conducted according to a standardized protocol. A separate test–retest study (10–14 days apart) among 144 sixth graders from the same sampling area as the main study was conducted before the main data collection.

The test–retest study did not include the weight measure, in order to avoid intruding excessively upon the participants, but the intra-class correlation (ICC) value for height showed substantial agreement (ICC = 1.00). All the self-reported measures obtained satisfactory values (ICC: 0.47–0.76), as shown in Table 1.

Physical activity
The dependent variable % daily MVPA was derived from objectively measured free-living physical activity assessed over 5 days with the ActiGraph GT1M and CSA model 7164 (Manufacturing Technology Inc., model 7164, Fort Walton Beach, Florida, USA). The accelerometers were handed out on a Wednesday and returned by the children to their teacher on the first feasible day following the last wear-day. A study staff member collected the accelerometers at the schools the same day they were returned or shortly thereafter.

Oral information and a demonstration on how to use the accelerometers were given the same day and immediately before the children were instructed to wear the accelerometers. Written information to take home was handed out. The children wore the accelerometers attached on the right hip with an elastic belt (to reduce extraneous movements) during waking hours, and were instructed to take it off during aquatic activities (showering, swimming, etc). The registration of physical activity data were set to start on the second day to avoid excessive activity likely to occur during the first wear-day. Two weekdays and 2 weekend days were recorded. Epochs of 10 s were chosen because children’s physical activity is shown to be spontaneous and this intensity varies in short bouts (Sirard & Pate, 2001). The software program “CSA-analyzer” (http://csa.svenssonsport.dk) was used for accelerometer data reduction and preparation. Only daytime activity (06:00–24:00 hours) was included in the analyses. Sequences of 20 min or more of consecutive zero counts were interpreted as representing non-wear time and were excluded for each individuals recording. Data were considered valid if a child had at least 3 days (including 1 weekend day) with at least 8 h (480 min) of activity recorded per day, as used previously in other studies (Kolle et al., 2009; Nilsson et al., 2009). Of those who received an accelerometer, 79% provided valid acceler-
Correlates of physical activity in children

Table 1. Biological, behavioral and psychological, and social-environmental correlates with cronbach’s α, test–retest results (ICC) and example of items for the correlates measured by scales

<table>
<thead>
<tr>
<th>Correlates</th>
<th>Mean (SD)</th>
<th>α</th>
<th>ICC</th>
</tr>
</thead>
<tbody>
<tr>
<td>Biological correlate</td>
<td>12.8 (n = 141)</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>Weight category: overweight/obese (%)</td>
<td>2.2 (1.2)</td>
<td>NA</td>
<td>0.57</td>
</tr>
<tr>
<td>Behavioral and psychological correlates</td>
<td>1.5 (1.1)</td>
<td>NA</td>
<td>0.65</td>
</tr>
<tr>
<td>Computer/game-use on weekend (h/day)</td>
<td>4.12 (0.75)</td>
<td>0.70</td>
<td>0.47</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>3.85 (0.75)</td>
<td>0.74</td>
<td>0.47</td>
</tr>
<tr>
<td>“Playing games and sports is the thing I like to do the best”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>“I can be physically active during my free time on most days even if I have the choice to watch TV or play video games instead”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social-environmental correlates</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social support from friends</td>
<td>2.92 (1.00)</td>
<td>0.84</td>
<td>0.76</td>
</tr>
<tr>
<td>“How often do your friends exercise or play sports with you?”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social support from parents</td>
<td>2.34 (0.75)</td>
<td>0.66</td>
<td>0.71</td>
</tr>
<tr>
<td>“How often does your mother or father encourage you to play, exercise or do sports?”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived parental regulation of TV-use</td>
<td>1.69 (0.74)</td>
<td>0.76</td>
<td>0.61</td>
</tr>
<tr>
<td>“How often do your teachers encourage you to exercise or play sports?”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived parental regulation of computer/game-use</td>
<td>3.64 (0.94)</td>
<td>0.62</td>
<td>0.64</td>
</tr>
<tr>
<td>“My mother and father try to make sure that I do not watch too much TV”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived social inclusion</td>
<td>3.52 (0.99)</td>
<td>0.67</td>
<td>0.53</td>
</tr>
<tr>
<td>“My mother and father try to make sure that I do not use the computer and play games too much”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived environmental opportunities at school and during leisure-time</td>
<td>4.41 (0.60)</td>
<td>0.79</td>
<td>NA</td>
</tr>
<tr>
<td>“There are other children near by home to go out and play and be physically active with”</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cronbach’s α derived from study sample.</td>
<td>Test–retest reliability (ICC) from separate test–retest study 10–14 days apart (n = 114).</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NA, not applicable, measure not included in test–retest; ICC, intra-class correlation; SD, standard deviation.</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Correlates of physical activity

Behavioral, psychological and social-environmental correlates and demographics

Behavioral, psychological, social-environmental correlates and gender were self-reported in an internet-based questionnaire. To fill it out, the children were taken to a separate room at the school in groups, according to the number of computers available. Two research team members assisted the children in case of technical problems or questions, and made sure the children answered independently of each other. The questionnaire took about 45 min to complete. Parental education was reported on the informed consent.

Two questions assessed hours of daily TV-watching (including DVDs) and computer-use and/or playing other electronic games, each question with six response categories ranging from 0.5–5 to 0–4 h, respectively. The single item approach for TV-viewing has shown evidence of validity (Bryant et al., 2007). Because the weekend questions and weekdays questions for these sedentary behaviors were highly correlated (r = 0.7) and weekend days are likely to provide more unstructured time and greater possibilities to choose sedentary behaviors over physical activity, we chose to only use the weekend measures.

Psychological correlates were enjoyment of physical activity (Brustad, 1993) and self-efficacy related to barriers for physical activity (Mośił et al., 2000), both assessed using a five-item scale. The social-environmental correlates consisted of: perceived social support from friends, assessed by a three-item scale; perceived social support from parents, assessed by a five-item scale (Sallis et al., 1999); perceived social support from teachers, assessed by a three-item scale. Social support from teacher was measured by means of a scale taken from a pilot study.
study within the European Youth Heart Study (Riddoch et al., 2005). Perceived environmental opportunities to be physically active were assessed by a four-item scale (Sallis et al., 1999); perceived parental regulation of TV and computer/game-use was assessed by a four-item scale taken from Hardy et al. (2006); and perceived social inclusion related to the school and class environment was assessed by a six-item scale based on a “social capital measure” (related to people in my area) developed by Hume et al. (2009). The items of this scale were modified to capture the quality of relationship with peers at school both within and outside the classroom (degree of closeness and willingness to ask for/provide help when necessary). All the items for these scales were rated on a five-point Likert-type scale coded 1 (lowest) to 5 (highest) and the response option was “totally disagree” to “totally agree” with a neutral midpoint, except for the social support constructs, which were phrased almost never, sometimes, “three to four times a week,” “three to four times a week,” “almost every day” and “every day.” All scales have been derived from theoretical models of physical activity and sedentary behaviors (Harter, 1978; Bandura, 1986) and have shown evidence of validity in previous studies (Sallis et al., 2000; Hardy et al., 2006; Ommundsen et al., 2008; Hume et al., 2009). Subjects with a response rate of approximately 70% or greater on the respective items in each scale were included when computing the composite scores for each scale. In order to obtain acceptable Cronbach’s \( \alpha \) values (\( \geq 0.6 \)) for enjoyment of physical activity and perceived regulation of TV and computer/game-use scales, one item in each of these three scales was omitted when the composite scores were computed. Table 1 includes examples of items for the multiple items variables and Cronbach’s \( \alpha \) values, all showing acceptable internal consistency values (\( \geq 0.62-0.84 \)).

Statistical analyses

For descriptive purposes, gender differences in accelerometer-assessed physical activity and anthropometrics were analyzed by independent \( t \)-tests and chi-square statistics. The same tests were used to examine differences between correlates among those who provided valid accelerometer data and those who did not. Only perceived social support from parents (\( P = 0.006 \)) was significantly different between the groups, being slightly higher among those who did not provide valid accelerometer data. Cronbach’s \( \alpha \) was used to assess the internal reliability of the psychological and social-environmental correlates within the study sample. ICC analyses were used to assess the test-retest reliability from the separate test-retest study.

Analyses in linear mixed models

Data were analyzed using IBM SPSS Statistics, version 15 (IBM Corporation, New York, New York, USA). The significance level was set to \( P < 0.05 \). Owing to schools being the unit of recruitment and the children being nested within schools, we first estimated an empty model with no predictors (no intercept model) in linear mixed models, to calculate the ICC to measure dependency between scores. The variance in the % daily MVPA was partitioned into within and between school components. The empty model revealed a small, but significant clustering effect of schools for % daily MVPA. The ICC was 0.11, indicating that 11% of the unexplained variance was between schools (group level) and 89% of the unexplained variance within schools (individual level). To account for this clustering effect, the analyses were continued in linear mixed models.

We applied a hierarchical regression approach with the principle of hierarchical ordering of proximal vs distal factors based on the socio-ecological framework and in line with the conceptual model for the HEIA study (Stokols et al., 1996; Lien et al., 2010). The analyses were built up of blocks containing categories of the correlates in which the order of the blocks of correlates was based on their relative proximity to the individual. The demographic variables, gender and parental education were entered as block 1 and treated as control factors in the analyses. Block 2 contained the biological correlate weight category (normal weight vs overweight/obese), seen as proximal to the individual. Block 3 contained the psychological and behavioral correlates reflecting greater proximity to the individual than the more distal social-environmental correlates, which were contained in block 4. The reason for the hierarchical ordering of the blocks was to be able to examine the relative importance of each block entered, in explaining the amount of variance in % daily MVPA, entering first the proximal ones potentially more amenable to change through intervention efforts (Sallis et al., 1999).

Two hierarchical regression analyses were conducted. First, we run an introductory analysis in which all the potential correlates were entered in the blockwise order as described. After controlling for gender and parental education, weight category (normal weight vs overweight/obese) was added in the second block (block 2). In the third block (block 3), all the psychological and behavioral correlates were added (enjoyment, self-efficacy, TV-viewing and computer/game-use on weekends). Lastly, all the social-environmental correlates were added in the fourth block (block 4) (perceived social support from friends, teacher and friends, perceived social inclusion, perceived environmental opportunities for physical activity and perceived parental regulation of TV and computer/game-use). All the independent variables (the correlates) were measured at the individual level and therefore entered as individual (level one) variables in the analyses, grand-mean centered.

In the second round, significant predictors in the introductory analysis were retained and included in a final blockwise hierarchical analysis with the same ordering of the blocks as in the introductory analysis. As a last additional block (block 5), we tested the moderation effect of weight category (i.e. normal weight vs overweight/obese) on the association between the remaining psychological and behavioral and social-environmental correlates (from blocks 3 and 4) and % daily MVPA. The interaction terms were added and tested one at a time.

Results

Descriptives

The children were 11.2 (0.3) years old. Table 2 shows the descriptive statistics of % daily MVPA and the accelerometer variables used to calculate it. The mean count per minute is included to describe the overall physical activity level. The children spent 8.6 (3.0)% of their measured activity time in MVPA. The girls engaged in significantly less MVPA than the boys, but on average both boys and girls obtained at least 60 min of daily MVPA. The anthropometric data are also presented in Table 2. The descriptive characteristic of the correlates showed relatively high mean scores for some of the correlates (Table 1).

Hierarchical regression in linear mixed models

Results from the introductory hierarchical regression analysis (not shown) revealed that neither enjoymen
nor TV-viewing on weekends (block 3) were significantly associated with % daily MVPA. Perceived social support from teachers and parents, perceived social inclusion, perceived environmental opportunities for physical activity and perceived regulation of TV and computer/game-use (block 4) were also shown to be non-related to % daily MVPA. However, being normal weight (block 2), self-efficacy (block 3) and social support from friends (block 4) were all positively related to % daily MVPA. The results from the second, final hierarchical regression analysis, in which the significant correlates from the introductory analysis were retained, are shown in Table 3.

The results of the hierarchical blockwise approach were assessed by inspecting each block’s fit (model fit), which is indicated by a decreasing value of the Akaike’s Information Criterion (AIC) and the explained variance (Hox, 2002). Total explained variance was obtained by comparing unexplained variation in the blocks with the empty model, and the unexplained variance was computed by summing up the variances within schools (level one) and between schools (level two). The AIC decreased from 5595 in the empty model (the no intercept model) to 5004 in the final model.

Table 3. Hierarchical regression (linear mixed models) examining correlates of % daily MVPA

<table>
<thead>
<tr>
<th>Fixed effects</th>
<th>Empty model</th>
<th>Block 2</th>
<th>Block 3</th>
<th>Block 4</th>
<th>Block 5</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>8.69 (0.18)***</td>
<td>8.58 (0.30)***</td>
<td>8.84 (0.30)***</td>
<td>8.76 (0.30)***</td>
<td>8.68 (0.30)***</td>
</tr>
<tr>
<td>Weight category (normal weight)</td>
<td>1.06 (0.25)***</td>
<td>0.88 (0.25)***</td>
<td>0.91 (0.25)***</td>
<td>0.99 (0.25)***</td>
<td></td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>0.55 (0.11)***</td>
<td>0.35 (0.13)**</td>
<td>0.35 (0.13)**</td>
<td>0.35 (0.13)**</td>
<td></td>
</tr>
<tr>
<td>Social support from friends</td>
<td>−0.36 (0.07)***</td>
<td>−0.26 (0.07)**</td>
<td>0.05 (0.16)**</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Computer/game-use on weekends × weight category</td>
<td>0.29 (0.09)**</td>
<td>0.29 (0.09)**</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Random effects</td>
<td>7.87***</td>
<td>7.99***</td>
<td>6.62***</td>
<td>6.58***</td>
<td>6.52***</td>
</tr>
<tr>
<td>Variation between schools</td>
<td>0.96***</td>
<td>0.99***</td>
<td>1.01***</td>
<td>1.01***</td>
<td></td>
</tr>
<tr>
<td>AIC</td>
<td>5595</td>
<td>5222</td>
<td>5027</td>
<td>5006</td>
<td>5004</td>
</tr>
</tbody>
</table>

Weight category coded: 0 = normal weight, 1 = overweight/obese.
Control factors: gender and parental education (entered as block 1) not shown.
*P<0.05,
**P<0.01,
***P<0.001.

Est., estimates; SE, standard error; AIC, Akaike’s Information Criterion; MVPA, moderate to vigorous physical activity; NS, non-significant.
model) to 5522 when adding the control factors (gender and parental education) in block 1. Furthermore, the AIC decreased for each of the added blocks of modifiable correlates entered in the final hierarchical analysis (blocks 2–5), shown in Table 3. The control factors (block 1) contributed to 7.5% of the total explained variance, while a total of 8.7% was explained by adding weight category (block 2) within the biological domain. The psychological and behavioral domain with self-efficacy and computer/game-use on weekends (block 3) increased the total explained variance to 13.6%. The social-environmental domain (block 5) with perceived social support from teachers increased the total explained variance to 14.1%. The total explained variance increased to 14.4% when adding the significant moderation effect of weight category on the association between computer/game-use on weekends and % daily MVPA (block 5) detected in the final hierarchical regression analysis, as shown in Table 3. The moderation effect showed that among the overweight/obese more time used on computer/games on weekends was associated with lower % daily MVPA, whereas as a weak positive trend between computer/game-use on weekends and % daily MVPA was revealed among the normal weight children (Fig. 1). No moderation effect of weight category was detected on the association between self-efficacy or peer-support and % daily MVPA.

Discussion

The proportion of time spent in MVPA was quite modest for these 11-year-olds, and the level of MVPA was closer to the level found for Norwegian 15- than for 9-year olds (Kolle et al., 2010). As hypothesized, modifiable correlates from different domains accounted for a significant amount of variation in % daily MVPA in these pre-adolescent children. Being normal weight, reporting a sense of self-efficacy and social support from friends were positively related to % daily MVPA, while computer/game-use on weekends was negatively associated to % daily MVPA. Each domain contributed significantly to the explained variance in % daily MVPA, with self-efficacy and computer/game-use on weekends from the psychological and behavioral domain accounting for the highest amount compared with correlates within the other domains. A moderation effect of weight category in the relationship between computer/game-use on weekends and % daily MVPA was also revealed.

The total explained variance in % MVPA was quite low (14%), but it is in line with other studies that have assessed physical activity objectively either by accelerometers or pedometers (Morgan et al., 2003; Lubans & Morgan, 2009). Studies using self-reported measures of physical activity have in general been able to account for more variance in MVPA, and this might be due to shared method variance between self-reported physical activity and correlates (Dishman, 1994).

Weight category correlate

We found that being normal weight was associated with a higher % daily MVPA compared with being overweight/obese. Our result is in line with the findings for BMI and % body fat in other studies in which children’s physical activity is assessed by accelerometers (Trost et al., 2001; Adkins et al., 2004;
shown that an increase in sedentary behaviors in young peoples lives (Biddle et al., 2004), and is consistent with the conclusion in reviews (Sallis et al., 2000; van der Horst et al., 2007). One possible explanation for this “no-association” could be the measuring of physical activity because forms of physical activity less likely to be driven by a sense of enjoyment are also captured by the accelerometers. The positive association found between sedentary behavior/physical inactivity and self-efficacy and % daily MVPA is in line with results from other studies assessing physical activity by accelerometers, in which self-efficacy is found to be a clear correlate of moderate or vigorous physical activity in children of both genders, including the same age group as in our study (Trost et al., 1999; Strauss et al., 2001; Dishman et al., 2009). In accordance with Nilsson et al. (2009), but in contrast to Strauss et al. (2001), no relationship between TV-viewing and % daily MVPA was detected. On the other hand, the inverse relationship between computer/game-use and % daily MVPA is in line with the findings by Strauss et al. (2001) in their sample of 10- to 16-year-olds. Our result indicates that computer/game-use possibly might work to replace time in MVPA. However, there might be time for both physical activity and screen behaviors in young peoples lives (Biddle et al., 2004), even though laboratory experiments have shown that young people are more likely to prefer sedentary activities, even when physically active alternatives are freely available (Vara & Epstein, 1993). This “replacement hypothesis” might be of particular relevance during weekends when young people in general have more discretionary time at their disposal and might substitute sedentary activities more easily for physical activity. The steady increase in various types of electronic games and type of computer activities for entertainment in the last decade could also have lead to these types of sedentary behaviors becoming a more easily available substitute for physical activity. It could well be that computer/game-use is an activity not so closely connected with specific time periods of the day or social context as is TV-viewing, and is therefore a greater threat to physical activities for children. Results from a prospective study have also shown that an increase in sedentary behaviors including computer/game-use was associated with a reduction in physical activity during a 22-month period in early adolescence (Raudsepp et al., 2008). Furthermore, cluster analysis has found that sedentary behaviors sometimes compete with and sometimes coexists with physical activity (Marshall et al., 2002). According to the results in our study, the moderator effect of weight category on the association between computer/game-use on weekends and % daily MVPA reflects a higher amount of computer/game-use being associated with less physical activity among the overweight/obese, but not among the normal weight children. This result is troublesome indicating that overweight/obese might be more apt to replace physical activity with computer/game-use.

