

Home environmental influences on adolescents' energy balance related behaviours

The HEIA cohort study

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HOME ENVIRONMENTAL INFLUENCES ON
ADOLESCENTS' ENERGY BALANCE RELATED
BEHAVIOURS:
THE HEIA COHORT STUDY



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SUMMARY

The global obesity epidemic represents an enormous potential threat to public health, because overweight and obesity are major risk factors of non-communicable diseases. The prevalence of overweight has furthermore increased among children and adolescents worldwide, and creates a growing health challenge for the next generation as children who are overweight are more likely to become overweight and obese as adults. Dietary, physical activity and sedentary behaviours are energy balance related behaviours (EBRB) that positively or negatively are related to weight status. It is agreed upon that the obesity epidemic is driven by large environmental changes over the past few decades, negatively influencing the EBRB. Social inequalities are furthermore consistently observed in children's and adolescents' weight status and health behaviours. Thus, there is a need for research to identify environmental factors influencing children's and adolescents EBRB across age and within diverse social groups, in order to establish good opportunities of a healthy future. The main aims of this thesis were first to investigate the changes and tracking in children's dietary behaviours during the transition into adolescence, and possible differences by parental education. Second to examine how the home environment influences young adolescents' dietary and sedentary behaviours between the ages of 11 and 13 years, including social differences as measured by parental education.

Longitudinal data from the Norwegian HEalth In Adolescents (HEIA) cohort study (2007–09) is included. Data was collected through questionnaires among a baseline sample of 975 adolescents at the age of 11 years (T0), and followed up at age 12 (T1) and 13 (T2) years. Furthermore, questionnaires were collected from both mothers (n=738) and fathers (n=630) at T0, and followed up at T2. Dietary intakes of fruits, vegetables, energy dense snacks, sugar sweetened soft drinks and sugar sweetened squash were examined prospectively, as well as screen time behaviours of television and video viewing (TV/DVD), and computer and electronic game use (PC/game). Parental education, parental modelling, parental regulation, availability and accessibility were explored as possible determinants in the home environment. Analyses of tracking was used to investigate changes and stability in dietary behaviours over time, and mediation analyses explored possible influences of the home environment on adolescents' prospective soft drink intake and screen time.

Tracking of the frequency of fruit, vegetable and snack intake, and in the amount of soft drinks and squash consumption was observed among boys and girls between the ages of 11 and 13 years. The intake of soft drinks did furthermore increase significantly during this time period. An inverse association was found between level of parental education and tracking in adolescents' soft drink and squash consumption, as higher odds of a stable low than a stable high intake of soft drinks and squash was observed among those with a higher level of parental education. A higher level of parental education did furthermore predict a lower intake of soft drinks at the age of 13 years. A higher availability and accessibility of soft drinks at home subsequently predicted an increased intake among adolescents between the ages of 11 and 13 years. Moreover, the relationship of parental education predicting adolescents' soft drink intake was explained through the accessibility of soft drinks at home, identified as a mediating factor. In addition, a higher level of parental education predicted less time spent on PC/games among 13 year olds. A positive relationship was observed between parental modelling and adolescents' TV/DVD time and an inverse relationship between parental regulation and adolescents' TV/DVD time was subsequently found between the ages of 11 and 13 years. Finally, maternal and paternal modelling of TV/DVD viewing were found to mediate the relationship of parental education predicting adolescents' TV/DVD time at the age of 13 years.

The present study contributes to international research by enhancing the understanding of children's and adolescents' dietary and sedentary behaviours in a longitudinal perspective. The findings indicate tracking of dietary behaviours between the ages of 11 and 13 years, and thus emphasize the importance of starting before the age of 11 years to prevent the establishment of unfavourable dietary behaviours later in adolescence. Moreover, the parental role in adolescents' dietary and screen time behaviours is highlighted through availability and accessibility in the home, parental modelling and regulation by implying that raising awareness of these determinants may result in a healthier lifestyle which further can influence weight status. Finally, the present analyses emphasize differences by parental education in adolescents' dietary and screen time behaviours which could contribute to social inequalities in health. The accessibility of soft drinks at home and parental modelling of TV/DVD time was identified as important targets in future health education and health promotion programs aiming to reduce social differences in such health behaviours among adolescents.