Psychological and behavioral correlates
Enjoyment showed no association with % daily MVPA, and is consistent with the conclusion in reviews (Sallis et al., 2000; van der Horst et al., 2007). One possible explanation for this “no-association” could be the measuring of physical activity because forms of physical activity less likely to be driven by a sense of enjoyment are also captured by the accelerometers. The positive association found between self-efficacy and % daily MVPA is in line with results from other studies assessing physical activity by accelerometers, in which self-efficacy is found to be a clear correlate of moderate or vigorous physical activity in children of both genders, including the same age group as in our study (Trost et al., 1999; Strauss et al., 2001; Dishman et al., 2009). In accordance with Nilsson et al. (2009), but in contrast to Strauss et al. (2001), no relationship between TV-viewing and % daily MVPA was detected. On the other hand, the inverse relationship between computer/game-use and % daily MVPA is in line with the findings by Strauss et al. (2001) in their sample of 10- to 16-year-olds. Our result indicates that computer/game-use possibly might work to replace time in MVPA. However, there might be time for both physical activity and screen behaviors in young peoples lives (Biddle et al., 2004), even though laboratory experiments have shown that young people are more likely to prefer sedentary activities, even when physically active alternatives are freely available (Vara & Epstein, 1993). This “replacement hypothesis” might be of particular relevance during weekends when young people in general have more discretionary time at their disposal and might substitute sedentary activities more easily for physical activity. The steady increase in various types of electronic games and type of computer activities for entertainment in the last decade could also have lead to these types of sedentary behaviors becoming a more easily available substitute for physical activity. It could well be that computer/game-use is an activity not so closely connected with specific time periods of the day or social context as is TV-viewing, and is therefore a greater threat to physical activities for children. Results from a prospective study have also shown that an increase in sedentary behaviors including computer/game-use was associated with a reduction in physical activity during a 22-month period in early adolescence (Raudsepp et al., 2008). Furthermore, cluster analysis has found that sedentary behaviors sometimes compete with and sometimes coexists with physical activity (Marshall et al., 2002). According to the results in our study, the moderator effect of weight category on the association between computer/game-use on weekends and % daily MVPA reflects a higher amount of computer/game-use being associated with less physical activity among the overweight/obese, but not among the normal weight children. This result is troublesome indicating that overweight/obese might be more apt to replace physical activity with computer/game-use.

Social-environmental correlates
Perceived peer-support for physical activity was positively associated with % daily MVPA in our study, which is in contrast with the finding of Prochaska et al. (2002), but in line with several other studies with objectively measured physical activity in age groups quite close to our sample (Strauss et al., 2001; Duncan et al., 2005; Lubans & Morgan, 2009). A study examining location-specific correlates of physical activity (self-reported) among youth has also identified that peer support generalized across several locations (Ommundsen et al., 2006). Our finding suggests that social support from friends may be an important influence for physical activity in the pre- and early adolescent period. Indeed, theories on social development support that peer influences increase in the transition from childhood to young adulthood (Kupersmidt & Dodge, 2004). Perceived social support from parents and teachers were not related to % daily MVPA in our study. The result for parent support contrasts with other studies including objectively measured physical activity (Strauss et al., 2001; Duncan et al., 2005). One possible explanation could be that the role of social support on physical activity is mediated by self-efficacy reflecting an indirect role of parental and teacher support on % daily MVPA (levers-Landis et al., 2003).

Neither the perceived parental regulations of TV-watching nor the perceived parental regulations of computer/game-use showed any association with % daily MVPA. It could be that measures of perceived regulation of sedentary behaviors better predict levels of sedentary behaviors. Indeed, it has been shown that sedentary behavior/physical inactivity are separate behaviors distinct from physical activity (and not just opposites on a continuum), and that these behaviors have their own set of correlates (Biddle et al., 2004).
No relationship between perceived social inclusion or perceived environmental opportunities in the micro-environmental settings of neighborhood and schools and % daily MVPA was found in our study neither. Although using a slightly modified measure for perceived social inclusion, the result contrasts with the findings of Hume et al. (2009), who identified a positive association between “social capital” (related to people in “my” area) and MVPA in a large sample of 9–12-year-olds. The different findings could possibly be due to cultural differences. Non-systematic observations of the schools and neighborhoods in this study indicate that the environmental possibilities for physical activity were generally quite good across the sample. Also, both the perceived social inclusion and perceived environmental opportunities measures revealed a high mean value as well as a low standard deviation (Table 1). Hence, a lack of association might as well be due to a possible ceiling effect.

There are several limitations of this study. First, the cross-sectional design prohibits inference of any causal relationship, and the generalizability of our findings may be limited because the sample was recruited from a restricted geographic area in Norway. Because not all the children provided valid accelerometer data, there could be some selection biases present. However, as shown previously, the only difference detected in the correlates investigated between those who did provide accelerometer data and those who did not was for perceived social support from parents. While the use of self-report instruments can be problematic, particularly among children and adolescents, the test–retest reliability as well as the internal consistency of the correlate measures were satisfactory. Using a mix of new and old types of accelerometers in this study could theoretically have reduced the reliability of the accelerometer data. However, there seems to be no clear consensus regarding the need to adjust accelerometer values related to this issue (Corder et al., 2007; John et al., 2010).

Study strengths include the objective assessment of physical activity, height and weight. In addition, we investigated modifiable correlates from multiple domains including established and more recent correlates examining a large sample of children in an age group in which they are at risk of reducing their physical activity. As called for, more than one sedentary behavior was examined. Lastly, multilevel analysis was used to account for the nesting of children within schools. In conclusion, the findings confirm that children’s physical activity is related to correlates from multiple domains. Being normal weight, self-efficacy related to barriers, and perceived social support from friends were positively related to % daily MVPA in these pre-adolescent children, while a negative association was found for computer/game-use on weekends. While modifiable biological, psychological, behavioral and social-environmental correlates were found to account for variation in % daily MVPA in these Norwegian pre-adolescents children, a lot of the variance is still left unexplained.

Perspectives
In future studies, it will be important to study additional factors that hold the potential to raise the amount of explained variation in children's physical activity. Prospective studies are needed in order to clarify whether weight status influences physical activity in children or vice versa. Results for self-efficacy indicate that it might be useful to teach children to cope with barriers that prevent them for being active, by teaching strategies on how to overcome tempting sedentary alternatives or by providing them with more attractive physical activity alternatives. Efforts to increase social support from friends might positively influence physical activity in pre-adolescents children. The interaction of weight category in the relation among computer/game-use and physical activity indicates that special attention to reduce computer/game-use on weekends by possibly offering attractive and suitable physical activity alternatives, might be needed to enhance physical activity for overweight/obese children. It also seems warranted to further examine possible moderating effects of weight status on relationships between correlates and physical activity in pre-adolescents. Intervention studies are called for to investigate whether the identified modifiable correlates will mediate physical activity change in children in the transition from childhood to adolescence. These issues will be addressed in upcoming studies within the HEIA study.

Key words: cross-sectional, modifiable correlates, children, accelerometers, physical activity, multilevel analysis, HEIA study.

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References


Paper II
Mid-way and post-intervention effects on potential determinants of physical activity and sedentary behavior, results of the HEIA study - a multi-component school-based randomized trial

Ingunn H Bergh1*, Mona Bjelland3, May Grydeland2,3, Nanna Lien3, Lene F Andersen1, Knut-Inge Klepp3, Sigmund A Anderssen2 and Yngvar Ommundsen1

Abstract

Background: There is limited knowledge as to whether obesity prevention interventions are able to produce change in the determinants hypothesized to precede change in energy balance-related behaviors in young people. The aim of this study was to evaluate the effect of a multi-component intervention on a wide range of theoretically informed determinants of physical activity (PA) and sedentary behavior (SB). Moderation effects of gender, weight status and parental education level and whether the perceived intervention dose received influenced the effects were also explored.

Methods: The HEIA study was a 20-month school-based, randomized controlled trial to promote healthy weight development. In total, 1418 11-year-olds participated at baseline and post-intervention assessment. Enjoyment, self-efficacy, perceived social support from parents, teachers and friends related to PA, perceived parental regulation of TV-viewing and computer/game-use and perceived social inclusion at schools were examined by covariance analyses to assess overall effects and moderation by gender, weight status and parental education, mid-way and post-intervention. Covariance analyses were also used to examine the role of intervention dose received on change in the determinants.

Results: At mid-way enjoyment (p = .03), perceived social support from teachers (p = .003) and self-efficacy (p = .05) were higher in the intervention group. Weight status moderated the effect on self-efficacy, with a positive effect observed among the normal weight only. At post-intervention results were sustained for social support from teachers (p = .001), while a negative effect was found for self-efficacy (p = .02). Weight status moderated the effect on enjoyment, with reduced enjoyment observed among the overweight. Moderation effects for parental education level were detected for perceived social support from parents and teachers. Finally, positive effects on several determinants were observed among those receiving a high as opposed to a low intervention dose.

Conclusion: The intervention affected both psychological and social-environmental determinants. Results indicate that social support from teachers might be a potential mediator of PA change, and that overweight adolescents might be in need of specially targeted interventions to avoid reducing their enjoyment of PA. Further studies should continue to assess how intervention effectiveness is influenced by the participants’ self-reported dose of intervention received.

Keywords: Moderation, Adolescents, Obesity prevention, Intervention, Social-ecological model, Effect, Randomized controlled trial

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Background

Engagement in physical activity (PA) and sedentary behavior (SB) are regarded as two important factors in obesity prevention programs [1]. School-based interventions to increase PA and reduce SB may promote healthy weight development, but the results are inconsistent [2]. One possible explanation for low efficacy or effectiveness is limited evidence as to how interventions induce behavior change [3] and for whom interventions are effective [4]. More research in order to improve this understanding of PA and SB change is called for [5,6].

According to the mediating framework, change in hypothesized determinants is a prerequisite for change in behavior [7]. Hence, potential determinants could be considered endpoints in themselves and thus would seem important to identify [8-10]. Knowledge about change in determinants will help tease out important influences that may pave the way for behavior change at a later stage, and by identifying changes in potential determinants one may avoid running the risk of underestimating important intervention effects in cases when behavior change cannot be observed.

Only a limited number of PA interventions targeting adolescents have reported the effects of change in determinants, and in about half of the identified studies no effect on these were detected [11]. However, changes in self-efficacy and enjoyment of PA have been identified, and these determinants have also been proven to mediate PA change in children and adolescents [5,6]. Effect on change in inter-personal determinants such as social support for PA is less investigated [5,6,11], and no one seems to examine the effect of the HEIA intervention upon theoretical informed psychological and social-environmental determinants of PA and SB change measured mid-way (after 8 months) and post-intervention (after 20 months), 2) to investigate moderating effect of gender, weight status and SES on the set of determinants and 3) to explore whether the degree of intervention exposure and participation influenced these outcomes.

Methods

Study design and population

Schools were recruited from towns/municipalities in seven counties in the south-eastern part of Norway. For logistic reasons schools had to have at least 40 pupils enrolled in 6th grade which qualified 177 schools to receive an invitation. Thirty-seven schools accepted the invitation, and all the 6th graders (n = 2165) in the attending schools and their parents/legal guardians were invited to participate (Figure 1) [20]. Of these, 1580 (73%) returned a parental signed informed consent form.

A cluster randomized design was used to evaluate the intervention; 12 schools were randomly assigned by simple drawing to the intervention group and 25 to the control group. The baseline data collection was conducted in September 2007 (in the beginning of 6th grade), the mid-way assessment was conducted in May 2008 (at the end of 6th grade; 8 months past baseline). All three assessments were administered over approximately four weeks, with parallel assessments in the intervention and control group.

The adolescents who participated in both the baseline and post-intervention data collections are included in the analyses; in total 1418 (908 in Control; 510 in Intervention; 89% of the 1580 returning the consent forms), and of those 1384 participated in the mid-way assessment (885 in Control; 499 in intervention; 87% of the 1580 returning the consent forms). Comparisons of the outcomes and demographic variables between those participating only at baseline and those participating at a) baseline and post-intervention and b) all three assessments, revealed significant lower values for perceived social inclusion at school
and a higher proportion of overweight adolescents (p = .007 and p = .01) among those lost to follow-up between baseline and post-intervention (n = 110) and between baseline and both mid-way and post-intervention (n = 144) (data not shown).

Intervention

A detailed description of the study design, the development and all the parts of the intervention (dietary, PA and SB) have been presented elsewhere [20]. The intervention consisted of a mix of individual-, group- and environmental strategies and components. All the PA and SB components and the targeted determinants are listed in additional file 1: Table S1 and it illustrates how several of the components were directed towards change in multiple determinants. The first part (in 6th grade) emphasized activities that were supposed to make PA enjoyable and create a sense of efficacy for PA. Most of the PA components included interactions with classmates to facilitate social cohesion and support. In the second part of the intervention (in 7th grade) some components targeting SB were included.

In short, the 6th grade components were: 1) One theoretical class-room lesson over 90 minutes, concerning PA and dietary behaviors in relation to the energy balance equation (the other four lessons focused primarily on dietary behavior). 2) Short PA breaks during lessons (once a week), 3) two active-commuting-to-school campaigns, 4) an “activity box” with sport- and play equipment for use during recess (including e.g. frisbees, jump-ropes, elastic bands, hockey-sticks, several types of balls). 5) fact sheets for parents (3 specifically on PA, 6 in total), and 6) one inspirational course for teachers responsible for the physical education (PE) classes in which the teachers practiced new ideas for lessons that they were to try out in the PE-classes. The lessons focused on type of novel, enjoyable games and activities with the intention to keep all the students in moderate to high intensity most of the class-time, and was based on the SPARK program [24]. The 7th grade components included: 1) an extension of PA breaks and 2) the two active-commuting to school campaigns in which the adolescents were provided with pedometers. The focus in this “pedometer challenges” was to stimulate both active commuting to schools as well as more daily PA. 3) Some of the equipment in the “activity box” was replaced due to loss from wear and tear. 4) A second inspirational course for PE-teachers was organized providing the teachers with additional lessons to try out in PE-classes (some included use of pedometers). 5) A computer tailoring program targeting SB, PA and dietary behaviors was added to the intervention with four sessions in total, including one on SB (both TV-viewing and computer/electronic game-use) and one on PA. 6) In addition new parental fact sheets targeting both PA and SB (3 on PA, 1 on TV and computer/game-use, 9 in total) were distributed to the parents now including child–parent homework assignments.

Each school year the intervention was initiated by a kick-off meeting with the involved teachers. The purpose of these meetings was to ensure that the whole team of
teachers knew the rationale, was familiar with the various intervention elements and were motivated to implement the components and support the targeted behaviors. During the school year the participating teachers received external support in form of short monthly e-mail reminders from the HEIA study group. All the adolescents in the intervention schools took part in the intervention, but only those with consent took part in the data collection. The control schools followed the regular Norwegian school curriculum including PE-classes (2 X 45 min/wk), but they were not restricted with respect to developing their own PA, SB or dietary initiatives.

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

**Measurements**

**Questionnaire data**

The adolescents self-reported the potential determinants of PA and SB, and gender in an internet-based questionnaire which took about 45 minutes to complete. Process evaluation questions tapping into the adolescents’ perception of exposure and participation in the intervention were included in the questionnaire for those in the intervention group at mid-way and post-intervention assessments. The questionnaires were completed in schools with trained personnel present.

**Outcome measures**

The outcome measures included nine hypothesized psychological and social-environmental determinants of PA and SB change. The psychological variables included an abbreviated and slightly modified version of the Enjoyment of PA scale [25] and the self-efficacy related to barriers for PA scale based on previous studies [26,27]. These changes were induced to keep the questionnaire at a reasonable length and to obtain satisfactory reliability estimates. The social-environmental variables were: Perceived social support for PA from parents assessed by five items; perceived social support for PA from friends assessed by three items [28]; Perceived social support for PA from teacher taken from a pilot study within the European Youth Heart Study [29] assessed by three items; Perceived Environmental opportunities to be physically active from Sallis et al. [28] with one added item and assessed by 4 items; Perceived parental regulation of TV-viewing and perceived parental regulation of computer/game-use, each assessed by four items modified from Hardy et al. 2006 [30] and Perceived social inclusion related to the school and class environment assessed by six items based on a "social capital measure" (related to people in my area/neighborhood) developed by Hume et al. 2009 [12] modified to capture the quality of relationship with peers at school both within and outside the classroom (degree of closeness and willingness to ask for/provide help when necessary). All the items were rated on a 5-point Likert-type scale coded 1 (lowest) to 5 (highest), and-phrased "totally disagree" to "totally agree" with a neutral midpoint, except for the social support constructs which were phrased “almost never or never”, "1 to 2 times a week", "3 to 4 times a week", “almost every day” and “every day”.

All the nine outcomes were assessed at baseline and post-intervention, while enjoyment, self-efficacy, perceived social support from parents and teachers were measured also at the mid-way assessment. All variables obtained acceptable internal reliability values (Cronbach’s alpha) at baseline (range 0.62-0.82), mid-way (range 0.68-0.75) and post-intervention (range 0.67-0.85). Examples of the items, the procedure for computing the composite scores, the results from a separate test-retest study showing moderate to high test-retest values (ICC), and the theoretical models from which these variables have been derived, have been reported elsewhere [22].

**Weight status and parental education**

Height and weight of the adolescents were measured objectively, and the baseline values were used to categorize the adolescents as normal weight and overweight by the age and gender specific cut-off values proposed by the International Obesity Task Force [31]. Due to the low proportion of obese in the sample at baseline (1.5% in total sample; 1.6% in Control; 1.3% Intervention), the overweight and obese were treated as one group in the analyses, and are referred to as the “overweight group” throughout the paper. Details of the procedures and test-retest values of the anthropometric measurements have been reported elsewhere [20,32]. Parental education was used as an indicator of SES, and was reported by the parents on the informed consent form. Parental education level was categorized into three levels: 12 years or less, between 13 and 16 years and 16 years or more, and the parents with the highest education was used or else the one available.

**Perceived intervention dose received**

To obtain information about the intervention dose received [17], the adolescents answered process questions about degree of exposure to or participation in the PA and SB intervention components both mid-way (6 questions) and post-intervention (7 questions). The response categories were yes (1) or no (0), while three of the questions had three or more response categories and were dichotomized into yes/no (Table 1). All the intervention components were formatted as a package and supposed to be implemented as such with components expected to mutually reinforce each other. Therefore, a sumscore for the total dose received at mid-way and post-intervention were calculated by adding and averaging the...
numbers of questions, giving scores ranging from 0.00 to 1.00 (0 = minimum and 1.00 = maximum degree of exposure/participation). By inspecting the distribution of the scores, we set a score equal or above 0.75 (75%) to represent a “high” dose received of the intervention and a score lower than 0.75 to represent a “low” dose received. The questions, the coding and the distribution (%) for the specific process questions and the perceived total intervention dose received mid-way and post-intervention are presented in Table 1.

Data analyses

Chi-square and independent t-tests were used to analyze drop-outs and to compare baseline characteristics and outcomes between groups (control vs. intervention, and low vs. high intervention dose received).

Clustering effects due to schools being the unit of recruitment was checked by the linear mixed model procedure. Only 0-4% of the unexplained variance in the outcomes was on the group (i.e. school) level, except for perceived social support from teachers being slightly higher (9%). Hence, for perceived social support from teachers we did check results by the linear mixed model procedure, adjusting for the school effect. Given that the same pattern of results was revealed when taking into account the potential clustering effect of school, it was decided to run and present all further analyses without adjusting for the clustering effect.

In the main analyses, the overall effects from baseline to mid-way and from baseline to post-intervention were investigated in two steps by one-way ANCOVA, with the mid-way and post-interventions values for the outcome measures as dependent variables, baseline values as covariates and group (intervention vs. control) as the independent variable.

Next, in separate analyses moderating influences on the effects were examined by two-way ANCOVA both at mid-way and at post-intervention for the following variables: gender, weight status (normal weight vs. overweight) and parental education level (<12 years, ≥≤12 years).