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LIST OF PAPERS

Article 1

Torunn H Totland, Mekdes K Gebremariam, Nanna Lien, Mona Bjelland, May Grydeland, Ingunn H Bergh, Knut-Inge Klepp and Lene F Andersen (2012). Does tracking of dietary behaviours differ by parental education in children during the transition into adolescence? *Public Health Nutr.* **16**(4): 673-682

Article 2

Torunn H. Totland, Nanna Lien, Ingunn H. Bergh, Mona Bjelland, Mekdes K. Gebremariam, Knut-Inge Klepp and Lene F. Andersen (2013). The relationship between parental education and adolescents' soft drink intake from the age of 11–13 years, and possible mediating effects of availability and accessibility. *Br. J. Nutr.* Feb 4:1-8 [Epub ahead of print]

Article 3

Torunn H. Totland, Mona Bjelland, Nanna Lien, Ingunn H. Bergh, Mekdes K. Gebremariam, May Grydeland, Yngvar Ommundsen and Lene F. Andersen (2013). Adolescents' prospective screen time by gender and parental education, the mediation of parental influences. *Int J Behav Nutr Phys Act.* July 16;10(1):89 [Epub ahead of print]

ABBREVIATIONS

BMI	Body Mass Index
EBRB	Energy Balance Related Behaviours
HEIA	HEalth In Adolescents
HBSC	Health Behaviour in School aged Children
ICC	Intra Class Correlation
IOTF	International Obesity Task Force
PC/game	Computer and electronic game
SES	Socio-Economic Status
SSB	Sugar Sweetened Beverage
TV/DVD	Television and video
WHO	World Health Organization

1 INTRODUCTION

Several health behaviours that contribute to the epidemic of non-communicable diseases in adults are initiated during adolescence, such as tobacco use, alcohol use, and obesity inducing behaviours of unhealthy diet, physical activity and sedentary behaviours [1, 2]. Adolescence is defined by the World Health Organization (WHO) as the time period between 10 and 19 years [3], and the age of 10-11 years are considered to be a key transition age in a primary prevention perspective [4]. The adolescent's health is a result of interaction between influences in early childhood and the biological, social and behavioural changes during adolescence [1, 5]. Brain development and other biological changes that occur during puberty are known to influence the onset of health behaviours during adolescence, that may be crucial for future health [1]. The surrounding environment, such as families, schools and peers, are further found to strongly affect adolescents' health, and may thus facilitate good opportunities of a healthy lifestyle [6, 7]. As adult health is a result of exposure and processes throughout the life course [5], adolescence is considered a phase of life where foundations for a healthy future may be established [1, 5, 8].

1.1 The childhood obesity epidemic

The global obesity epidemic represents an enormous threat to public health, because overweight and obesity are major risk factors of non-communicable diseases like coronary heart disease and type 2 diabetes [9, 10]. Moreover, the second report on the prevention of cancer pointed out overweight and obesity as the major cause of several types of cancer [11]. Childhood overweight and obesity contribute to the obesity epidemic in adults as these children are more likely to become overweight or obese as adults [12-14], and thereby create a potential health challenge for the next generation worldwide [15].

Overweight and obesity are defined by the WHO [16] as abnormal or excessive fat accumulation that presents a risk to health. The crude measure of obesity is body mass index (BMI). An adult person with a BMI equal to or more than 25 kg/m^2 is classified as overweight, and a BMI equal to or more than 30 kg/m^2 is considered to be obesity [17]. Because BMI changes substantially with age during childhood, international based cut off points are needed to provide a tool for comparing prevalence rates across countries [18]. Age and gender specific BMI cut off values were thus proposed by the International Obesity Task

Force (IOTF), to internationally quantify childhood obesity [18]. The short term health consequences of overweight in children are not clear [16]. However, some effects of obesity are already observed in children, such as elevated low density lipoprotein cholesterol, high blood pressure, type 2 diabetes, asthma [11, 19, 20] and psychological related health outcomes [16, 20]. Long term health consequences of childhood overweight and obesity have further been observed in adulthood, such as metabolic disease, cardiovascular risk, morbidity and premature mortality [12, 20, 21].

1.1.1 Prevalence and trends

The prevalence of overweight and obesity has increased among children and adolescents worldwide [12, 15, 22], as well as in most European [22-24] and Nordic [25] countries during the past decades. A recent cross-sectional study among 10-12 year old children from seven European countries (the ENERGY study) found that 26% of boys and 22% of girls were overweight or obese, based on IOTF cut off points on objective measures [26]. Higher prevalence of overweight and obesity was observed in children from the southern and eastern parts of Europe compared to the northern parts [26, 27]. The prevalence of overweight and obesity among Norwegian boys and girls participating in the ENERGY study was 15% and 14% respectively [26]. This is comparable with what was observed in a national representative sample of 9 and 15 year olds, with IOTF cut offs on objective measured weight and height [28]. The figures from Norway are similar to what has been observed in other Nordic countries within this age group [27, 29, 30].

Cross-sectional trend data from a WHO collaborative survey among 43 countries across Europe and North America; the Health Behaviour in School aged Children (HBSC) study, reported an average increase of overweight and obesity from 14% among 11 year olds and 13% among 13 year olds in 2005-06 [31] to 15% and 14% in 2009-10 [32], respectively. The measures were based on IOTF based cut off points on self-reported data. National representative data among Norwegian 13 year olds showed an increase from 8% to 13% between 1993 and 2000, in cross-sectional trend data based on IOTF cut offs on self-reported data [33]. The Norwegian Child Growth Study observed an increase of overweight and obesity from 15% to 18% based on IOTF cut-offs on objective measures, among national samples of eight year olds (3rd graders) in the period from 2008 to 2010 [34]. However, the 2012 data of this study showed a prevalence of 16% overweight and obesity among Norwegian eight year olds [35]. This corresponds with the newest trend data in Sweden

showing a stable development of overweight and obesity among children and adolescents during the last years [30]. A recent review furthermore suggested that the prevalence of childhood obesity is levelling off both in the United States, Australia, Japan and in some European countries [36]. Although, this trend does not seem to have reached those with low socioeconomic status (SES) to the same degree as those with higher SES [36, 37]. A lack of objectively measured weight and height data on national representative samples have furthermore been reported in Europe [25, 37], and the stability of trend data needs further investigation [36-38].

1.1.2 Obesity prevention

The core problem of overweight and obesity is an imbalance between energy intake and expenditure over a prolonged period of time [12]. Although, the underlying factors are a complex constitution of societal and biological factors [12]. Genetic factors are well known to influence individuals' susceptibility to obesity [39, 40]. However, the increasing prevalence of obesity during the last decade is probably largely driven by environmental changes that encourage unhealthy lifestyles [40, 41]. Overweight and obesity among children are difficult to treat [42, 43], thus a public health effort to prevent unhealthy weight gain is needed [41, 44]. Public health efforts including recommendations of obesity prevention programs in Europe were discussed by the WHO already in 1997 [17], and several policy documents emphasizing the need for action have subsequently been published [9, 15, 45]. A Norwegian status report was presented in 2000 [46], followed by several national policy documents prioritizing children and adolescents across social groups in health promotion and disease prevention [47-50]. The importance of starting early in life in order to prevent obesity inducing behaviours of becoming habitual is highlighted [2, 13, 15, 50]. It is furthermore stated that parents are considered important in preventing children's weight related problems, and should be included in the prevention of obesity [7, 15, 50, 51].

The obesogenic environment provides less opportunities for healthy eating and activity behaviours [10], and is acknowledged to be an important promoter of the obesity epidemic [9, 52]. Regular physical activity and a high intake of dietary fibre are considered to be convincing protective factors against obesity, moreover supportive home and school environments are reported as probable protective factors for this matter [9, 10]. Convincing risk factors of obesity are sedentary lifestyles and a high intake of energy dense and micronutrient poor foods and a high intake of sugar sweetened beverages (SSB), while heavy

marketing of energy-dense foods is considered to be a probable risk factor of obesity [9, 10]. Beneficial effects on children's BMI are observed in obesity prevention programs that include a combination of lifestyle approaches [42, 53, 54]. Strategies to prevent obesity in children by encouraging healthy eating and activity behaviours are considered to be beneficial for all children and adolescents, despite weight status [43]. However, caution should be made that the strategies do not promote disordered eating and weight related harassment [43].

1.2 Energy balance related behaviours (EBRB)

Factors that raise energy intake or decrease energy expenditure by even a small amount may cause overweight or obesity in the long-term. Energy balance related behaviours (EBRB) refer to dietary, physical activity and sedentary behaviours that positively or negatively may influence weight status [55]. Thus, knowledge on EBRB is needed to understand the prevalence of obesity and other non-communicable diseases [26, 56, 57]. However, no single factor is responsible for obesity by itself, but rather the coexistence of EBRB that result in a positive energy balance within each individual [55]. Important dietary behaviours that are associated with increased overweight and obesity are a low intake of fibre, frequent energy dense snacking and frequent consumption of SSB, and important associations of activity behaviours are a low level of physical activity and more time spent sedentary [9, 55].