Table 1 Exposure to/participation in the PA and SB intervention components and total perceived intervention dose received

<table>
<thead>
<tr>
<th>Response categories</th>
<th>Coded: no (0)/yes (1)</th>
<th>Yes % (n)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mid-way: questions assessing perceived exposure/participation</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Have you completed in class assignment about diet, PA and SB?</td>
<td>Yes/no</td>
<td>92.9 (446)</td>
</tr>
<tr>
<td>Have you noticed HEIA-posters in the classroom?</td>
<td>Yes/no</td>
<td>82.2 (480)</td>
</tr>
<tr>
<td>Have you participated in the active transport campaign?</td>
<td>Yes/no</td>
<td>89.0 (435)</td>
</tr>
<tr>
<td>Have you participated in one or more HEIA-breaks with PA?</td>
<td>Yes/no</td>
<td>82.7 (401)</td>
</tr>
<tr>
<td>Have you used the equipment in the “activity box” during recess?</td>
<td>Each school day or almost each school day (yes)/once a week, rarely or never (no)</td>
<td>41.7 (287)</td>
</tr>
<tr>
<td>Have you used movement bands in the PE-classes?</td>
<td>Yes/no or does not know (no)</td>
<td>47.5 (235)</td>
</tr>
</tbody>
</table>

**Total intervention dose received midway (n = 492)**

<table>
<thead>
<tr>
<th>Range: 0.00-1.00 High dose ≥0.75</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total intervention dose received</td>
</tr>
</tbody>
</table>

| **Post-intervention:** | |
|-----------------------|-----------------------|-----------|
| Have you completed the computer tailoring session about PA? | Yes/no | 88.1 (436) |
| Have you completed the computer tailoring session about TV and computer/game-use? | Yes/no | 87.2 (436) |
| Have you noticed HEIA-posters in the classroom? | Yes/no | 75.2 (377) |
| Have you participated in a “pedometer challenge” (related to active commuting/active daily living)? | yes twice | 83.4 (416) |
| Have you participated in one or more HEIA-breaks with PA during school lessons? | Yes/no | 78.4 (389) |
| Have you used the equipment in the “activity box” during recess? | Each school day or almost each school day (yes)/once a week, rarely or never (no) | 39.2 (197) |
| Have you used “Basse” (ball made of rubber bike wheels) during school hours? | Yes everyday (yes)/one day per week/no or does not know what Basse is (no) | 26.8 (134) |

**Total intervention dose received post intervention (n = 503)**

<table>
<thead>
<tr>
<th>Range: 0.00-1.00 High dose ≥0.75</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total intervention dose received</td>
</tr>
</tbody>
</table>

PA = Physical activity, SB = Sedentary behavior.
Sample: Norwegian adolescents 11-13 year-olds from the HEIA study.
13–16 years, >16 years). For cases in which significant moderating influences were revealed, subgroup analyses were carried out using one-way ANCOVA to test for differences between the control and intervention for each subgroup.

Lastly, the effect of the perceived intervention dose received (low vs. high) on the determinants were analyzed first at mid-way and then at post-intervention, with one-way ANCOVA within the intervention schools only. The mid-way and post-interventions values for the outcome measures were entered as dependent variables, baseline values as covariates and intervention dose received (high vs. low) as the independent variable.

Data were checked to ensure there were no violations of the assumptions for the ANCOVA analyses. All statistical analyses were performed by IBM SPSS Statistics, version 18.0 (IBM Corp., Somers, New York, USA). The significance level was set at $p < 0.05$ for all analyses, except for the interaction tests where $p < 0.10$ was used.

Results

Table 2 shows the baseline characteristic for the study population by condition. No significant differences between the intervention and control group were revealed for the demographic variables.

In Table 3 the means (SD) for all the outcomes are shown at the baseline, mid-way and post-intervention assessments. There were no significant differences between the intervention and control group at baseline.

Main effects

Table 4 shows the effect of the intervention on the four determinants assessed mid-way, and the effect on all the nine determinants measured post-intervention.

At mid-way there were small significant positive effects of the intervention on both enjoyment and perceived social support from teachers, and a borderline significant positive effect for self-efficacy. No effect on perceived social support from parents was observed (Table 4). For enjoyment the change was expressed as a small increase in the intervention group, and a small decrease in the control group (Table 3). The level of social support from teachers stayed about the same in the intervention group, but there was slight decrease in the control group (Table 3). For self-efficacy the borderline significant change reflected a slightly greater increase in the intervention group compared to the control group.

At post intervention a negative intervention effect was detected for self-efficacy (Table 4), reflecting a small reduction in self-efficacy in the intervention group with no change in the control group (Table 3). A positive intervention effect was revealed for perceived social support from teachers (Table 4) seen as a somewhat smaller reduction in the intervention group compared to the control (Table 3). No effects on any of the other determinants were observed.

Interaction and subgroups effects

At mid-way no interaction effects of gender or parental education were found on change in the four determinants assessed. However, weight status moderated the effect of the intervention on change in self-efficacy ($p = 0.01$) (Figure 2a). Similarly, no interaction effects of gender was found at post-intervention, but weight status moderated the effect on change in enjoyment ($p = 0.02$) (Figure 2b). Also, parental education level moderated the effect on pre to post-intervention change in perceived social support from parents ($p = 0.07$) (Figure 2c) and from teachers ($p = 0.003$) (Figure 2d).

The results of the corresponding subgroup analyses mid-way and post-intervention are shown in Table 5. At mid-way the effect of the intervention on self-efficacy was different for the normal weight and overweight adolescents. While the normal weight reported higher self-efficacy, a trend (non-significant) for reporting lower self-efficacy among the overweight was observed. Post-intervention, the effect on enjoyment differed for the normal weight and overweight. While no effect on change in enjoyment among the normal weight was observed, the overweight group reported a reduction in enjoyment.

In addition, at post-intervention the effect on perceived social support from parents and from teachers differed by the adolescents’ SES. Adolescents with medium parental education reported lower social support from parents compared to the control group. There was no intervention effect on change in perceived social support from parents among those with...
the lowest and highest parental education. In contrast, there was a positive intervention effect on change in perceived social support from teachers among those with lowest and highest parental education. No intervention effect on change in perceived social support from teachers was found among those with medium parental education.

Perceived intervention dose received
At mid-way 273 (55.5%) of the adolescents in the intervention group reported a high intervention dose received, whereas 156 (31.0%) reported this at the time of the post-intervention (Table 1). Table 6 show the influence on change in the examined determinants within the intervention group.

Table 3 Baseline, mid-way and post-intervention characteristics for PA and SB determinants in the control and intervention group

<table>
<thead>
<tr>
<th></th>
<th>Baseline (n = 908)</th>
<th>Mid-way (n = 510)</th>
<th>Post-intervention (n = 908)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Mean</td>
<td>SD</td>
<td>p</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>4.13 (0.76)</td>
<td>4.09 (0.77)</td>
<td>0.35</td>
</tr>
<tr>
<td>Social support from parents</td>
<td>3.99 (0.75)</td>
<td>3.99 (0.78)</td>
<td>0.07</td>
</tr>
<tr>
<td>Social support from teachers</td>
<td>1.61 (0.65)</td>
<td>1.75 (0.77)</td>
<td>1.47</td>
</tr>
<tr>
<td>Social support from friends</td>
<td>2.96 (1.00)</td>
<td>2.96 (1.04)</td>
<td>2.80</td>
</tr>
<tr>
<td>Environmental opportunities for PA</td>
<td>4.26 (0.77)</td>
<td>4.27 (0.76)</td>
<td>4.11</td>
</tr>
<tr>
<td>Parental regulation TV-viewing</td>
<td>3.64 (0.96)</td>
<td>3.68 (0.93)</td>
<td>4.41</td>
</tr>
<tr>
<td>Parental regulation computer/game-use</td>
<td>3.55 (0.99)</td>
<td>3.53 (1.01)</td>
<td>4.38</td>
</tr>
<tr>
<td>Social inclusion at school</td>
<td>4.43 (0.61)</td>
<td>4.39 (0.62)</td>
<td>4.36</td>
</tr>
</tbody>
</table>

PA = Physical activity, SB = Sedentary behavior, SD = Standard deviation.

Perceived intervention dose received
At mid-way 273 (55.5%) of the adolescents in the intervention group reported a high intervention dose received, whereas 156 (31.0%) reported this at the time of the post-intervention (Table 1). Table 6 show the influence on change in the examined determinants within the intervention group.

Table 4 Effects on determinants for PA and SB mid-way and post intervention

<table>
<thead>
<tr>
<th></th>
<th>Mean†</th>
<th>95% CI</th>
<th>Mean†</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control (n = 908)</td>
<td>Intervention (n = 510)</td>
<td>Control (n = 908)</td>
<td>Intervention (n = 510)</td>
<td></td>
</tr>
<tr>
<td>Enjoyment</td>
<td>4.07 (4.03, 4.12)</td>
<td>4.15 (4.10, 4.21)</td>
<td>4.10 (4.05, 4.15)</td>
<td>4.15 (4.10, 4.22)</td>
<td>.03</td>
</tr>
<tr>
<td>Perceived social support from parents</td>
<td>3.99 (3.90, 4.00)</td>
<td>4.01 (3.95, 4.07)</td>
<td>3.95 (3.89, 4.01)</td>
<td>4.00 (3.95, 4.07)</td>
<td>.05</td>
</tr>
<tr>
<td>Perceived social support from teachers</td>
<td>3.86 (3.81, 3.91)</td>
<td>3.76 (3.70, 3.83)</td>
<td>3.86 (3.81, 3.91)</td>
<td>3.83 (3.77, 3.89)</td>
<td>.02</td>
</tr>
<tr>
<td>Social support from friends</td>
<td>2.95 (2.86, 2.96)</td>
<td>3.19 (3.10, 3.28)</td>
<td>2.91 (2.82, 2.99)</td>
<td>3.02 (2.93, 3.11)</td>
<td>.10</td>
</tr>
<tr>
<td>Environmental opportunities for PA</td>
<td>4.12 (4.07, 4.16)</td>
<td>4.21 (4.13, 4.30)</td>
<td>4.12 (4.07, 4.16)</td>
<td>4.21 (4.13, 4.30)</td>
<td>.08</td>
</tr>
<tr>
<td>Parental regulation TV-viewing</td>
<td>3.42 (3.35, 3.48)</td>
<td>3.37 (3.29, 3.46)</td>
<td>3.42 (3.35, 3.48)</td>
<td>3.46 (3.38, 3.54)</td>
<td>.40</td>
</tr>
<tr>
<td>Parental regulation computer/game-use</td>
<td>3.28 (3.21, 3.34)</td>
<td>3.30 (3.21, 3.34)</td>
<td>3.28 (3.21, 3.34)</td>
<td>3.34 (3.25, 3.43)</td>
<td>.68</td>
</tr>
<tr>
<td>Social inclusion at school</td>
<td>4.36 (4.31, 4.40)</td>
<td>4.33 (4.27, 4.39)</td>
<td>4.36 (4.31, 4.40)</td>
<td>4.39 (4.33, 4.47)</td>
<td>.47</td>
</tr>
</tbody>
</table>

PA = Physical activity, SB = Sedentary behavior, CI = Confidence intervals.

† Adjusted for baseline values of determinants.

One-way Ancova analyses.

Sample: Norwegian adolescents 11-13 year-olds from the HEIA study.
Compared to adolescents reporting a low intervention dose received those reporting a high dose showed significantly higher adjusted mean values on enjoyment, self-efficacy and perceived social support from teachers. Parallel dose specific post-intervention findings were observed for enjoyment, perceived social support from friends, perceived environmental opportunities for PA and for perceived social inclusion at school (Table 6).

Discussion
This study examined mid-way and post-intervention effects of a 20 month school-based obesity prevention intervention upon a wide range of determinants of PA and SB. In addition moderating effects of gender, weight status and parental education were assessed and the influence of perceived intervention dose received by the participants on the determinants was explored.

For the whole sample favorable effects on both psychological and social-environmental determinants of PA were found mid-way. However, post-intervention the effect was only sustained for social support from teachers, whereas an unexpected negative effect on self-efficacy for PA was revealed. The intervention did not affect any of the SB determinants. Moderation effects of weight status and parental education were observed, and subgroup analyses showed that the intervention did not work equally well in all subgroups. In addition, analyses of intervention dose received indicated that the effect on the determinants was influenced by the adolescents’ reported degree of exposure to and participation in the intervention.

Psychological determinants
Most of the intervention components that targeted the adolescents emphasized promoting enjoyment of PA, possibly explaining the overall positive mid-way effect on enjoyment. Our finding are consistent with the results of a 12 week long intervention among younger girls [33] and would seem encouraging given that enjoyment of PA has been shown to be of great importance for activity initiation and continued interest [34]. Moreover, enjoyment has been identified as a mediator of PA change in adolescent girls [35]. However, in accordance with results from a longer lasting intervention with a similar age group as the current one [36] no overall favorable effect on enjoyment was seen post-intervention, while a clear reduction in enjoyment was detected among the overweight. The latter result would seem troublesome, and might reflect that various intervention activities have not met with the needs of those being overweight.

Even though there was an overall marginally positive mid-way effect for self-efficacy, the subgroup analyses revealed a positive effect among the normal weight only, while there was a tendency towards a negative effect on
As self-efficacy among the overweight. Despite focusing on low threshold intervention activities, the negative mid-way trend for self-efficacy together with the reduction of enjoyment seen post-intervention among the overweight could well reflect that the overweight group has not felt at ease with these activities provided over time. Indeed, a sense of competence and feeling efficacious has been shown to be a key factor for enjoying PA [37,38]. Alternatively, social comparison processes with those being normal weight might have led to unfavorable self-perceptions and enjoyment among the overweight [39].

As to self-efficacy post-intervention, the results showed an effect in the undesired direction for the whole sample. However, this type of unexpected result has also been seen in other studies [40,41]. Due to the comprehensive nature of our intervention we cannot draw conclusion to which intervention components the effect can be attributed. However, it could well be that participants were more unaware of barriers to PA change in the first school-year of the intervention, but as the intervention moved along they might have become more aware of and realistic about barriers for PA.

| Table 5 Effects on determinants for PA and SB, by weight status and parental education level |
|---------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|
|                                | Control | Intervention | Control | Intervention |
|                                | Baseline Crude Mean SD | Baseline Crude Mean SD | p1 Adjusted Mean† 95% CI | Adjusted Mean† 95% CI | p† |
| **Mid-way**                   |         |           |         |           |         |         |         |
| Self-efficacy                  |         |           |         |           |         |         |         |
| Normal weight                  | 3.80 (0.77) | 3.80 (0.77) | 0.25 3.85 (3.75, 3.96) | 3.86 (3.76, 3.96) | .68 |
| Overweight                     | 3.70 (0.87) | 3.70 (0.87) | 0.008 3.85 (3.76, 3.95) | 3.86 (3.76, 3.95) | .01 |
| **Post-intervention**          |         |           |         |           |         |         |         |
| Enjoyment                      |         |           |         |           |         |         |         |
| Normal weight                  | 4.10 (0.77) | 4.10 (0.77) | 0.45 3.95 (3.85, 4.06) | 3.96 (3.86, 4.06) | .68 |
| Overweight                     | 4.08 (0.84) | 4.08 (0.84) | 0.06 4.02 (3.93, 4.12) | 3.98 (3.88, 4.08) | .06 |
| Social support from parents    |         |           |         |           |         |         |         |
| Low PE (>12 years)             | 2.17 (0.73) | 2.17 (0.73) | .70 2.15 (2.05, 2.25) | 2.20 (2.11, 2.29) | .09 |
| Medium PE (>13 to 16 years)    | 2.49 (0.80) | 2.49 (0.80) | .20 2.40 (2.30, 2.50) | 2.45 (2.36, 2.55) | .01 |
| High PE (>16 years)            | 2.46 (0.84) | 2.46 (0.84) | .30 2.43 (2.33, 2.53) | 2.50 (2.41, 2.60) | .09 |
| Social support from teachers   |         |           |         |           |         |         |         |
| Low PE (>12 years)             | 1.62 (0.73) | 1.62 (0.73) | .65 1.55 (1.45, 1.65) | 1.60 (1.49, 1.70) | .01 |
| Medium PE (>13 to 16 years)    | 1.73 (0.75) | 1.73 (0.75) | .48 1.69 (1.59, 1.80) | 1.74 (1.64, 1.84) | .01 |
| High PE (>16 years)            | 1.75 (0.78) | 1.75 (0.78) | <.001 1.69 (1.59, 1.80) | 1.75 (1.65, 1.85) | .01 |

PA = Physical activity, SB = Sedentary behavior, SD = Standard deviation, CI = Confidence interval, PE = parental education level.
One-way Ancova analysis,
\( n \) for Control vs. Intervention in analyses for subgroups: normal weight (737, 752 vs. 404, 417), overweight (121, 125 vs. 51, 53), low PE (262, 113 vs. 71, 71), medium PE (302, 111 vs. 178), high PE (285, 287 vs. 171).
† Adjusted for baseline values.
p1 = Independent t test, p2 = One way Ancova.
Sample: Norwegian adolescents 11-13 year-olds from the HBDA study.

Support from parents among the adolescent with medium level of parental education is not readily explainable. While one could assume that this was due to baseline differences between control and intervention group this was, however, not the case (Table 5).

To our knowledge, this is the first study to report a positive effect on perceived social support from teachers and this was observed both mid-way and post-intervention. These results are encouraging because teachers are in the position to reach most adolescents and hold the role as change facilitators in most school-based interventions. The post-intervention subgroup differences for parental education level revealed that the effect on social support from teachers was predominantly seen among adolescents with lower and higher parental education background. Most importantly, these results indicate that teachers also seem to be able to reach children with lower socio-economic status when it comes to providing support for PA, and that teacher support may be a source of social influence that holds the potential to influence the social gradient that seems to exist concerning PA among adolescents [42]. The yearly kick-off meetings for the teachers targeting the whole teacher team at each school to support the intervention might have contributed to a sense of enhanced support from teachers. At the same time low baseline values means that there was greater room for improvement in...
social support from teachers compared to many of the other determinants.

The intervention did not have an impact on determinants for SB post-intervention (perceived regulation of parental TV-viewing and computer/game-use), even though mid-way effects on TV-viewing and computer/game-use among girls have been documented previously in the HEIA study [23]. One explanation could be that the intervention targeting SB (in 7th grade only) was not extensive enough to influence the determinants of SB, since the components included only one computer tailoring session and one fact sheet to parents. No effect on perceived social inclusion at school was found either. However, all these determinants showed quite high baseline values (range 3.53–4.34, Table 3). Hence, a possible ceiling effect might also explain these post-intervention results.

In line with one other study among children [43], no effect modification by gender was found on the potential determinants. Results indicate that possible working mechanisms for PA change do not differ by gender. It also corresponds with findings for change in PA itself in children and adolescents. Van Sluijs et al. 2007 [18] concluded that most intervention studies observed no differential response by gender in PA change, and in a recent review by Cragg et al. 2011 [44] there was no consistent evidence of an association between gender and PA change among 10–13 year olds. Moderation effects of weights status on PA have been found in a previous cross-sectional study [22] and on mid-way effect on SB

### Table 6 Influence of intervention dose received on the determinant for PA and SB

<table>
<thead>
<tr>
<th>Intervention dose received</th>
<th>Crude Mean (SD) Baseline</th>
<th>p1</th>
<th>Adjusted Mean</th>
<th>95% CI</th>
<th>p2</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Mid-way</strong> (low n = 219, high n = 273)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enjoyment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.03 (0.82)</td>
<td>.12</td>
<td>4.03 (3.94, 4.12)</td>
<td>.001</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>4.13 (0.72)</td>
<td>4.22 (4.15, 4.30)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Self-efficacy</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>3.72 (0.85)</td>
<td>.001</td>
<td>3.91 (3.83, 4.00)</td>
<td>.005</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>3.97 (0.72)</td>
<td>4.07 (4.00, 4.15)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived social support from parents</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>2.30 (0.75)</td>
<td>.65</td>
<td>2.39 (2.30, 2.48)</td>
<td>.27</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>2.43 (0.77)</td>
<td>2.46 (2.38, 2.54)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perceived social support from teachers</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>1.66 (0.71)</td>
<td>.02</td>
<td>1.62 (1.53, 1.71)</td>
<td>&lt;.001</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>1.82 (0.89)</td>
<td>1.86 (1.78, 1.94)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Post-intervention</strong> (low n = 387, high n = 156)*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enjoyment</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low</td>
<td>4.03 (0.79)</td>
<td>.01</td>
<td>3.82 (3.74, 3.91)</td>
<td>.01</td>
<td></td>
</tr>
<tr>
<td>High</td>
<td>4.22 (0.67)</td>
<td>4.02 (3.89, 4.15)</td>
<td></td>
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PA = Physical activity, SB = Sedentary behavior, SD = Standard deviation, CI = Confidence interval.

*n varies slightly for the different outcomes due to the incomplete data.

† Adjusted for baseline values.

p1 = Independent t-test, p2 = One-way Ancova.