The concept of tracking is used in epidemiology literature to describe the longitudinal development of behaviours [58], and is generally used to indicate the risk of future diseases in subjects at an early age [59]. The study of tracking patterns is important when measuring stability and change in behaviour over time, and may help determine the proper timing for interventions to target a specific behaviour. Evidence of the tracking of EBRB between adolescence and into adulthood is reported [60-62], but relatively few studies have studied tracking between childhood and adolescence [61, 63]. Hence, there is a need for research to investigate longitudinal changes and tracking of EBRB in children during transition into adolescence [5, 63, 64].

This thesis focus on the EBRB related to dietary behaviours of young adolescents' consumption of fruits, vegetables, energy dense snacks and SSB, as well as behaviours of inactivity by adolescents' screen time, which will be further elaborated.

1.2.1 Dietary behaviours

Healthy dietary behaviours is particularly important among children and adolescents, given that these behaviours tend to be continued into adulthood [60]. Moreover, rapid changes in individuals' dietary behaviours may occur during adolescence [5, 65, 66]. Many children and adolescents fail to meet the dietary recommendations [67-69]. Thus, it is important to start at an early age in order to prevent unhealthy dietary behaviours of becoming habitual [56].

Investigating dietary behaviours in children during transition into adolescence longitudinally is therefore recommended in order to provide important information on when, how and why dietary changes occur [70-73], to be able to develop strategies for interventions [74, 75] and then further influence future health.

Fruits and vegetables

The intake of fruits and vegetables are considered to be part of a healthy balanced diet and has been associated with a lower risk of obesity [9, 76], especially based on their contribution to the intake of fibre [9, 77]. But more studies are needed in order to elucidate this relationship [78, 79]. A European study found the intake of fruits and vegetables to be lower than the recommended daily intake among both European and Norwegian 11 year olds [68]. The Norwegian national dietary survey among children and adolescents from the year of 2000 reported that 47% of boys and 48% of girls in 8th grade consumed less than 500 grams of fruit and vegetables a day [69]. On average the intake of fruits and vegetables were 255 grams/day among Norwegian 13 year olds in 2000 [69], and 216 grams/day in Norwegian 11 year olds in 2003 [68] in national representative samples. The intake of fruits and vegetables in different European countries are highly diverse, however figures from the Scandinavian countries are comparable [68]. Despite the low consumption, cross-sectional trend data from the HBSC study showed an increased frequency intake of fruits among Norwegian 11 year olds between 2001 and 2005 [80]. Results from another Norwegian cross-sectional trend study showed a decrease in frequency intake between 2001 and 2008 among 11-12 year olds, when both fruit and vegetable consumption were included [81].

Sugar sweetened beverages (SSB)

Soft drink consumption is found to be one of the EBRB associated with a positive energy balance among children and adolescents, and an important factor to consider in the prevention of obesity among children and adolescents [9-11, 82]. Furthermore, the consumption of soft

drinks is associated with an increased risk of tooth decay [83, 84]. The Norwegian national dietary survey among 13 year olds reported that on average 18% of the total energy intake were from added sugar [85], while the Norwegian nutrient recommendation is to limit the intake of added sugar to a maximum of 10% of the total energy intake [86]. The consumption of SSB among the 13 year olds contributed with 48% and 41% of the total intake of added sugar among boys and girls, respectively [69]. The consumption of soft drinks vary across Europe, reporting intakes from 92 ml/day among Greek girls to 700 ml/day among Dutch boys in a study of 10-12 year old adolescents from seven European countries in 2010 [26]. The consumption was 275 and 174 ml/day in Norwegian boys and girls [26], which is slightly less than the average of 336 and 242 ml/day reported among boys and girls in the Norwegian national dietary survey among 13 year olds in 2000 [69]. However, a decreasing cross-sectional trend in Norwegian adolescents' consumption frequency of soft drinks was observed among 11 and 12 year olds from 2001 to 2008 [87]. This is consistent with cross-sectional trend data from the HBSC study, showing a decrease in the consumption frequency of soft drinks among Norwegian 11 year olds from 2001 to 2005 [80].