Sample: Norwegian adolescents 11-13 year-olds from the HEIA study.
in a prospective study from the HEIA study [23]. However, no other studies have, to our knowledge, explored moderating effects of weight status and parental mediation on change in determinants for PA and SB among adolescents.

Our conflicting results on some of the determinants, especially among the overweight group, point to the importance of studying subgroup differences in the response to the intervention. Change in the expected direction in a determinant (the hypothesized mediator) is supposed to precede a desired change in behavior [3]. Hence, the no-effect and negative effect detected in determinants in some of the subgroups could work against desirable behavioral effects (i.e. in PA or SB).

**Perceived intervention dose received**

The marked decrease in the proportion reporting a high intervention dose received from the mid-way (55.5%) to the post-intervention assessment (31.0%) could be one explanation for why effects were detected on several of the determinants mid-way, but not post-intervention. Furthermore, the adolescent reporting a high intervention dose received mid-way had significantly higher values on three out of four determinants than those reporting a low dose. Similar differences were found for enjoyment, social support from friends, perceived environmental opportunities for PA and perceived social inclusion at school (Table 6). This indicates that the intervention had an effect on change in these determinants among those most exposed to the intervention. However, the adolescents reporting a high intervention dose received mid-way showed significantly higher baseline values on self-efficacy and perceived social support from teachers compared to those receiving a low dose. No differences in effects between the high and low intervention dose groups were seen for perceived social support from parents and perceived parental regulation of TV-viewing and computer/game-us (Table 6). Change in these parental related determinants was primarily targeted through the fact-sheets to the parents, and parental reported degree of exposure to the fact sheets would possibly be a better indication of the influence of implementation on these determinants.

No differences in effects between the high and low intervention dose groups were seen for perceived social support from parents and perceived parental regulation of TV-viewing and computer/game-us (Table 6). Change in these parental related determinants was primarily targeted through the fact-sheets to the parents, and parental reported degree of exposure to the fact sheets would possibly be a better indication of the influence of implementation on these determinants.

However, overall the results from examining the intervention dose received suggest that the results revealing no effects in some of the outcomes in the main analyses might be due to an insufficient implementation of the intervention rather than insufficient intervention strategies. In support for this supposition, mid-way results from teacher reports of degree of implementation indicate that the overall degree of implementation was moderate [45]. It could be that the short e-mail reminders to the teachers to prompt the implementation of the various components were not sufficient to ensure a high degree of implementation over the course of the intervention.

There are both strengths and limitations to this study. The strengths include the high quality design and the theoretically based intervention in a large, long term study in a sample drawn from a region within a European country. Effects on potential determinants for both PA and SB were examined at two time points with high response rates. The analyses of moderating effects and corresponding subgroup differences added knowledge about intervention effectiveness across subgroups. As called for, the influence of perceived exposure to and participation in the intervention on the outcomes was explored. The limitations include the power analyses which were based on detecting change in PA and BMI, and not in the determinants [20]. However, the sample size of the study is larger than many previous studies including effect analyses on determinants [5,6,11]. The determinants assessed showed acceptable internal reliability at all time points and were significantly different from teacher reports of degree of implementation [22], but they might not have been sensitive enough for detecting change. The intervention was also extended to include an additional component (the computer tailoring program) in the last part. Therefore it is not possible to tease out whether the post-intervention results are related to this addition or to the intervention duration in itself. The wordings of the specific items measuring the determinants were directed towards PA and SB in general. It might have made it easier to detect intervention related changes in the determinants if they were phrased to match the intervention components more precisely since the different components were partly tailored to influence the behaviors in specific context. However, this was not possible in order to keep the questionnaire at reasonable length. While social desirability could have influenced the outcomes especially in the intervention group, the changes in the undesired direction for some of the outcomes go against such a line of reasoning. The seasonal difference between baseline (fall) and the two other data collection (spring) could also have affected the results. However, the weather conditions in Norway are quite similar for the two seasons in question and seasonal differences might be more pronounced in the actual behavior. The generalization of our findings might be somewhat weakened because a higher proportion than expected of the adolescents and parents declined to give consent. There might also be a possible attrition bias present due to the somewhat higher proportion of overweight adolescents and the lower values for perceived social inclusion.
found among those who only participated at baseline compared to several time-points. However, no differences between the control and intervention group were found among the non-responders at baseline (data not shown).

Conclusion
The HEIA intervention did positively influence both psychological and social-environmental determinants, but also negative effects were observed. Further, effects on more of the determinants were seen mid-way than at the end of the intervention. In general, the effects obtained on the determinants were modest at best, and their practical relevance might be questioned. Still, from a public health perspective, all determining factors need to change for favorable changes in factors with potential to influence PA may be important in order to inform intervention efforts at the population level.

Moderation effects and corresponding subgroup differences of both weight status and parental educational level were found. Most notably, the intervention did not seem to work equally well on change in enjoyment for the normal and overweight adolescents. More formative evaluation to better understand how to reach overweight adolescents seems needed. Finally, future research should continue to examine moderation effect of weight status on determinants of energy-balance related behaviors and examine how exposure to and participation in interventions influence intervention effectiveness.

Additional file

Additional file 1: Table S1. PA and SB intervention components and targeted determinants in the HEIA study.

Competing interests
The authors declare that they have no competing interests.

Acknowledgements
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Authors’ contributions
All authors are responsible for the reported research. IHB 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. KI K, LF A, SA, and YO were mainly involved in designing the study while M B, MG, and IHB, were mainly responsible for planning and conducting the data collections and the intervention. All authors provided critical revision of the paper, and read and approved the final manuscript.

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References


Paper III
Exploring mediators of accelerometer assessed physical activity in young adolescents in the HEalth In Adolescents study – a group randomized controlled trial

Ingunn H Bergh1*, Maartje M van Stralen2, May Grydeland3, Mona Bjelland4, Nanna Lien4, Lene F Andersen5, Sigmund A Anderssen3 and Yngvar Ommundsen1

Abstract

Background: There is a shortage of information about the factors that mediate physical activity intervention effects which involve youth. The purpose of this study was to examine whether personal, social and physical-environmental factors mediated the intervention effect on physical activity and whether gender and weight status moderated mediated effects in the Health In Adolescents Study – a school-based intervention to promote healthy weight development among young adolescents.

Methods: Participating schools were randomized to Control (n = 25) and Intervention (n = 12). The intervention components to enhance physical activity targeted change through theoretically informed mediators embedded in a social-ecological framework. Accelerometer assessed physical activity (mean count per minute) and self-efficacy, enjoyment, perceived social support from parents, teachers and friends and perceived environmental opportunities were measured by questionnaires at baseline and post-intervention after 20 months among 700 11–13 year-old adolescents (Intervention = 485; Control = 215). The product-of-coefficient test was used to examine mediation.

Results: No mediating effect of any of the hypothesized mediators was identified and gender and weight status did not moderate any mediated effects with the exception of weight status that moderated the mediated effect of enjoyment. Few intervention effects were seen on the mediators, except for a positive change in social support from teachers among girls and the normal weight, and a negative effect on enjoyment and self-efficacy among the overweight. However, change in enjoyment, self-efficacy, perceived social support from friends and environmental opportunities were associated with change in mean count per minute with some variation across the investigated subgroups, and thus show evidence of being potential mediators of physical activity change in adolescents.

Conclusions: While no mediation effects were observed, change in both personal and social-environmental factors predicted change in physical activity behavior. Hence, a social-ecological approach targeting a wide range of determinants to promote change in physical activity holds promise. Overweight and normal weight adolescents may not respond in the same way to school-based physical activity interventions. Therefore, strategies to better reach the overweight seem needed. Future studies should continue to identify mediating and moderation mechanisms in physical activity change in adolescents.

Keywords: Mediation, Adolescents, Accelerometer, Physical activity, Intervention
Background

Regular physical activity (PA) is associated with a decreased risk of health problems in all age groups [1-3]. However, initiation and maintenance of regular PA seem especially important for children in the transition from childhood into adolescence. In this period of life children go through rapid physical and psychosocial changes, and gain more autonomy and decision making power when it comes to health behaviours [4]. At the same time a marked decrease in physical activity level is seen [5,6], and many adolescents in the Western world are not sufficiently active [7]. Therefore, important health benefits can be achieved if PA is encouraged. Recent reviews show that PA in adolescents can be effectively changed through interventions [8,9], but the effects observed are small. This might be due to not targeting potentially effective mechanisms (i.e. theoretical mediating variables) that are substantially related to changes in PA [10]. Mediators are modifiable or intervening variables that specify the causal sequence between an intervention and an outcome (e.g. behaviour) [11]. By specifying mediating mechanisms, i.e. what works (i.e. effective intervention components) and what does not work (i.e. ineffective intervention components) in PA interventions, we can prompt future intervention developers to add effective intervention components and remove/adapt ineffective ones.

A recent systematic literature review aimed at examining mediators of overweight prevention interventions in youth, indicated that most publications from PA interventions containing a mediation analyses focused on the mediating effects of personal determinants (e.g. self-efficacy or intention) [12]. Mediating effects of the (perceived) social and physical-environmental factors have not been extensively examined [12]. In addition, studies using an objective measure of PA are called for because it provides a more valid measure of overall PA level in children and young adolescents for whom recall and accuracy of self-report is especially challenging [13].

Intervention effects and their mediators may not be equally effective across subgroups such as gender or groups according to initial weight status [14,15]. One intervention strategy may not cover the diverse needs of various subgroups; i.e. different subgroups may need different types or doses of intervention strategies. Thus, exploring for “whom” working mechanisms of intervention are effective or not is possible with moderation analysis of mediated effect. Moderators are variables that affect the direction and/or strength of the relation between the independent (e.g. the intervention) and the outcome [16]. Results from the HEAlth In Adolescents (HEIA) study – an intervention designed to promote healthy weight development among young adolescents – show different intervention effects on energy-related behaviours for gender and weight status. favourably results on sedentary behaviours among girls have been reported [17]. In addition, unpublished findings already show that the intervention did affect overall physical activity expressed as mean count per minute (mcpm) among girls and normal weight adolescents but not among boys and overweight adolescents (unpublished observations, Grydeland M). In addition weight status has been found to moderate effects on determinants of PA [18]. Hence, subgroup intervention and mediating effects by gender and weight status seem important to examine. By conducting a moderation analysis of mediated effect, one examines whether the mediated effect differs across levels of a moderating/grouping variable, and this may help reveal for whom an intervention program is most effective [16].

The primary aim of the present study was to examine whether changes in personal, social and physical-environmental determinants mediated the effect of change in PA behaviour in the HEIA study (Figure 1). The intervention was developed to change all the underlying constructs, and it was hypothesised that changes in these constructs would act as mediators in predicting changes in PA from baseline (BL) to post-intervention (PI). The secondary aim was to explore whether gender and weight status moderated the mediated effects of the intervention.

Methods

This study included data on a Norwegian 20 month group randomized controlled trial. The HEIA study aimed at promoting healthy weight development among 11–13 year olds through changes in PA, sedentary behaviours and dietary habits. A detailed description of the design and development has been presented previously [19]. Ethical approval and research clearance was obtained from the Regional Committees for Medical Research Ethics and the Norwegian Social Science Data Service.
Procedure and participants
Eligible schools had to have more than 40 pupils in 6th grade to participate and be located in the Eastern part of Norway. To meet the criteria the schools were recruited from the largest towns/municipalities in seven counties. Thirty-seven schools were included, and 12 schools were randomly assigned by simple drawing to the intervention group and 25 to the control group (Figure 2). All the 6th graders in these schools (n = 2165) and their parents/legal guardians were invited to participate. Of these, 1580 (73%) returned a signed parental informed consent form. The BL data were collected in 6th grade during fall 2007, the mid-way assessment at the end of 6th grade during spring 2008, and the PI assessment was administered at the end of 7th grade in spring 2009.

At BL, 1528 adolescents completed an Internet-based questionnaire at school, of which 1439 were present and willing to wear an accelerometer and of which 1129 (79%) obtained valid accelerometer data. At PI, 1418 answered the questionnaire, 1396 accelerometers were handed out, and 892 (64%) of those participants provided valid accelerometer data. Included in this paper are 700 participants (485 in Control and 215 in Intervention) that had valid accelerometer data at both BL and PI. As accelerometer data was not collected mid-way, this paper reports on the BL and PI data.

Intervention
The intervention was based on the social-ecological framework and the conceptual model of the HEIA study [19]. It was designed to increase environmental opportunities for PA at school, improve social support, self-efficacy and enjoyment in order to enhance overall level of PA. The PA components described in detail elsewhere [19] included: active commuting campaigns, sports equipment for recess activities, posters in classrooms, one class-room lesson including PA in relation to energy-balance, weekly activity breaks during lessons, 2 inspirational courses for physical education teachers presenting instructional material for PE lessons based on the SPARK Program [21], a computer tailoring program including PA behaviour, fact sheets for parents and yearly kick-off meetings for the teachers. The intervention was implemented by the school staff to increase the feasibility of dissemination of the intervention within the school system in a later phase.

Measures
PA behaviour
The purpose of PA intervention components was to influence overall PA, and therefore mcpm was selected as the outcome variable being a summary measure of total PA. Mcpm was derived from objectively measured PA assessed over 4 consecutive days with the ActiGraph GT1M and CSA model 7164 (ActiGraph, Pensacola, Florida, USA). Since outcomes on mcpm measured by model 7164 and GT1M have shown to differ [22], a free-living validation study of the monitors used in the HEIA study was conducted. As model 7164 was shown to measure 11% higher mcpm than GT1M, a correction factor of 0.9 was applied to the outcomes from model 7164 to be comparable to the GT1M outcome. Data were considered valid if a child had at least three days (including one weekend day) with at least eight hours of
activity recorded per day. The procedure for collecting, registering and preparing the data is described elsewhere [23].

**Mediators**

Six theoretically derived personal, social and physical-environmental mediators of the intervention were assessed in the electronic questionnaire based on validated measurements: Enjoyment of PA [24] (e.g. “Playing games and sports is the thing I like to do best; Cronbach’s α at BL/PI: 0.72/0.75) and self-efficacy related to barriers for PA [25,26] (e.g. I can be physically active during my free time on most days even if I have the choice to watch TV or play video games instead; α: 0.75/0.78) were both assessed with 5 items. Perceived social support from parents (e.g. How often does your mother or father encourage you to play, exercise or do sports? α: 0.70/0.72) was also assessed by 5 items, while Perceived social support from friends (e.g. How often do your friends exercise or play sports with you? α: 0.84/0.84) and Perceived social support from teachers (e.g. How often do your teachers encourage you to exercise or play sports? α: 0.78/0.68) taken from a pilot study within the European Youth Heart Study [28] were assessed by 3 items. Perceived environmental opportunities to be physically active at school and during leisure time (e.g. There are other children near my home to go out and play or physically active with; α: 0.70/0.74) was assessed by 4 items with one added item [27]. All the items for these measures were rated on a 5-point Likert scale coded 1 (“totally disagree”) to 5 (“totally agree”) except for the social support constructs which were phrased “almost never or never”, “one or two times a week”, “three to four times a week”; “almost every day”, “every day”. The computation of the composite scores and results from a separate test-retest study showing acceptable test-retest values (ICC) for these constructs are reported elsewhere [23].

**Demographic measures, puberty and anthropometrics**

Adolescents reported gender and age in the electronic questionnaire. Parental education was reported by the parents on the informed consent form and categorised into 12 years or less, between 13 and 16 years and more than 16 years. Pubertal status was assessed by gender specific versions of the paper questionnaire using the Pubertal Developments Scale (PDS) based on the Pubertal Category Score [29]. The adolescents were categorized into three groups: pre-, early-, or mid/late/post pubertal at baseline [20]. Height and weight were measured by project staff [19,20]. The body mass index cut-off values proposed by the International Obesity Task Force [30] were used to categorize the adolescents as normal weight and overweight/obese.

**Statistical analyses**

Independent T-tests and Chi-square tests were conducted to test for differences between the intervention and control group in demographics, mcpm and mediators at baseline, and to test for differences between those lost and those attained at the PI-assessment. If the intervention and control group differed in demographics, mcpm and/or mediator, this specific variable was controlled for in the statistical analysis. Analyses were performed using IBM SPSS Statistics, version 18.0. The alpha level was set at p < .05.

To account for the clustering of the data within schools, Linear Mixed Models analyses with a random intercept for two levels (school (2); individual (1)) were used to analyse the mediated effects. All analyses were adjusted for gender, weight status, parental education level, puberty at BL, and months for assessing accelerometer at BL (September-December) and PI (March-May). A few extreme outliers in the outcome variable (mcpm) were replaced with the mean value ± 3SD according to suggested procedures by Field [31]. Assumptions for regression analyses were met. All predicting variables were grand mean centred in order to decrease multicollinearity and to increase interpretation.

To assess mediating effects, the product-of-coefficient test was used [32]. This test consists of (Figure 1): (1) estimating the main effects of the intervention on changes in the outcome variable, wherein the mcpm at PI was regressed on the intervention condition and mcpm at BL (c-coefficient); (2) estimating the effect of the intervention on changes in the potential mediators (a-coefficient) by regressing the PI-values of the mediator onto the intervention condition adjusted for BL-values of the mediator; (3) estimating the independent effect of changes in the potential mediator on changes in mcpm adjusted for the intervention condition (b-coefficient) by regressing the PI-value of mcpm onto the intervention condition, BL-values of mcpm and the PI- and BL-values of the mediator; and (4) computing the product of the two coefficients (ab-coefficient), representing the mediated effect. The statistical significance of the mediated effect was estimated by dividing the product-of-coefficient by its standard error. For the calculation of the standard error the Sobel test was used \( SE_{ab} = \sqrt{\text{var}(\text{mcpm}) + b^{2}\text{var}(\text{a})} \) [33]. Since mediating effects can still exist without a significant intervention effect on the outcome [34], mediation analyses were also conducted in absence of a significant main effect.

In addition, the moderating influences of gender and weight status on the mediating effects were studied (Figure 3). For each moderator (e.g. gender), separate mediation models for the subgroups (e.g. boys and girls) were conducted, and product-of-coefficients (ab-coefficient) of both subgroups were compared. If the ab-
coefficients in each subgroup are significantly different from one another, there is significant moderation of the mediated effect. To test difference in ab-coefficients between the subgroups for statistical significance, the difference was divided by the pooled standard error (\(e_{\text{pooled}} = \sqrt{\frac{s_{\text{ab, boys}}^2 + s_{\text{ab, girls}}^2}{2}}\)).

**Results**

Table 1 shows the baseline characteristics of adolescents in the control and intervention groups. No significant differences in the distribution of the demographic variables between the control and intervention groups were found. More boys than girls (60.9% vs. 47.0%, \(p < .001\)) were found among those participating at BL only. Mcpm (mean 526.3 vs. 499.3, \(p = .007\)), enjoyment (mean 4.17 vs. 4.06, \(p = .008\)), self-efficacy (mean 3.90 vs. 3.82, \(p = .05\)) and social support from parents (mean 2.41 vs. 2.32, \(p = .03\)) were higher in those with BL data only compared to those with accelerometer data at both time-points. Among those lost to PI, mcpm were higher (mean 541.0 vs. 507.2, \(p = .04\)) in the control group compared to the intervention group, but no other differences were found.

The BL/PI wear time (min/day) for the accelerometers was for the control and intervention group 792.5/791.5 and 789.3/771.1, respectively. Table 2 shows the BL- and PI-values and the intervention effect on mcpm (1st step mediation analysis, c-coefficient). There was a borderline significant intervention effect on change in mcpm for all (\(c = 49.9; 95\% \text{ CI} (-0.4; 100.1), p = .05\)), and a significant effect among the girls (\(c = 64.7, 95\% \text{ CI} (5.1; 124.4), p = .03\)), but not for boys (\(c = 31.7, 95\% \text{ CI} (35.2; 98.6), p = .35\)). There was also a significant effect among the normal weight (\(c = 62.3, 95\% \text{ CI} (9.8; 114.8), p = .02\)), but a trend for a negative effect among the overweight adolescents (\(c = -96.1, 95\% \text{ CI} (-211.3; 19.0), p = .12\)).

Table 3 shows effect of the intervention on the mediators (2nd step mediation analysis; a-coefficient), the effect of the mediator on mcpm (3rd step mediation analysis; b-coefficient) and the mediated effects of all hypothesized mediators of the intervention effect on mcpm (4th step; \(a*b\)). The intervention was effective in changing perceived social support from the teachers (\(a = 0.12, 95\% \text{ CI} (0.02; 0.21), p = .02\)) but did not affect the other potential mediators.
Changes in enjoyment, self-efficacy and social support from friends were significantly and positively associated with change in mcpm. No relationships were found between changes in social support from parents and teachers, or environmental PA opportunities and mcpm. None of the hypothesized mediators mediated the intervention effect on mcpm.

Table 4 shows the separate mediation models by gender. Among girls, but not boys, the intervention was effective in changing social support in teachers ($a = 0.18; 95\% \text{ CI} (0.05; 0.31), \ p = .01$). In addition the b-coefficient analyses showed significant positive associations between changes in self-efficacy and environmental opportunities and changes in mcpm among girls. Change in enjoyment and social support from friends was associated with enhanced PA behaviour among boys. No significant moderation of gender on the mediated intervention effects was found, indicating that the working mechanisms of the interventions did not differ between boys and girls.

Table 5 shows the separate mediation models by weight status. Among normal weight, but not overweight adolescents, the intervention was effective in changing social support in teachers ($a = 0.13, 95\% \text{ CI} (0.03; 0.23), \ p = 0.01$). A negative intervention effect on enjoyment ($a = -0.47, 95\% \text{ CI} (-0.90; -0.04), \ p = .03$) and self-efficacy ($a = -0.63, 95\% \text{ CI} (-1.03; -0.23), \ p = 0.002$) was seen among overweight adolescents. Significant positive associations between changes in self-efficacy, social support from friends and environmental opportunities and changes in mcpm among the normal weight were found. Among the overweight, the only significant association seen was between changes in enjoyment and mcpm. Weight status did moderate the mediating effect of enjoyment, indicating that the mediating effect of enjoyment on the intervention differed among normal weight and overweight adolescents. No other mediating effects were identified in the normal weight or overweight adolescents.

**Discussion**

None of the personal, social or physical-environmental constructs targeted in the intervention were found to mediate the PA outcome (mcpm). Regarding enjoyment and self-efficacy as mediators, our findings partly contrast previous results. One the one hand, a mediation effect of enjoyment and strong evidence for a mediation effect of self-efficacy have been observed [12,35-38]. On the other hand, results from other studies support our findings for these constructs [12]. Regarding perceived social support and physical-environmental opportunities as mediators, our findings are in line with previous research which has revealed no clear evidence for mediating effects for social support or environmental measures [12]. The lack of mediation findings in this study was mainly due to the lack of intervention effects on the potential mediators. In addition, gender did not moderate any of the mediation effects of the intervention effect on mcpm, but a moderated mediation effect of weight status on enjoyment was observed.

The only mediator positively affected by the intervention was perceived social support from teachers. The subgroup analyses revealed that this effect was present in girls and normal weight adolescents only. However, since changes in teacher support were not associated with change in mcpm (non-significant b-coefficient) teacher support did not stand out as a mediator of the intervention effect. Teacher support is less studied than support from friends and parents [12], but teachers are in a position to reach most adolescents and thus may play the role of possible change facilitators in school-based interventions. Haerens et al. [38] found a positive association between teachers’ social support and school related sports activities. One explanation for the lack of

| Table 2 Physical activity (mcpm) at baseline and post-intervention and intervention effect on physical activity |
|---|---|---|---|---|---|---|
| | Baseline | Intervention | | Baseline | Intervention | |
| | Control (n = 485) | Intervention (n = 215) | p | Control (n = 485) | Intervention (n = 215) | c-coefficient |
| Mcpm | Mean (SD) | Mean (SD) | | Mean (SD) | Mean (SD) | (95% CI) | p |
| All | 510.7 (146.0) | 473.5 (145.8) | .002 | 563.8 (255.3) | 569.8 (251.6) | 49.9 (- 0.4; 100.1) | .05 |
| Girls | 478.3 (127.9) | 463.7 (151.3) | .32 | 506.3 (229.6) | 534.9 (234.4) | 64.7 (5.1; 124.4) | .03 |
| Boys | 549.1 (156.8) | 488.1 (136.7) | .002 | 631.9 (267.6) | 622.2 (268.3) | 31.7 (- 35.2; 98.6) | .35 |
| Normal weight | 517.2 (142.5) | 482.4 (145.9) | .007 | 564.7 (251.7) | 584.5 (248.5) | 62.3 (9.8; 114.8) | .02 |
| Overweight | 468.2 (160.0) | 406.2 (114.8) | .08 | 566.3 (282.5) | 431.9 (173.0) | - 96.1 (- 211.3; 19.0) | .12 |

Mcpm = mean count per minute. Analyses were adjusted for school clustering, gender, pubertal status, months for measuring physical activity, weight category and parental education. Significant results in bold.
<table>
<thead>
<tr>
<th>Mediators</th>
<th>Baseline</th>
<th>Intervention</th>
<th>Mediation analyses</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control (n = 475-480)</td>
<td>Intervention (n = 210-215)</td>
<td>Control (n = 483-485)</td>
<td>Intervention (n = 210-215)</td>
</tr>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>p</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Enjoyment</td>
<td>4.09 (0.78)</td>
<td>4.01 (0.76)</td>
<td>.21</td>
<td>3.97 (0.82)</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>3.81 (0.77)</td>
<td>3.83 (0.75)</td>
<td>.70</td>
<td>3.84 (0.83)</td>
</tr>
<tr>
<td>Social support friends</td>
<td>2.92 (1.00)</td>
<td>2.86 (1.07)</td>
<td>.47</td>
<td>2.73 (1.00)</td>
</tr>
<tr>
<td>Social support parents</td>
<td>2.30 (0.78)</td>
<td>2.37 (0.76)</td>
<td>.34</td>
<td>2.23 (0.80)</td>
</tr>
<tr>
<td>Social support teachers</td>
<td>1.67 (0.72)</td>
<td>1.79 (0.83)</td>
<td>.08</td>
<td>1.43 (0.57)</td>
</tr>
<tr>
<td>Environmental opportunities</td>
<td>4.22 (0.80)</td>
<td>4.26 (0.82)</td>
<td>.54</td>
<td>4.08 (0.89)</td>
</tr>
</tbody>
</table>

Mcpm = mean count per minute.
Baseline differences between the potential mediators were tested with independent t-test.
Significant results in bold.
significant association between teacher support and PA in our study could be that the objectively assessed overall PA, which covers both within school and out-of school activity, has deflated the effect of teacher support.

Among overweight adolescents, we found a negative intervention effect on enjoyment and self-efficacy. This is in line with previous mid-way assessment results and indicates that the intervention activities did not meet the needs of those who are overweight [18]. Despite our focus on changing behaviours and not weight status, the children were aware of the main purpose of the intervention (to promote a healthy weight development). Hence, overweight adolescents may have felt uncomfortable during the intervention, which eventually could have led to a psychological reactance reducing their enjoyment and self-efficacy for PA [39]. Alternatively, social comparison processes between normal weight and overweight adolescents might have led to unfavorable self-perceptions and stigmatization [40,41]. However, the negative impact on self-efficacy may also reflect a more realistic interpretation of barriers to PA among the overweight prompted by the intervention.

The non-significant intervention effect on the other mediators (social support from friends and parents, perceived environmental opportunities) and PA can have several explanations. First, ineffective intervention strategies and/or insufficient implementation of those strategies may explain the limited effect on the potential mediators in general. Previous process evaluation in a larger sample showed that only 31% of the adolescents reported being exposed to/participated to a high degree in the PA intervention components in the last school year [18]. The same result was observed in the current sample (data not shown). Both the length of the intervention and the responsibility given to teachers in implementing the intervention could have led to great variation in implementation quality between the schools, and could probably partly explain the limited effects on both the mediators and the outcome.

Second, a possible mismatch could have existed between the specific intervention strategies and potential mediators they were meant to target. Generally, the intervention components were developed to facilitate active play at schools, active transport to and from schools and more daily-living PA. Several of these PA behaviours might represent more or less habitual forms of activity and are thus likely to be automatized and facilitated by environmental and situational cues [42] rather than by changes in cognitions such as self-efficacy and social support. Self-efficacy and social support might be constructs that are better able to predict conscious- and intention driven activities such as typical sport activities.

Third, the limited effect on the mediator could also be explained by relatively high BL values in several of the constructs (Table 3) and/or an insensitivity of the measurement instruments to detect change. The mediator measures were directed towards PA in general. By phrasing the items towards the specific contexts targeted, they might have been more sensitive to change. This, however, would have extended the length of our questionnaire, thus causing a threat to the overall validity. It could also well be that an intervention by measurement effect may have occurred [34], meaning that the intervention affected the response to the items making it less likely to detect an effect.
## Table 5 Effect on mediators, effect of mediators on mcpm, mediated effect and moderated mediation of weight-status

<table>
<thead>
<tr>
<th>Mediator</th>
<th>Weight status</th>
<th>Intervention p</th>
<th>Effect mediator on mcpm p</th>
<th>Mediated effect ab (95% CI) p</th>
<th>Moderated mediation p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Enjoyment</td>
<td>Normal weight</td>
<td>-0.01 (-0.17; 0.16)</td>
<td>.94</td>
<td>24.40 (-0.15; 48.94)</td>
<td>.05</td>
</tr>
<tr>
<td></td>
<td>Overweight</td>
<td>-0.47 (-0.90; -0.04)</td>
<td>.03</td>
<td>97.65 (35.34; 159.95)</td>
<td>.003</td>
</tr>
<tr>
<td>Self-efficacy</td>
<td>Normal weight</td>
<td>-0.09 (-0.26; 0.08)</td>
<td>.30</td>
<td>24.73 (21.25; 72.22)</td>
<td>&lt;.000</td>
</tr>
<tr>
<td></td>
<td>Overweight</td>
<td>-0.63 (1.03; -0.23)</td>
<td>.002</td>
<td>5.97 (-5.87; 66.80)</td>
<td>.85</td>
</tr>
<tr>
<td>Social support friends</td>
<td>Normal weight</td>
<td>-0.01 (-0.16; 0.14)</td>
<td>.90</td>
<td>45.23 (23.47; 66.98)</td>
<td>&lt;.000</td>
</tr>
<tr>
<td></td>
<td>Overweight</td>
<td>-0.15 (-0.67; 0.36)</td>
<td>.54</td>
<td>26.68 (24.53; 77.88)</td>
<td>.30</td>
</tr>
<tr>
<td>Social support parents</td>
<td>Normal weight</td>
<td>-0.03 (-0.06; 0.10)</td>
<td>.70</td>
<td>0.70 (-22.11; 36.10)</td>
<td>.64</td>
</tr>
<tr>
<td></td>
<td>Overweight</td>
<td>-0.03 (-0.36; 0.31)</td>
<td>.88</td>
<td>23.61 (-51.40; 98.63)</td>
<td>.53</td>
</tr>
<tr>
<td>Social support teachers</td>
<td>Normal weight</td>
<td>0.13 (0.03; 0.23)</td>
<td>.01</td>
<td>-9.21 (-43.49; 25.27)</td>
<td>.60</td>
</tr>
<tr>
<td></td>
<td>Overweight</td>
<td>0.12 (0.19; 0.43)</td>
<td>.43</td>
<td>43.32 (-4.41; 128.05)</td>
<td>.31</td>
</tr>
<tr>
<td>Environmental opportunities</td>
<td>Normal weight</td>
<td>0.11 (-0.06; 0.29)</td>
<td>.19</td>
<td>24.75 (1.62; 47.87)</td>
<td>.04</td>
</tr>
<tr>
<td></td>
<td>Overweight</td>
<td>0.10 (-0.35; 0.56)</td>
<td>.65</td>
<td>-24.56 (-79.42; 30.30)</td>
<td>.38</td>
</tr>
</tbody>
</table>

Mcpm = mean count per minute.
Significant result in bold.

http://www.biomedcentral.com/1471-2458/12/814
Despite a limited effect on the potential mediators, changes in personal, social and physical environmental determinants were associated with changes in PA with differences among gender and weight status groups. Self-efficacy (girls and normal weight only), perceived environmental opportunities (girls only), social support from friends (boys and normal weight only) and enjoyment (boys and overweight only) were associated with PA change. Hence, these factors hold potential to be included in future interventions. The findings add support to previous studies in which a change in enjoyment and self-efficacy has been found to be positively related to self-reported PA in intervention studies [35-37,43]. Social support from friends has been shown to mediate accelerometer assessed moderate-to-vigorous PA in girls [44], and our results indicate that it might be a relevant mediator for boys as well. The result for perceived environmental opportunities shows that the environment does play a role, and the mediating role of environmental factors on adolescents’ PA seems important to examine further.

Strengths and limitations
This study has both strengths and limitations. In addition to the randomized controlled design, the intervention was theoretically informed and included mediators representing both the social and physical environmental domains as well as the personal domain. All the mediators showed acceptable internal consistency. Moderated mechanisms were explored and PA was assessed objectively in a sample of adolescents that was younger than previously examined [12]. However, accelerometers assessed PA are not able to capture water activities, record cycling, upper body movements, carrying a load correctly or detect context specific changes in PA, and using logs in addition to accelerometers could have compensated for these drawbacks [45,46]. The larger than expected drop-out [19], could have caused a loss of power and may have influenced the results, especially among the overweight. There exists several sets of BMI reference data that are intended to define childhood overweight [47]. Therefore, we cannot rule out the possibility that the results for the moderated mediation of weight status might have been slightly different applying for example the cut off values for the World Health Organizations’ growth curves or the Center for Disease Control. Still, within the HEIA study we choose to use the IOTF’s criteria for defining overweight/obesity to allow for comparing prevalence data across nations [47,48].

In conclusion, no mediated effects on PA change through the mediators could be observed. This was mainly due to the lack of intervention effect upon most of the hypothesized mediators, even though the HEIA intervention did have a borderline significant effect on mcppm in the total sample, and a significant effect was seen among girls and normal weight adolescents (unpublished observations, Grydeland M). Both personal, social and physical-environmental factors were identified as potential mediators of objectively measured PA, and the results indicate that enjoyment and self-efficacy, social support from friends and perceived environmental opportunities seem worthwhile to target in future interventions. However, unfavourable results of the intervention were revealed for the overweight group.

Further mediation analyses of PA change among adolescents based on a social-ecological framework including a broad based set of mediators seem warranted. Strategies better able to affect mediators and efforts to secure sufficient strength of the implementation should be emphasized. This would make it more likely to obtain changes in the mediators and, consequently, to detect a relationship between change in the mediators and change in PA. When developing prevention studies targeting energy-related behaviours it seems necessary to include strategies tailored to gender and weight status.

Abbreviations
PA: Physical activity; Mcpm: Mean count per minute; BL: Baseline; PI: Post intervention.

Competing interests
The authors declare that they have no competing interests.

Authors’ contribution
IHB conducted the statistical analyses assisted by MM van S, wrote the first draft of the manuscript and made the greatest contribution to the paper. MG, MR, NL, LFA, SA and YO participated in designing the study, project planning and data collection. All authors have critically revised the manuscript, and read and approved the final version of the manuscript.

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References


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Paper IV
Title
Post-intervention effects on screen behaviours and mediating effect of parental regulation: the HEalth In Adolescents study – a multi-component school-based randomized controlled trial

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Key words: sedentary behaviour, obesity prevention, intervention, mediation, moderation, adolescents
Abstract

Background: To improve effectiveness of future screen behaviour interventions, one needs to know whether an intervention works via the proposed mediating mechanisms and whether the intervention is equally effective among subgroups. Parental regulation is identified as a consistent correlate of screen behaviours, but prospective evidence as well as the mediation role of parental regulation is largely lacking. This study investigated post-intervention main effects on screen behaviours in the HEIA-intervention – a school-based multiple-behaviour study, as well as the mediation effects of parental regulation by adolescents’ and parents’ report. In addition, moderating effects of gender and weight status on the intervention and mediating effects were explored.

Methods: Participating schools were randomized to Control (n=25) or Intervention (n=12) condition. Adolescents (n= 908 Control; 510 Intervention) self-reported their weekday and weekend TV-viewing and computer/game-use. Adolescents, mothers (n=591 Control; 244 Interventions) and fathers (n=469 Control; 199 Intervention) reported parental regulation of the screen behaviours post-intervention (at 20 month). The product-of-coefficient test using linear regression analysis was conducted to examine main and mediating effects.

Results: There was no intervention effect on the screen behaviours in the total sample. Gender moderated effect on weekend computer/game-use, while weight status moderated the effect on weekday TV-viewing and computer/game-use. Stratified analyses showed a favourable intervention effect on weekday TV-viewing among the normal weight. Parental regulation did not mediate change in the screen behaviours. However, stronger parental regulation was associated with less TV-viewing and computer/game-use with effects being conditional on adolescents’ versus parental reports. Parental regulation of the screen behaviours, primarily by the parental report, was associated with change in the respective behaviours.
**Conclusion:** Multiple behaviour intervention can produce modest effect on TV-viewing but may not affect all equally well. Effects of screen time behaviour intervention may differ by both gender and weight status. In future interventions parents should be encouraged to regulate their adolescents’ TV-viewing and computer/game-use on both weekdays and weekends as parental regulation was identified as a determinant of these screen behaviours. However, future intervention studies may need to search for more effective intervention strategies targeting parental regulation.
Background

Overweight and obesity among children and adolescents are associated with adverse physical and psychosocial health consequences [1,2]. The high prevalence rates of both overweight/obesity and the unhealthy energy-balance related risk behaviour (diet, physical activity and sedentary behaviours) among young European adolescents calls for effective interventions [3]. Interventions targeting diet and physical activity have shown positive effects on BMI in children and adolescents [4], and a recent meta-analysis show that reducing time spent on screen behaviours as a part of multiple behaviour interventions can affect BMI in young people [5].

Overall sedentary time, as well as time spent in front of electronic screens such as TV and computers are associated with other unhealthy behaviours (e.g. snacking, smoking and alcohol use), poorer socio-cognitive development and unfavourable physical health outcomes including higher body fatness in youth [6-9]. Adolescents engage in a variety of sedentary pursuits, but TV-viewing and computer-use (e.g. playing games, surfing on the internet, social media-use) contribute to a major portion of the time young people spend being sedentary [10,11]. In addition, screen behaviours are established quite early in life, and seem relatively stable over time [12,13].

Interventions to reduce screen behaviours have primarily focused on TV-viewing and have to a great extent been implemented as part of multiple behaviours interventions [9,14]. Meta-analyses show that interventions to reduce screen time can be effective, but effects are small [15,16]. The effect of recent multiple behaviour interventions on TV-viewing are however mixed with some studies showing an effect [17], some revealing an unexpected effect [18] or studies showing an effect among subgroups only [19,20].
Behaviours can be changed by interventions targeting modifiable factors associated with the behaviours, the so called mediators [21]. Knowledge about how to optimise effects of interventions targeting screen behaviour has been called for [15], but to improve effectiveness one needs to know whether an intervention works via the proposed mechanisms, by conducting mediation analysis [22].

Up till now most studies exploring mediators of intervention effects have focused on personal mediators [23]. Emerging evidence, however, shows that health behaviours in youth are highly influenced by environmental factors, and home environmental factors in particular [23]. Parental rules and regulation on screen time have been identified as one of few consistent modifiable correlates of children’s and adolescents’ screen behaviours [24-29]. However, prospective evidence of determinants of screen time behaviours is lacking [30]. Also, just a couple of studies have examined potential mediators of screen behaviour change, and none have to our knowledge investigated mediated effects of home environmental variables factors like parental regulation on changes in screen behaviours [23].

However, one type of intervention may not affect all equally well, and intervention effects and their mediators may not be equally effective across subgroups [31]. In the HEIA-study – a multi components school-based obesity prevention intervention, we have previously reported mid-way effects (after eight months) on screen behaviours in girls but not in boys, while weight status moderated effect on computer/game-use among boys [32]. Hence, by examining whether intervention effects on screen behaviours are moderated by gender and weight status and whether gender and weight status moderate the mediators, it is possible to identify for
whom an intervention is most (in) effective as well as whether mechanism of change differ by these subgroups.

The aims of the present study were: 1) to examine the effects of HEIA intervention on screen behaviours (TV/DVD-viewing and computer/game-use) post-intervention; 2) to assess whether parental regulation of TV-viewing and computer/game-use (as perceived by the adolescents and reported by mother and fathers) mediated intervention effects on screen behaviours and 3) to explore whether gender and weight status moderated the intervention and mediated effects.

**Methods**

The HEIA study was a Norwegian 20 month randomized controlled school-based trial among 11-13 year-olds. A healthy weight development was promoted through targeting changes in physical activity, screen- and dietary behaviours. This paper focuses on screen behaviours only. The intervention intervened on determinants framed within a social-ecological approach as described in the conceptual model of the HEIA-study. A detailed description of the design and the development of the study are presented previously [33].

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

**Procedure and Participants**

Schools were recruited from town/municipalities in seven counties in the south-eastern part of Norway. For logistic reasons schools had to have at least 40 pupils enrolled in 6th grade. Thirty seven schools out of 177 eligible schools accepted the invitation, and 12 schools were
randomly assigned by simple drawing to the intervention group and 25 to the control group (Figure 1). All the 6\textsuperscript{th} graders in these schools (n=2165) and their parents/legal guardians (hereafter called parents) were invited to participate. Of these, 1580 returned a signed, parental informed consent form for the adolescents.

(FIGURE 1 ABOUT HERE)

Baseline data were collected during four weeks in September 2007 in 6\textsuperscript{th} grade and post-intervention data at the end of 7\textsuperscript{th} grade in May 2009. Adolescents (n=1418: 908 Control; 510 Intervention) and their parents, both mothers (n=835) and fathers (n=668) who participated at both baseline and post-intervention are included in the analyses (Figure 1).

**Intervention**

Individual-, group-, and environmental strategies and component were implemented during the intervention. Each school year the intervention was initiated by a kick-off meeting with the teachers at the involved grade level at each school to ensure that the whole team of teachers knew the rationale of and was familiar with the various intervention components to be implemented. During the school year the participating teachers received external support in the form of short monthly e-mail reminders from the HEIA-study group.

Intervention components targeting primarily diet and physical activity behaviour were continuously implemented across 6\textsuperscript{th} and 7\textsuperscript{th} grade. During 7\textsuperscript{th} grade intervention components comprised some slight variation in format and content to capture continued interest from both teachers and adolescents. In addition a computer-tailoring program was added in 7\textsuperscript{th} grade which included one session specifically targeting screen behaviours (plus one session
targeting physical activity and two sessions targeting dietary behaviours). The computer tailoring was implemented during school hours and each session took about 15 minutes to complete. After completing the screen behaviour session in which the adolescents answered questions about their own screen behaviours, each adolescent received a personal tailored feedback letter with specific suggestions for what to change (or not) and with suggestions on how to change their own TV-viewing and computer/game-use. In addition, two of eight parental fact sheets in 7th grade, included focus on screen behaviours. The first of these facts sheets informed about the targeted behaviours of the intervention in 7th grade (including screen behaviours). The theme for the other fact sheet was: “TV-viewing – the most common leisure time activity among Norwegian children/adolescents”. The specific targeted determinant in this fact sheet was parental regulation of TV-viewing and computer/game-use. This sheet was meant to be delivered to the parents by the adolescents after the completion of the computer tailoring session about screen behaviours. All components of the intervention and targeted determinants are described in detail elsewhere [33,34].

Measures and procedures
The adolescents’ self-reported age, gender, potential mediators (parental regulation of TV-viewing and computer/game-use) and screen behaviours in an internet-based questionnaire which took about 45 min to complete, and participated in measurements of anthropometric parameters at baseline and post-intervention. Parental paper and pencil questionnaires were brought home to the parents by the adolescents and returned to the teachers in a sealed envelope which were collected from the school by project staff. Parental education was reported by the parents on the informed consent and categorized into 12 years or less, between 13 and 16 years and more than 16 years. The parent with the longest education was used for the adolescents’ parental educational background, or else the one available.
Adolescents’ screen behaviours

Two questions assessed the hours spent watching TV (including DVDs) during a regular weekday and weekend day on a six-point scale ranging from 0.5 hours to 5 hours, and two questions assessed the number of hours spent on the computer, playing TV-games or other electronic games on a regular weekday and a weekend day on a six-point scale ranging from 0 hours to 4 hours.

Mediators

The adolescents reported two mediators of screen behaviour both assessed by four items using a 5-point Likert scale (1 “totally disagree” to 5 “totally agree”) based on Hardy et al. [35]:

Perceived parental regulation of TV-viewing (e.g. “My mother and father try to make sure I do not watch too much TV“; Cronbach’s alpha (α) at baseline/post-intervention of three items: 0.62/0.73) and Perceived parental regulation of computer/game-use (e.g. “My mother and father try to make sure that I do not use the computer and play games too much”; α at baseline/post-intervention of three items: 0.67/0.74)

The mothers and fathers also reported two (corresponding) potential mediators of the adolescents TV and computer/electronic game-use; Parental regulation of TV-viewing with six items using a 5-point Likert scale (e.g. “I permit my child to watch the TV programmes he/she wants to”; α at baseline/post-intervention of five items: 0.68/0.63 reported by mothers, 0.69/0.69 by fathers) and Parental regulation of computer/game-use with four items using a 5-point Likert scale (e.g. “I restrict how much time my child spend using the computer for playing games and so on”; α at baseline/post-intervention: 0.76/0.75 reported by mothers, 0.74/0.74 by fathers), based on Hardy et al. [35].
A separate test-retest study was conducted prior to the main study: adolescents (n=114), mothers (n=44) and fathers (n=35). The adolescents’ screen behaviours and perceived parental regulation of TV-viewing and computer/game-use, and parents reports of regulation of TV-viewing and computer/game-use showed either moderate, good or excellent test-retest results (ICC=0.43-0.84).

Differences in associations of parents’ and adolescents’ reports of regulation with adolescents’ TV-viewing and computer usage have been found [25]. Hence, to avoid limitations related to using only adolescents’ proxy report of parents behaviours (regulation) [36], both adolescents’ and parents’ report of screen behaviour regulation were investigated.

**Anthropometrics**

Height and weight of the adolescents were measured by project staff [33]. The baseline values were used to categorize the adolescents as normal weight and overweight/obese using the body mass index cut-offs values proposed by the International Obesity Task Force [37].

**Statistical analyses**

Independent t-tests and chi-square tests were conducted to test for differences between the intervention and control group in demographics, screen behaviours and mediators at baseline for adolescents and parents, and in the attrition analyses.

As school clustering effects explained only between 1.7-2.1% of the unexplained variance in the screen behaviours, all analyses were done without adjusting for the school clustering [38]. The product-of-coefficient test using linear regression was conducted to examine main
and mediating effects [39] applying the script by Preacher & Hayes [40]. This test consists of:

1) estimating the main effect of the intervention on the four screen behaviours (c-coefficient);
2) estimating the effect of the intervention on changes in the potential mediators (a-coefficient);
3) estimating the independent effect of changes in the potential mediators on change in the screen behaviours adjusted for the intervention condition (b-coefficient); and (4) computing the product of the two coefficients (a*b), representing the mediated effect. The confidence interval of the mediated effect was calculated using bootstrapping with 1000 resamples of the data. Since mediating effects can still exist without a significant intervention effect on the outcome [41], mediation analyses were also conducted in its absence.

Secondly, in separate analyses the moderating influences of gender and weight status on the main effects were studied by linear regression models including the relevant interaction terms (e.g. intervention*gender). When significant moderating influences were revealed, subgroup analyses based on the moderator (girls vs. boys) and/or weight status (normal vs. overweight) were carried out for the main and mediated effects, using the same product-of-coefficient test based applying the script by Preacher and Hayes [40].

Thirdly, the moderating influences of gender and/or weight status on the mediating effects were studied (Figure 2) by conducting the separate mediation model method. In this method, the ab-coefficients for the groups (normal weight vs. overweight) are compared (e.g. a*bboys – a*bgirls) and if they were significantly different from each other, it indicates a significant moderation of the mediated effect. To test difference in ab-coefficients between the subgroups for statistical significance, the difference was divided by the pooled standard error (e.g. 

\[ s_{pooled} = \sqrt{\left(s_{ab_{normal\ weight}}^2 + s_{ab_{overweight}}^2\right)} \] [42].
To control for potential effects of covariates, all analyses on TV-viewing were adjusted for parental education level and weight status, and all analyses on computer/game-use were adjusted for parental education level, weight status and gender. Analyses were performed using IBM SPSS Statistics, version 18.0. The alpha level was set at \( p < .05 \), except for the moderation test where \( p < .10 \) was used [31,43].

**Results**

**Baseline characteristics**

No significant baseline differences between the control and intervention group were found for the demographic variables or the screen behaviours (Table 1 and 2).

TABLE 1 ABOUT HERE

The attrition analyses showed no differences between adolescents who participated twice (n=1418) and those participating at baseline only (n=110) for baseline values for the screen behaviours, the mediators (parental regulation), the gender distribution, age or parental education. However, a higher number of overweight adolescents were found among those participating at baseline only (22.9% vs. 13.4%, \( p=0.01 \)). Among those lost to post-intervention, no differences between control and intervention group were found (data not shown).
In the subsample containing parents and adolescents weekday TV-viewing was significantly higher among those adolescents with mothers (1.5 vs. 1.4, \(p=.03\)) and fathers (1.5 vs. 1.4, \(p=.007\)) participating at baseline only (n mothers=831; n fathers=746) vs. both time-points (n mothers=579, n fathers = 664), and weekday computer/game-use was significantly higher among those adolescents with fathers (1.2 vs. 1.0, \(p=0.02\)) participating at baseline only (n=744) vs. both time-points (n=665) (data not shown).

**Intervention effect on screen behaviours**

The results of the main effect analyses on the screen behaviours are shown in Table 2. There were no main effects seen in the total sample. However, weight status moderated the effect on weekdays TV-viewing \((p=.04)\) and on computer/game-use \((p=.08)\), and gender moderated the effect on weekend computer/game-use \((p=.09)\). The following stratified analyses (Table 2) revealed an effect on weekday TV-viewing \(c=-0.12; 95\% \text{ CI } (-0.24, -0.01); p=.04)\).

**(TABLE 2 ABOUT HERE)**

Table 3 shows the baseline and post-intervention values of the investigated mediators. Mothers’ and fathers’ reports of regulation of TV-viewing and fathers’ report of regulation of computer/game-use were significantly higher in the intervention group, but baseline values were adjusted for in all analyses.

**(TABLE 3 ABOUT HERE)**

**Mediated effect**
Table 4 shows effect of the intervention on the mediators (parental regulation), the effect of the mediator on the screen behaviours, and the mediated effects of all hypothesized mediators of the intervention effect on the screen behaviours reported by the adolescents, and the mothers and the fathers respectively in the total sample. The intervention did not affect parental regulation (a-coefficients) neither when reported by the adolescents themselves or by any of the parents.

Changes in adolescents’ perception of parental regulation of TV-viewing and computer/game-use were not associated with change in any of the corresponding screen behaviours. However, more regulation of TV-viewing by mothers’ reports was associated with less weekday TV-viewing ($b=-0.17$; (CI=$-0.29$, $0.06$), $p<.01$) and weekend TV-viewing ($b=-0.16$; (CI=$-0.30$, $-0.02$); $p<.05$). Enhanced regulation of computer/game-use by both mothers’ ($b=-0.17$; (CI=$-0.27$, $-0.07$); $p<.001$) and fathers’ ($b=-0.14$; (CI=$-0.24$, $-0.04$); $p<.01$) reports were associated with less weekday computer/game-use. None of the hypothesized mediators reported by the adolescents or the parents mediated the intervention effect on any of the behaviours.

**Moderation of gender on mediated effect on weekend computer/game-use one**

Table 5 shows the separate mediation models by gender for weekend computer/game-use. There were no intervention effects on change in parental regulation indices among girls or boys neither when reported by the adolescents nor by their parents, and parental regulation of computer/game-use were not associated with change in computer/game-use on weekends. No mediation effect in girls or boys or moderation effects of gender on the mediated intervention effects were found.
**Moderation of weight status on mediated effect on weekday TV and computer/game-use**

Table 6 shows the separate mediation models by weight status for weekday TV-viewing and computer/game-use. There were no intervention effects on change in parental regulation indices among normal weight or overweight adolescents neither when reported by the adolescents nor their parents.

**Discussion**

**Main and moderated effects on the screen behaviours**
There was no main effect on any of the screen behaviours in the whole sample, but moderation effects of gender and weight status were revealed. The stratified follow-up analyses showed a significant effect among the normal weight (comprising 84% of the sample) on weekday TV-viewing. TV-viewing has been forwarded as the most important screen behaviour when it comes to prevention of overweight probably due to TV-viewings’ association with caloric intake (snacking) [44]. Nevertheless, the mid-way assessment (at 8 months) showed effect on both TV-viewing and computer/game-use, but in girls only [32]. In addition, the magnitude of the effect on daily weekday TV-viewing in this study (about 7 min/day) is less than the largest effect observed at the mid-way assessment (about 18 min/day) [32]. However, a reduction in effect as the intervention moves along is in line with the review by Kamath et al. [14] showing larger in-treatment effects than post-treatment effects of intervention targeting screen behaviours. Still, small effects for behaviours that are common in a large part of a population, as is the case for TV-viewing among youth, may be important at the population level [15].

The effect on TV-viewing may also have contributed to the favourable post-intervention effects observed in the HEIA-study for total sedentary time (22 min in girls) [45]. In addition, the effect on TV-viewing could possibly have been caused by a displacement of TV-viewing with physical activity since a post-intervention effect on overall physical activity among the normal weight has been observed [45]. These effects taken together could contribute to a change in the energy-balance that might be of importance in obesity prevention. Indeed, a small effect on BMI has also been observed among girls in the HEIA study (Grydeland et al, unpublished observations). However, both this study and the other findings from the HEIA-study, support reviews pointing out that energy-balance related behaviour interventions may not reach all equally well and effects may vary by gender and weigh status [4,31].
In addition, the intervention effect on weekday TV-viewing among the normal weight, together with the tendency (non-significant) for an effect in the undesired direction among the overweight (Table 2) may explain the apparent non-effect in the total sample. This is in line with the supposition by Kamath et al. [14] that variation in results could stem from studies with both normal weight and overweight compared to intervention with only normal weight. It is also discussed that prevention of excessive weight in those who are not yet overweight may be more effective than targeting mixed groups [46]. However, we can only speculate why the overweight did not respond to the intervention as intended. It might be that they lack alternatives to screen entertainment, or respond with a sort of reactance (by becoming more sedentary) when confronted with initiatives to reduce TV-viewing [47]. Indeed, unexpected results among the overweight group have also been seen previously in the HEIA-study. An unbeneficial effect on enjoyment of physical activity among the overweight has been reported [34]. At the same time there was no effect on accelerometer assessed physical activity among the overweight, but rather a tendency for an unfavourable effect in this group [45].

**Mediating effects and moderated mediating effects**

In line with previous mediating studies of screen behaviours change, lack of mediated effects, were mainly due to the lack of intervention effect on the potential mediators [23]. Ineffective strategies or too low intervention dosage received may explain this. The parental fact sheet targeted parental regulation might not have been powerful enough to create an impact on the potential mediators. In addition, the relatively high baseline values of the parental regulation constructs (mean: 3.53–4.20, Table 3) both by adolescents’ and parents’ reports may have led to ceiling effects, and it may also be that the measures were not sensitive enough to detect
change. No mediation effect on screen behaviours have been identified by other previously examined potential mediators either [48-50].

Although parental regulation was not affected by the intervention, changes in parental regulation of both TV-viewing and computer/game-use were associated with changes in the respective behaviours in the expected direction (b-coefficient analyses, Table 4 and 6) with some differences among the subgroups. This is an important finding, providing prospective evidence for increase in parental regulation predicting reduction in screen behaviours.

Interestingly, mothers’ reports of regulation of screen behaviours were more often associated with reduction in the screen behaviours than fathers’ reports, which may mean that mothers are more involved in trying to regulate the adolescents’ TV-viewing and computer/game-use. However, both parents’ reports of regulation were more often found to be associated with change in the screen behaviours than adolescents’ perceived regulation of these behaviours. This difference may be due to young adolescents having difficulties recalling accurately or and/or parents being prone to a social desirability response bias. Another reason could be that parents and adolescents differ in their perception about parental practices. In addition, the wording of the regulation measures was a bit more specifically phrased to the parents compared to the adolescents, which could have influenced the results. However, it seems important to assess, include and describe reports by both parents (mothers and fathers) and children/adolescents, when assessing parental regulation of screen behaviours. In addition both mothers and fathers should be encouraged to regulate their adolescents screen behaviours. Change in parental regulation was primarily found to be associated with change in weekday screen behaviours (except for mothers’ reports of regulation of weekend TV-viewing) which is in line with recent cross-sectional findings for restriction on sedentary
behaviour [51]. Hence, interventions need to stimulate parents to regulate TV-viewing and
computer/game-use on weekends also.

The intervention did not affect mother’s regulation of TV-viewing either among the normal
weight or overweight adolescents, and no complete mediation effects were seen on change in
weekday TV-viewing in either group. Still, we found a moderated mediating effect of weight
status on mothers’ parental regulation on weekday TV-viewing (Table 6, ∆ab-coefficient).
This result indicates that the mediating mechanisms of mothers’ parental regulation of TV-
viewing weekday differed between normal weight and overweight adolescents. The stronger
influence of mother’s regulation on TV-viewing among the overweight (Table 6, b-
coefficient) may partly explain the result, which may also indicate that mothers’ parental
regulation is a more influential determinant among overweight adolescents.

**Strength and limitations**

This was a randomized controlled, long term intervention study including a relative large
sample size with high retention rate for the adolescents. To our knowledge this is the first
intervention study to investigate whether change in parental regulation, using both parents’
and adolescents’ reports, mediated young adolescents’ screen behaviours. Furthermore, main
and mediated effects on both TV-viewing and computer/game-use were investigated, in
addition to moderating effect of gender and weight status on the main effects on the screen
behaviours and on the mediation mechanisms. Few studies have up to now included data from
both mother and fathers, but this study explored mediation of parental regulation reported by
both parents.
Both the internal consistency and the test-retest results (ICC) of the parental regulation measures were acceptable. However, the measures were phrased in a general format and did not differentiate between regulation on weekday and weekend as the report of screen behaviours did. A more context specific phrasing of the investigated mediators could possibly have improved their sensitivity to measure change. No differences for the screen behaviours were seen between those adolescents providing data at both time points and those lost to post-intervention. However, not all parents of participating adolescents did answer the parental survey, and the attrition analyses for the adolescents with parental data show that parents who did provide data at both time points were parents of adolescents having slightly more favourable screen behaviours than those adolescents with parents who were lost to post-intervention. So the parents included and retained in the study may be a biased subsample.

Other limitations include the single items used to measure TV-viewing and computer/game-use, which gives only crude estimates [52]. However, the test-retest results (ICC) for these outcomes were moderate to high. While social desirability may have led to an under-reporting of the screen behaviours and a possible over-reporting of the potential mediators, descriptive results do not support this supposition given higher post-intervention values for the screen behaviours and lower post-intervention values of the mediators in both conditions (Table 2 and 3). However, adolescents lost to post-intervention assessment were more likely to be overweight, which may indicate that the proportion of overweight may be somewhat lower in this sample than the population it represents. All the same, there were no differences between the control and intervention group among those lost to post-intervention or in the analysed sample.

**Conclusion**
The HEIA intervention did show it is possible to produce a small effect on TV-viewing as part of a long term intervention targeting several energy-related behaviours simultaneously. Gender and weight status seem to be important moderators in EBRB interventions and further studies should continue to investigate for whom intervention are effective or not. Parental regulation did not mediate screen behaviour effects and more intense targeting of this potential mediator may be needed probably combined with other strategies. Nevertheless, mothers’ and fathers’ reports of regulation of TV-viewing and computer/game-use seem to be social-environmental determinants of both TV-viewing and computer/game-use. Thus, parental regulation is warranted to target in future interventions, and both fathers and mothers should be encouraged to regulate their adolescents’ screen behaviours on both weekdays and weekends. However, more studies investigating mediation effect of screen behaviours are warranted.
Competing interests

The authors declare that they have no competing interests.

Authors’ contribution

IHB conducted the statistical analyses assisted by MM van S, wrote the first draft of the manuscript and made the greatest contribution to the paper. MB, MG, NL, K-IK, SAA and YO participated in designing the study, project planning and data collection. All authors have critically revised the manuscript, and read and approved the final version of the manuscript.

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References


Figure Legends

**Figure 1** Flow diagram of recruitment, randomization, consent received and participants in the HEIA study

**Figure 2.** Conceptual model of moderation of a mediated effect
Table 1 Baseline characteristics for intervention and control group in the HEIA study

<table>
<thead>
<tr>
<th></th>
<th>Control (n= 908)</th>
<th>Intervention (n= 510)</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Age (mean; SD)</strong></td>
<td>11.2 (0.27)</td>
<td>11.2 (0.26)</td>
<td>.38</td>
</tr>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls (n, %)</td>
<td>434 (47.8%)</td>
<td>253 (49.6%)</td>
<td>.55</td>
</tr>
<tr>
<td><strong>Weight status</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Overweight/obese (n, %)</td>
<td>130 (14.5%)</td>
<td>55 (11.4%)</td>
<td>.12</td>
</tr>
<tr>
<td><strong>Parental education</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Low (≤12 years) (n, %)</td>
<td>275 (31.1%)</td>
<td>129 (26.2%)</td>
<td>.15</td>
</tr>
<tr>
<td>13-16 years (n, %)</td>
<td>317 (35.8%)</td>
<td>186 (37.7%)</td>
<td></td>
</tr>
<tr>
<td>&gt;16 years (n, %)</td>
<td>293 (33.1%)</td>
<td>178 (36.1%)</td>
<td></td>
</tr>
</tbody>
</table>

a n varies somewhat for weight status and parental education level
b Overweight/obese is presented and treated as one group in the analyses due to the low proportion of obese (C=1.6%; I=1.2%)
### Table 2 Descriptives for screen behaviours, main intervention effects in all and by weight status and gender

<table>
<thead>
<tr>
<th>Table</th>
<th>Baseline&lt;sup&gt;a&lt;/sup&gt;</th>
<th>Post-intervention</th>
<th>Main intervention effect</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Control (n=908)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Intervention (n=510)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Control (n=908)&lt;sup&gt;b&lt;/sup&gt;</td>
<td>Intervention (n=510)&lt;sup&gt;b&lt;/sup&gt;</td>
</tr>
<tr>
<td></td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td><strong>Weekday TV-viewing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>1.45 (0.99)</td>
<td>1.47 (1.08)</td>
<td>1.70 (1.06)</td>
<td>1.63 (1.15)</td>
</tr>
<tr>
<td>Normal weight&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.39 (0.93)</td>
<td>1.48 (1.08)</td>
<td>1.66 (1.03)</td>
<td>1.58 (1.10)</td>
</tr>
<tr>
<td>Overweight&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.82 (1.21)</td>
<td>1.64 (1.15)</td>
<td>1.90 (1.16)</td>
<td>2.07 (1.39)</td>
</tr>
<tr>
<td><strong>Weekend TV-viewing</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>2.15 (1.19)</td>
<td>2.25 (1.29)</td>
<td>2.47 (1.23)</td>
<td>2.40 (1.27)</td>
</tr>
<tr>
<td><strong>Weekday comp/game-use</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>1.13 (0.92)</td>
<td>1.07 (0.92)</td>
<td>1.37 (1.04)</td>
<td>1.32 (1.02)</td>
</tr>
<tr>
<td>Normal weight&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.09 (0.89)</td>
<td>1.05 (0.87)</td>
<td>1.36 (1.03)</td>
<td>1.28 (0.99)</td>
</tr>
<tr>
<td>Overweight&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.38 (1.02)</td>
<td>1.31 (1.16)</td>
<td>2.00 (1.21)</td>
<td>1.71 (1.20)</td>
</tr>
<tr>
<td><strong>Weekends comp/game-use</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>All</td>
<td>1.51 (1.10)</td>
<td>1.53 (1.12)</td>
<td>1.82 (1.17)</td>
<td>1.78 (1.20)</td>
</tr>
<tr>
<td>Girls&lt;sup&gt;c&lt;/sup&gt;</td>
<td>1.24 (1.00)</td>
<td>1.20 (0.95)</td>
<td>1.68 (1.12)</td>
<td>1.51 (1.09)</td>
</tr>
<tr>
<td>Boys</td>
<td>1.75 (1.14)</td>
<td>1.84 (1.19)</td>
<td>1.94 (1.19)</td>
<td>2.05 (1.24)</td>
</tr>
</tbody>
</table>

<sup>a</sup>c-coeff: c-coefficient; Comp/game: computer/game-use

TV-viewing and comp/game-use reported as hours/day

Baseline differences for screen behaviours were tested with independent t-test; no significant differences were found.

<sup>b</sup>n varies slightly for the different behaviours

<sup>c</sup>Subgroup analyses based on preceding significant interaction analyses by gender or weight status

Effect analyses for the whole sample for TV-viewing were adjusted for weight status and parental education level

Effect analyses for the whole sample for computer/game-use were adjusted for gender, weight status and parental education level
Table 3
Baseline and post-intervention descriptives of parental regulation of TV-viewing and computer/game-use

<table>
<thead>
<tr>
<th>Parental regulation TV-viewing, reported by</th>
<th>Baseline Control</th>
<th>Baseline Intervention</th>
<th>Post-intervention Control</th>
<th>Post-intervention Intervention</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
<td>Mean (SD)</td>
</tr>
<tr>
<td>Adolescents</td>
<td>3.64 (0.96)</td>
<td>3.68 (0.93)</td>
<td>3.41 (1.07)</td>
<td>3.38 (1.05)</td>
</tr>
<tr>
<td>Mothers</td>
<td>4.06 (0.75)</td>
<td>4.18 (0.66)*</td>
<td>3.92 (0.71)</td>
<td>4.02 (0.68)</td>
</tr>
<tr>
<td>Fathers</td>
<td>3.96 (0.75)</td>
<td>4.19 (0.71)**</td>
<td>3.80 (0.77)</td>
<td>3.90 (0.77)</td>
</tr>
<tr>
<td>Parental regulation comp/game-use, reported by</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adolescents</td>
<td>3.55 (0.98)</td>
<td>3.53 (1.01)</td>
<td>3.28 (1.11)</td>
<td>3.28 (1.10)</td>
</tr>
<tr>
<td>Mothers</td>
<td>4.13 (0.84)</td>
<td>4.20 (0.70)</td>
<td>3.98 (0.80)</td>
<td>3.97 (0.80)</td>
</tr>
<tr>
<td>Fathers</td>
<td>3.99 (0.82)</td>
<td>4.14 (0.72)**</td>
<td>3.77 (0.83)</td>
<td>3.87 (0.79)</td>
</tr>
</tbody>
</table>

Comp/game: computer/game-use
TV and comp/game-use reported as hours/day
*Baseline differences between control and intervention for mediators were tested with independent t-test
*p<.05, **p<.0001, otherwise non-significant
Mediation analyses for TV-viewing were adjusted for weight status and parental education level
Mediation analyses for computer/game-use were adjusted for gender, weight status and parental education level.
n in analyses varies slightly for the different mediator/outcome combinations
### Table 4: Intervention effect on mediators, effect of mediators on four screen behaviours and mediated effect

<table>
<thead>
<tr>
<th>Mediator: Parental regulation of TV-viewing reported by</th>
<th>Effect on mediator (95% CI)</th>
<th>Effect of mediator on weekday TV viewing b (95% CI)</th>
<th>Mediated effect ab (95% CI)</th>
<th>Effect on mediator (95% CI)</th>
<th>Effect of mediator on weekend TV-viewing b (95% CI)</th>
<th>Mediated effect ab (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adolescents</td>
<td>-0.04 (-0.15; 0.07)</td>
<td>-0.04 (-0.10; 0.01)</td>
<td>0.00 (0.00; 0.01)</td>
<td>-0.03 (-0.14; 0.09)</td>
<td>-0.01 (-0.13; 0.00)</td>
<td>0.00 (0.00; 0.06)</td>
</tr>
<tr>
<td>Mothers</td>
<td>0.03 (-0.07; 0.12)</td>
<td>-0.17 (-0.29; -0.06)**</td>
<td>-0.01 (-0.02; 0.01)</td>
<td>0.02 (-0.08; 0.12)</td>
<td>-0.16 (-0.30; -0.02)*</td>
<td>-0.00 (-0.02; 0.01)</td>
</tr>
<tr>
<td>Fathers</td>
<td>-0.00 (-0.12; 0.11)</td>
<td>-0.04 (-0.15; 0.07)</td>
<td>-0.00 (-0.01; 0.01)</td>
<td>-0.02 (-0.14; 0.09)</td>
<td>-0.08 (-0.30; -0.02)</td>
<td>0.00 (-0.01; 0.03)</td>
</tr>
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</table>

<table>
<thead>
<tr>
<th>Mediator: Parental regulation of comp/game-use reported by</th>
<th>Effect on mediator (95% CI)</th>
<th>Effect of mediator on weekday comp/game-use b (95% CI)</th>
<th>Mediated effect ab (95% CI)</th>
<th>Effect on mediator (95% CI)</th>
<th>Effect of mediator on weekend comp/game-use b (95% CI)</th>
<th>Mediated effect ab (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Adolescents</td>
<td>0.03 (-0.09; 0.15)</td>
<td>-0.01 (-0.06; 0.04)</td>
<td>-0.00 (-0.01; 0.00)</td>
<td>0.03 (-0.10; 0.15)</td>
<td>-0.02 (-0.07; 0.04)</td>
<td>-0.00 (-0.01; 0.00)</td>
</tr>
<tr>
<td>Mothers</td>
<td>-0.04 (-0.15; 0.08)</td>
<td>-0.17 (-0.27; -0.07)**</td>
<td>0.07 (-0.01; 0.03)</td>
<td>-0.03 (-0.10; 0.15)</td>
<td>-0.05 (-0.16; 0.07)</td>
<td>0.00 (-0.00; 0.02)</td>
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<tr>
<td>Fathers</td>
<td>0.05 (-0.08; 0.18)</td>
<td>-0.14 (-0.24; -0.04)**</td>
<td>-0.01 (-0.01; 0.03)</td>
<td>0.05 (-0.10; 0.15)</td>
<td>-0.06 (-0.16; 0.07)</td>
<td>-0.00 (-0.03; 0.00)</td>
</tr>
</tbody>
</table>

*p < .05, **p < .01, ***p < .001, otherwise non-significant

Comp/game-use: computer/game-use

Mediation analyses for TV-viewing were adjusted for weight status and parental education level.

Mediation analyses for computer/game-use were adjusted for gender, weight status and parental education level.

n in analyses varies slightly for the different mediator/outcome combinations.
Table 5: Effect on mediators, effect of mediators on outcome, mediated effect and moderated mediation of gender

<table>
<thead>
<tr>
<th>Mediator</th>
<th>Girls</th>
<th>Boys</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention effect on parental reg.</td>
<td>Mediated effect on weekend comp/game-use</td>
</tr>
<tr>
<td></td>
<td>a (95% CI)</td>
<td>b (95% CI)</td>
</tr>
<tr>
<td>Parental regulation of comp/game-use, reported by</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Adolescent</td>
<td>-0.07 (-0.24; 0.10)</td>
<td>0.04 (-0.04; 0.12)</td>
</tr>
<tr>
<td>Mother</td>
<td>-0.09 (-0.26; 0.08)</td>
<td>0.03 (-0.12; 0.18)</td>
</tr>
<tr>
<td>Father</td>
<td>0.15 (-0.04; 0.34)</td>
<td>0.07 (-0.06; 0.20)</td>
</tr>
</tbody>
</table>

*p<.10, *p <.05, **p <.01, otherwise non-significant
Comp/game-use: computer/game-use
Analyses stratified by gender were adjusted for weight status and parental education level
n in analyses varies slightly for the different mediator/outcome combinations
Table 6: Effect on mediators, effect of mediators on outcomes, mediated effect and moderated mediation of weight-status

| Mediators | Normal weight | | | | Overweight | | |
|-----------|---------------|-----------------|-----------------|-----------------|---------------|-----------------|-----------------|-----------------|
|           | Intervention effect on mediator | Effect of mediator on weekday TV-viewing | Mediated effect ab (95% CI) | Intervention effect on mediator | Effect of mediator on weekday TV-viewing | Mediated effect ab (95% CI) | Moderated Mediation | Delta ab (95% CI) |
| Parental regulation of TV-viewing, reported by | | | | | | |
| Adolescents | -0.05 (-0.18; 0.08) | -0.04 (-0.10; 0.02) | -0.02 (-0.00; 0.01) | 0.00 (-0.34; 0.35) | -0.07 (-0.24; 0.10) | -0.00 (-0.06; 0.04) | 0.01 (-0.01; 0.03) |
| Mothers | 0.01 (-0.09; 0.10) | -0.13 (-0.26; -0.01)* | -0.00 (-0.02; 0.01) | 0.22 (-0.13; 0.57) | -0.39 (-0.71; -0.06)* | -0.09 (-0.33; 0.01) | 0.09 (0.08; 0.10)** |
| Fathers | -0.00 (-0.12; 0.12) | -0.07 (-0.18; 0.04) | -0.00 (-0.01; 0.02) | 0.08 (-0.26; 0.42) | 0.42 (-0.09; 0.93) | 0.03 (-0.13; 0.29) | -0.03 (-0.09; 0.03) |
|           | | | | | | |
| Parental regulation of comp/game-use, reported by | | | | | | |
| Adolescents | 0.05 (-0.08; 0.18) | -0.01 (-0.06; 0.05) | -0.00 (-0.01; 0.00) | -0.11 (-0.47; 0.24) | -0.04 (-0.19; 0.12) | 0.01 (-0.01; 0.06) | -0.01 (-0.03; 0.05) |
| Mothers | -0.05 (-0.17; 0.07) | -0.15 (-0.26; -0.04)** | 0.01 (-0.01; 0.04) | 0.05 (-0.36; 0.47) | -0.28 (-0.55; -0.01)* | -0.02 (-0.16; 0.09) | 0.03 (-0.07; 0.01) |
| Fathers | 0.06 (-0.07; 0.20) | -0.16 (-0.26; -0.06)** | -0.01 (-0.04; 0.01) | -0.05 (-0.45; 0.36) | 0.04 (-0.37; 0.45) | -0.00 (-0.14; 0.11) | -0.01 (-0.05; 0.03) |

*p < .10, *p < .05, **p < .01, ***p < .001 otherwise non-significant

Comp/game-use: computer/game-use

Stratified analyses on TV-viewing were adjusted for parental education level

Stratified analyses on computer/game-use were adjusted for gender and parental education level

N in analyses varies slightly for the different mediator/outcome combinations
177 schools
37 participating schools (21%)
  n=2165 6th graders
Cluster randomisation

INTERVENTION
  12 schools: n=784
    consent: n=566 (72%)

  BASELINE (BL)
    Adolescents, questionnaire: n=553 (71%)
    body measure: n=527 (67%)
    Parents
      Mothers: n=460
      Fathers: n=392

  20 MONTH POST-INTERVENTION (PI)
    Adolescents, questionnaire: n=518 (66%)
    Participated BL & PI: n=510
    Parents
      Mothers: n=246
      Participated BL & PI: n=244
      Fathers: n=201
      Participated BL & PI: n=199

CONTROL
  25 schools: n=1381
    consent: n=1014 (73%)

  BASELINE (BL)
    Adolescents, questionnaire: n=975 (71%)
    body measure: n=958 (69%)
    Parents
      Mothers: n=800
      Fathers: n=676

  20 MONTH POST-INTERVENTION (PI)
    Adolescents, questionnaire: n=945 (68%)
    Participated BL & PI: n=908
    Parents
      Mothers: n=603
      Participated BL & PI: n=591
      Fathers: n=479
      Participated BL & PI: n=469
Intervention

Parental regulation (mediator)

Screen behaviour

Parental regulation (mediator)

Screen behaviour

Moderator=0

\[ a_0 \]

\[ b_0 \]

\[ c_0 \]

H0: \( a_0 \cdot b_0 - a_1 \cdot b_1 = 0 \)

H1: \( a_0 \cdot b_0 - a_1 \cdot b_1 \neq 0 \)

Moderator=1

\[ a_1 \]

\[ b_1 \]

\[ c_1 \]
APPENDIX 1 Survey items form the adolescents’ electronic questionnaire and the parental questionnaires

1) VARIABLES FROM THE ADOLESCENTS’ QUESTIONNAIRE USED IN THE THESIS, FOLLOWING THE ORDER IN THE QUESTIONNAIRE.

The English wording of the items are shown in *Italic*, the response option are not translated but explained in the Method section of the thesis.

**Gender:**

*Are you a boy or a girl?*

*Er du jente eller gutt?*

- Jente
- Gutt

**TV-viewing (including DVD’s) on a regular weekday and weekend day**

1) *How many hours do you normally watch Television/or DVDs on a normal weekday?*

2) *How many hours do you normally watch Television/or DVDs on a normal weekend day or vacation day?*

**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
Computer/game-use (e.g. surfing on internet, MSN, Gameboy, Nintendo, Playstation) on weekday and weekend

1) How many hours do you normally use the computer/play TV-games or other electronic games on a normal weekday?

2) How many hours do you normally use the computer/play TV-games or other electronic games on a normal weekend day or vacation day?

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
**Enjoyment of physical activity**

1) It is more fun to exercise, play or do athletics/physical activity than to do other things
2) To train, play or do athletics/physical activity is the thing I like to the best
3) Wish I could do more exercise, play or athletics/physical activity than I get a chance to
4) I usually prefer to watch rather than train, play or do athletics/physical activity
5) I really like doing PE at school*

*This item was added in a pilot study to the EYHS study

| Det er morsommere å drive med trening, lek eller idrett/fysisk aktivitet enn å gjøre andre ting |
|-----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|----------------------------------|
| Å drive med trening, lek eller idrett/fysisk aktivitet er det beste jeg vet |
| Jeg skulle ønske jeg kunne drive mer med trening, lek eller idrett/fysisk aktivitet enn det jeg har anledning til å gjøre |
| Jeg liker bedre å se på enn å drive med trening, lek eller idrett/fysisk aktivitet |
| Jeg liker veldig godt gym på skolen |
Perceived social support from friends

1) How often do your friends exercise or play sports with you?
2) How often do you ask your friends to play out or play sport with you?
3) How often do your friends ask you to play out with them?

Hvor ofte trener, leker eller driver du med idrett/fysisk aktivitet med vennene dine?
- Nesten aldri eller aldri
- 1 eller 2 ganger i uken
- 3 eller 4 ganger i uken
- Nesten hver dag
- Hver dag

Hvor ofte SPØR DU vennene dine om å trene, leke eller drive idrett/fysisk aktivitet med deg?
- Nesten aldri eller aldri
- 1 eller 2 ganger i uken
- 3 eller 4 ganger i uken
- Nesten hver dag
- Hver dag

Hvor ofte SPØR VENNENE DINE deg om å trene, leke eller drive med idrett/fysisk aktivitet?
- Nesten aldri eller aldri
- 1 eller 2 ganger i uken
- 3 eller 4 ganger i uken
- Nesten hver dag
- Hver dag
Perceived social support from parents

1) How often does your mum or dad tell (encourage) you to exercise or play sports?
2) How often does your mum or dad take you to exercise or play sports?
3) How often does your mum or dad watch you take part in exercise or play sports?
4) How often does your mum or dad exercise or play sports with you?
5) How often does your mum or dad tell you that exercise is good for your health?
Perceived social support from parents continued

Hvor ofte trener, leker eller driver moren eller faren din med idrett/fysisk aktivitet sammen med deg?

- Nesten aldri eller aldri
- 1 eller 2 ganger i uken
- 3 eller 4 ganger i uken
- Nesten hver dag
- Hver dag

Hvor ofte sier moren eller faren din at idrett/fysisk aktivitet er bra for helsen din?

- Nesten aldri eller aldri
- 1 eller 2 ganger i uken
- 3 eller 4 ganger i uken
- Nesten hver dag
- Hver dag

Hvor ofte snakker lærerne dine om trening, lek eller idrett/fysisk aktivitet utenom gyntimene?

- Nesten aldri eller aldri
- 1 eller 2 ganger i uken
- 3 eller 4 ganger i uken
- Nesten hver dag
- Hver dag
Perceived social support from teachers

1) How often do your teachers talk about exercise (training, playing or doing sport/physical activity) outside the PE-classes (originally in lessons)
2) How often do your teachers organise or play games with you (training, plays sports/physical activity ) apart from PE-classes
3) How often do your teachers tell you to exercise or play sports (exercise), play, do sports/physical activity

Hvor ofte snakker lærerne dine om trening, lek eller idrett/fysisk aktivitet utenom gymtimene?
- Nesten aldri eller aldri
- 1 eller 2 ganger i uken
- 3 eller 4 ganger i uken
- Nesten hver dag
- Hver dag

Hvor ofte organiserer lærerne dine trening, lek eller idrett/fysisk aktivitet utenom gymtimene?
- Nesten aldri eller aldri
- 1 eller 2 ganger i uken
- 3 eller 4 ganger i uken
- Nesten hver dag
- Hver dag

Hvor ofte oppmuntrer lærerne dine deg til å drive med idrett/fysisk aktivitet?
- Nesten aldri eller aldri
- 1 eller 2 ganger i uken
- 3 eller 4 ganger i uken
- Nesten hver dag
- Hver dag
Self-efficacy (related to barriers)

1) I can be physically active during my free time on most days
2) I can ask my parents or other adults to do physically things with me
3) I can be physically active during my free time on most days even if I have the choice to watch TV or play video games instead
4) I can be physically active during my free time on most days even if it is very hot or cold outside
5) I can ask my best friends to be physically active with me during my free time on most days

Hvor enig eller uenig er du i disse utsagnene?

Sett ett kryss for hver linje

<table>
<thead>
<tr>
<th></th>
<th>Helt uenig</th>
<th>Litt uenig</th>
<th>Verken enig eller uenig</th>
<th>Litt enig</th>
<th>Helt enig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeg greier å være fysisk aktiv de fleste dager</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jeg greier å spørre foreldrene mine eller andre voksne om å trene, leke eller drive med idrett sammen med meg</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jeg greier å være fysisk aktiv de fleste dager selv når jeg har mulighet til å se på TV eller spille TV-spill og data i stødet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jeg greier å være fysisk aktiv de fleste dager selv om det er dårlig vær ute</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jeg greier å få med meg vennene mine på fysisk aktivitet de fleste dager</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Perceived environmental opportunities

1) There are playgrounds or parks close to my home where I can play
2) At schools there are playgrounds or fields where I can play around*
3) During recess at schools there is equipment I can play and do sports with
4) There are other children nearby to go out and play with

*This item was added to capture availability of equipment to stimulate playing games/being physical active in the school yard

Hvor enig eller uenig er du i disse utsagnene?

Sett ett kryss for hver linje

<table>
<thead>
<tr>
<th>Det finnes steder der jeg bor hvor jeg kan trene, leke eller drive med idrett/fysisk aktivitet, for eksempel lekeplasser, idrettsplasser, parker, haller</th>
<th>Helt uenig</th>
<th>Litt uenig</th>
<th>Litt enig</th>
<th>Verken enig eller uenig</th>
<th>Helt enig</th>
</tr>
</thead>
<tbody>
<tr>
<td>På skolen er det lekeplasser eller områder hvor jeg kan løpe rundt og leke eller drive med idrett/fysisk aktivitet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>I frimittene og i skolegården er det utstyr jeg kan bruke til å leke eller drive idrett/fysisk aktivitet med</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Det er andre på min alder (barn eller ungdommer) i nabolaget som jeg kan gå ut med eller drive idrett/fysisk aktivitet med</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Perceived social inclusion at school

1) I know many at my school
2) I know the other in my group (class) quite well
3) There are many at school I can ask about help if I need it
4) I can thrust the others in my group (class)
5) Everyone has someone they know ell at my school
6) The pupils in my group (class) is willing to help each other out

Hvor enig eller uenig er du i disse utsagnene?

Sett ett kryss for hver linje

- Jeg kjenner mange på skolen min
  - Helt uenig
  - Litt uenig
  - Verken enig eller uenig
  - Litt enig
  - Helt enig

- Jeg kjenner de andre i gruppen (klassen) min ganske godt
- Det er mange på skolen jeg kan spørre om hjelp dersom jeg skulle trenge det
- Jeg kan stole på de andre i gruppen (klassen) min
- Alle har noen de kjenner godt på skolen min
- Elever i gruppen (klassen) min er villige til å hjelpe hverandre
  - Helt uenig
  - Litt uenig
  - Verken enig eller uenig
  - Litt enig
  - Helt enig
Perceived parental regulation of TV-viewing

1) My mother and/or father try to make sure I do not watch too much TV
2) My mother and/or father switch off the TV if they think I am watching too much
3) My mother and/or father let me watch TV when I do something good
4) My mother and/or father think that they need to monitor my TV watching so that I don’t watch too much

Hvor enig eller uenig er du i disse utsagnene?

*Sett ett kryss for hver linje*

<table>
<thead>
<tr>
<th>Moren og/eller faren min prøver å passe på at jeg ikke ser for mye på TV</th>
<th>Helt uenig</th>
<th>Litt uenig</th>
<th>Verken enig eller uenig</th>
<th>Litt enig</th>
<th>Helt enig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moren og/eller faren min slår av TV når de synes jeg ser for mye på TV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moren og/eller faren min lar meg få se på TV når jeg har gjort noe de synes er bra</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Moren og/eller faren min mener at dersom de ikke følger med på TV-bruken min, så vil jeg se for mye på TV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Perceived parental regulation of computer/game-use

1) My mother and/or father try to make sure I do not use the computer, play TV-games or other games too much
2) My mother and/or father turns off the computer/TV-games or other games if they think I am doing it too much
3) My mother and/or father let me watch use the computer, play TV-games or other games when I have done something they think is good
4) My mother and/or father think that they need to monitor my computer-use / how much I play games, so that I don’t watch too much
2) VARIABLES FROM THE PARENTAL QUESTIONNAIRES USED IN THE THESIS (separate questionnaires for mother and father, but same questions used), FOLLOWING THE ORDER IN THE QUESTIONNAIRE.

Parental regulation of TV-viewing

1) I do not allow the television on during meal times
2) I allow my child to watch any television show he/she chooses
3) I restrict how much time my child spend watching television
4) My child is no allowed to watch television games until his/her homework is done
5) My partner and I have the same views about how much television our child should watch
6) My partner support the rules I make about when our child is able to watch television

55. Hvor enig eller uenig er du i de følgende utsagnene om TV-bruk?

<table>
<thead>
<tr>
<th></th>
<th>Helt uenig</th>
<th>Litt uenig</th>
<th>Verken enig eller uenig</th>
<th>Litt enig</th>
<th>Helt enig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeg tillater ikke at TV er på under måltider</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jeg tillater barnet mitt å se på de TV-programmene han/hun har lyst til</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Jeg regulerer hvor mye barnet mitt ser på TV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Barnet mitt får ikke se på TV før han/hun er ferdig med leksene</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partneren min og jeg har samme syn på hvor mye barnet vårt får se på TV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Partneren min støtter de reglene jeg foreslår for når barnet vårt får se på TV</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Parental regulation of computer/game-use

1) I restrict how much time my child play electronic games and use the computer
2) My child is no allowed to play electronic games or use the computer for entertainment until his/her homework is done
3) My partner and I have the same views about how much our child is allowed to play electronic games and use the computer
4) My partner support the rules I make about when our child is able to watch television

56. Hvor enig eller uenig er du i de følgende utsagnene om data, TV-spill eller andre elektroniske spill? (For eksempel surfing på Internett, MSN, Gameboy, Nintendo, Playstation).

Tenk på all slik bruk, unntatt bruk av data til lekser

<table>
<thead>
<tr>
<th>Sett ett kryss for hver linje</th>
<th>Helt enig</th>
<th>Litt enig</th>
<th>Verken enig eller uenig</th>
<th>Litt uenig</th>
<th>Helt uenig</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jeg regulerer hvor mye barnet mitt spiller elektroniske spill og bruker data</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Barnet mitt får ikke spille elektroniske spill eller bruke data til underholdning før han/hun er ferdig med leksene</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Partneren min og jeg har samme syn på hvor mye barnet vårt får spille elektroniske spill og bruke data</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
<tr>
<td>Partneren min støtter de reglene jeg foreslår for når barnet vårt får spille elektroniske spill og bruke data</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
<td>❌</td>
</tr>
</tbody>
</table>
APPENDIX 2
**Appendix 2 Consent form (Including items on parental educational level in Norwegian)**

**SAMTYKKEERKLÆRING FOR "HEIA-PROSJEKTET"**

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:**

| __________________________ | __________________________ |
| Elevernes navn (blokkbokstaver) | 
| Skole | Klasse/gruppe |
| __________________________ | __________________________ |
| Sted | Dato | Underskrift foresatt(e) |

**Foresatte 1: Jeg samtykker til å delta**

| __________________________ | __________________________ |
| Hvilken relasjon har du til barnet som blir med i undersøkelsen? | Hva er din høyeste fullførte utdanning? |
| □ Jeg er moren til barnet | □ Mindre enn 7 års utdanning |
| □ Jeg er faren til barnet | □ Folkeskole/grunnskole/ungdomsskole (7-9 år) |
| □ Jeg er stemoren til barnet | □ Gymnas/yrkesskole e.l. (inntil 12 år) |
| □ Jeg er stefaren til barnet | □ Universitet-/høyskoleutdanning (inntil 4 år) |
| □ Jeg er barnets kvinnelige foresatt | □ Universitet-/høyskoleutdanning (mer enn 4 år) |
| □ Jeg er barnets mannlige foresatt | |

**Foresatte 2: Jeg samtykker til å delta**

| __________________________ | __________________________ |
| Hvilken relasjon har du til barnet som blir med i undersøkelsen? | Hva er din høyeste fullførte utdanning? |
| □ Jeg er moren til barnet | □ Mindre enn 7 års utdanning |
| □ Jeg er faren til barnet | □ Folkeskole/grunnskole/ungdomsskole (7-9 år) |
| □ Jeg er stemoren til barnet | □ Gymnas/yrkesskole e.l. (inntil 12 år) |
| □ Jeg er stefaren til barnet | □ Universitet-/høyskoleutdanning (inntil 4 år) |
| □ Jeg er barnets kvinnelige foresatt | □ Universitet-/høyskoleutdanning (mer enn 4 år) |
| □ Jeg er barnets mannlige foresatt | |

_Dette samtykkeskjemaet returneres til kontaktlærer i konvolutten snarest._
APPENDIX 3
### Appendix 3. Psychological, social and physical-environmental construct, number of items, scales, example of items, Cronbach’s alpha ($\alpha$) and test-retest results (ICC)

<table>
<thead>
<tr>
<th>Construct</th>
<th># items in composite score</th>
<th>$\alpha$: BL/PI</th>
<th>ICC*</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Reported by adolescents:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Enjoyment of PA</td>
<td>4$^a$</td>
<td>0.72/0.75</td>
<td>0.47</td>
</tr>
<tr>
<td>Self-efficacy related to barriers for PA</td>
<td>5</td>
<td>0.76/0.79</td>
<td>0.47</td>
</tr>
<tr>
<td>Perceived social support for PA from parents</td>
<td>5</td>
<td>0.67/0.70</td>
<td>0.71</td>
</tr>
<tr>
<td>Perceived social support for PA from friends</td>
<td>3</td>
<td>0.84/0.84</td>
<td>0.76</td>
</tr>
<tr>
<td>Perceived social support for PA from teachers</td>
<td>3</td>
<td>0.76/0.72</td>
<td>0.61</td>
</tr>
<tr>
<td>Perceived social inclusion at school</td>
<td>6</td>
<td>0.80/0.85</td>
<td>NA</td>
</tr>
<tr>
<td>Perceived environmental opportunities for PA</td>
<td>4$^c$</td>
<td>0.65/0.75</td>
<td>0.48</td>
</tr>
<tr>
<td>Perceived parental regulation of TV-viewing</td>
<td>3$^b$</td>
<td>0.62/0.73</td>
<td>0.64</td>
</tr>
<tr>
<td>Perceived parental regulation of computer/game-use</td>
<td>3$^b$</td>
<td>0.67/0.74</td>
<td>0.53</td>
</tr>
<tr>
<td><strong>Reported by parents:</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Parental regulation of TV-viewing, mother</td>
<td>5$^b$</td>
<td>0.68/0.63</td>
<td>0.43</td>
</tr>
<tr>
<td>Parental regulation of TV-viewing, father</td>
<td>5$^b$</td>
<td>0.69/0.69</td>
<td>0.77</td>
</tr>
<tr>
<td>Parental regulation of computer/game-use, mother</td>
<td>4$^d$</td>
<td>0.76/0.75</td>
<td>0.77</td>
</tr>
<tr>
<td>Parental regulation of computer/game-use, father</td>
<td>4$^d$</td>
<td>0.74/0.74</td>
<td>0.85</td>
</tr>
</tbody>
</table>

BL=Baseline; PI=Post-intervention, PA=Physical activity, NA=Not applicable (not included in test-retest)

Chronbach’s alpha ($\alpha$) values reported from sample in paper II and IV ($n=1418$, Figure 6)

*Test-retest reliability (ICC) from separate test–retest study 10–14 days apart ($n=114$), $n$ varies slightly for the various variables

$^b$ In order to obtain acceptable Cronbach’s alpha values ($\alpha\geq.60$) one item was omitted when the composite score was computed

$^c$ In order to capture the availability of equipment to stimulate playing games/being physically active in the school yard one item was added to the original scale

$^d$ The measure for parental regulation of computer/game-use was based on the items in the measure for parental regulation of TV-viewing, but two of the items did not apply for parental regulation of computer/game-use

$^e$ The wording of the items in each measure is shown in Appendix 1
**Appendix 4** Test-retest reliability (ICC) of screen time behaviours from separate test-retest (n=114)

<table>
<thead>
<tr>
<th>Screen time behaviours</th>
<th>n</th>
<th>ICC</th>
</tr>
</thead>
<tbody>
<tr>
<td>TV-viewing weekday (hours/day)</td>
<td>109</td>
<td>0.58</td>
</tr>
<tr>
<td>TV-viewing weekend (hours/day)</td>
<td>110</td>
<td>0.57</td>
</tr>
<tr>
<td>Computer/game-use weekday (hours/day)</td>
<td>106</td>
<td>0.50</td>
</tr>
<tr>
<td>Computer/game-use weekend (hours/day)</td>
<td>109</td>
<td>0.65</td>
</tr>
</tbody>
</table>
APPENDIX 5
Appendix 5: The “flower” illustrating the intervention settings and main components of the intervention, used when presenting the intervention for the teachers, adolescents and parents.

Note: The leisure time components were planned for but not implemented to the degree as intended.
APPENDIX 6
Dato: 16.03.07
Deres ref.: S-07034b

Vi viser til møte som fant sted 15. mars 2007 med prosjektleder Nanna Lien, prosjektmedarbeider førstemannens Sigmund Alfred Anderssen, komitéleder Tor Norseth og nestleder Ulrich Abildgaard og komitésekreter. Møtets siktenål 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

[Signature]

Tor Norseth
Leder

Johanne Kronn-Hansen
Sekreter

Kopi:
Stipendiat Mona Bjelland, Avdeling for ernæringsvitenskap, Pb. 1046 Blindern, Universitetet i Oslo
Stipendiat May Grydeland, Norges idretthøgskole, Pb.4014 Ullevål stadion, 0806 Oslo
TILRÅDING AV BEHANDLING AV PERSONOPPLYSNINGER

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

16073
Filotundersøkelse av målområder og spørreskjema til intervensjonsundersøkelsen Promoting healthy weight among school children
Behandlingsansvarlig Universitetet i Oslo, ved institusjonens sørste leder
Daglig ansvarlig Nanna Lien

Personvernomnombudet har vurdert prosjektet, og finner at behandlingen av personopplysninger vil være reguleret av § 7-27 i personopplysningsloven. Personvernomnombudet tilhører det projekten gjennomføres.

Personvernomnombudets tilrådning forutsetter at prosjektet gjennomføres i tråd med opplysningene gitt i meldeskjemaet, korrespondanse med ombudet, eventuelle kommentarer samt personopplysningsloven/ -helseregistreloven med forskrifter. Behandlingen av personopplysninger kan settes i gang.

Det gjøres oppmerksom på at det skal ges ny melding dersom behandlingen endres i forhold til de opplysninger som ligger til grunn for personvernomnombudets vurdering. Endringsmeldinger gis via et eget skljbema.

Personvernomnombudet har lagt ut opplysninger om prosjektet i en offentlig database, http://www.vid.no/personvern/database/


Vennlig hilsen
Bjørn Henriksen
Katrine Usaker Segadal

Kontaktperson: Katrine Usaker Segadal tlf: 55 58 35 42

Vedlegg: Prosjektvurdering.
Personvernombudet for forskning, NSD

Prosjektvurdering - Kommentar

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


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

Kopi av tilrådning fra Regional komité for medisinsk forskningsetikk bes ettersendt.
Appendix 7. Gender, age, anthropometrics, and parental education status of participants at baseline based on the sample in Paper II and IV (Figure 6)

<table>
<thead>
<tr>
<th></th>
<th>Total (n=1418)</th>
<th>Control(^a) (n=908)</th>
<th>Intervention(^a) (n=510)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Gender</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Girls (%, n)</td>
<td>48.4 (687)</td>
<td>47.8 (434)</td>
<td>49.6 (253)</td>
</tr>
<tr>
<td>Boys (%, n)</td>
<td>51.6 (731)</td>
<td>52.2 (474)</td>
<td>50.4 (257)</td>
</tr>
<tr>
<td><strong>Age</strong> (mean, SD)</td>
<td>11.2 (0.27)</td>
<td>11.2 (0.27)</td>
<td>11.2 (0.26)</td>
</tr>
<tr>
<td><strong>Anthropometrics</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height cm (mean, SD)</td>
<td>148.5 (6.8)</td>
<td>148.51 (6.8)</td>
<td>148.6 (6.8)</td>
</tr>
<tr>
<td>Weight (mean, SD)</td>
<td>39.8 (7.86)</td>
<td>39.87 (7.93)</td>
<td>39.7 (7.7)</td>
</tr>
<tr>
<td>BMI (mean, SD)</td>
<td>17.9 (2.6)</td>
<td>18.0 (2.7)</td>
<td>17.8 (2.6)</td>
</tr>
<tr>
<td>Normal weight (%, n)</td>
<td>86.6 (1191)</td>
<td>85.5 (764)</td>
<td>88.6 (427)</td>
</tr>
<tr>
<td>Overweight/Obese (%, n)</td>
<td>13.4 (185)</td>
<td>14.5 (130)</td>
<td>11.4 (55)</td>
</tr>
<tr>
<td><strong>Parental education</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;12 years (%, n)</td>
<td>29.3 (404)</td>
<td>275 (31.1)</td>
<td>129 (26.2)</td>
</tr>
<tr>
<td>13-16 years (%, n)</td>
<td>36.5 (503)</td>
<td>317 (35.8)</td>
<td>186 (37.7)</td>
</tr>
<tr>
<td>&gt;16 years (%, n)</td>
<td>34.4 (471)</td>
<td>293 (33.1)</td>
<td>178 (36.1)</td>
</tr>
</tbody>
</table>

\(^a\) No significant difference between the groups (p>.05)

n varies slightly for anthropometric variables and parental education