Energy dense snacks

Energy dense and micronutrient poor snacking is also considered to be a risk factor of obesity [9, 10], and may furthermore displace children's intake of more healthful snacks such as fruit and vegetables [79]. In the Norwegian national dietary survey during the year of 2000, chocolate, cakes and sweets contributed with 24% and 32% of the total intake of added sugar in 13 year old boys and girls, respectively [69]. Moreover, the total intake of saturated fat was 13% in boys and 14% in girls measured as percentage of the total energy intake [69], which exceeds the Norwegian nutrient recommendation of a maximum of 10% of the total energy to be from saturated fats [86]. Chocolate, cakes, sweets and other snacks contributed with 24% and 29% of the total intake of saturated fat in boys and girls [69]. Data on adolescents' intake of snacks seem to be limited, but the number of snacking occasions have increased in both the United States and in European countries during the last decades [70, 88]. Recent Australian data does, however, report a slight decline in the intake of energy dense snacks among 12-13 year olds in 2004/2005 and followed up two years later [89]. A decrease in the consumption of sweets between 2001 and 2005 was also observed in all age groups of 11, 13, 15 and 16 years in the Norwegian data from the HBSC study [80].

1.2.2 Sedentary behaviours

Sedentary behaviours can be defined as low-energy expenditure activities [90-93], and reflect specific behaviours of very low intensity that indicate absence of activity [92, 94, 95]. It is important to notice that sedentary time and a failure to meet physical activity recommendations are considered as separate behaviours, and should be addressed independently [90, 93, 96]. The most common sedentary behaviours are related to desk-based work and education, motorized transport, sitting while socializing and screen time [90, 95]. Screen time includes time spent on watching television and videos, playing computer and electronic games and working on the computer, that is a major contributor to children and adolescents' time spent sedentary [97]. Television viewing is by far the most studied sedentary behaviour among children and adolescents [90-92], and other media based behaviours such as electronic games additionally needs to be addressed [94, 95]. Tracking of sedentary behaviours is observed from childhood and adolescence into adulthood [64], and time spent sedentary during childhood is further associated with several negative health consequences in adulthood [91, 98]. Hence, opportunities for good health and future patterns of adult health may be established in the transition phase of children growing into adolescence [1]. Priority should be given to gather new evidence from prospective studies of the sedentary behaviours of children and adolescents [60, 91, 95].

Screen time behaviours

Television viewing is associated with BMI and overweight among adolescents [91, 92, 99], as well as physical and psychosocial health [92]. However the evidence relating computer use and video games to obesity is less clear [99]. There are no stated recommendations to limit children or adolescents screen time in Norway. Although, several countries suggest a recommendation of spending a maximum of two hours/day on electronic media use [100-102]. The HBSC study reported in 2009-10 that 56% of 11 year olds watched television or video and DVD two hours or more on weekdays, which was a slightly larger proportion than the average reported by participating Norwegian 11 year olds [32]. Adolescents living in Europe are generally exceeding the media recommendations [103], however differences are found between countries [26, 104]. A recent review reported children and adolescents' average time spent watching television to be in the range of 1.5-3.7 hours/day among boys and in the range of 1.4-3.0 hours/day among girls [90]. This is in correspondence with a previous review [93] as well as recent data from Europe including the Nordic countries [26,

104]. A recent European study further reported that the average frequency of time spent on television among Norwegian 10-12 years olds was 1.8 and 1.6 hours/day in boys and girls respectively, and average computer time was 1.5 hours/day among boys and 1.2 hours/day among girls [26]. Cross-sectional trend data among Norwegian adolescents show a decline in time spent on television viewing from 1993 through 2005 [80]. The figures are opposite for the use of computers and electronic games, showing an increase in usage between 2001 and 2005 [80].

1.3 Determinants of EBRB

Correlates and determinants refers to reproducible factors associated with behaviour, and are often used synonymously [105]. However, the term correlates are normally used cross-sectional, and do not support causal interferences [105]. Determinants may directly or indirectly influence behaviour, hence an indirect relationship may be affected through a third variable such as a confounder, covariate, moderator or mediator [106]. When the determinant influences a behaviour through an intermediate variable in the causal sequence, the variable is called a mediator [106]. Several determinants are related to EBRB, although the relationships differ from behaviour to behaviour and between target groups [55]. Thus, one single factor cannot be accountable for explaining behaviour, but rather a set of factors from multiple domains [107]. Determinants of EBRB may be non-modifiable such as sociodemographic characteristics or modifiable factors such as influences from the surrounding environment. A main challenge in obesity prevention lies in creating supportive environments for making healthy lifestyle choices [52]. It is therefore essential to determine factors in the environment that may influence the different EBRB, in order to support a healthy weight development [52, 55, 108]. Longitudinal studies are currently needed in order to identify possible environmental determinants of adolescents' EBRB [94, 109-111].

Theories and models can help to identify potential determinants of EBRB. Previous theories used to explain health related behaviours mainly focused on individual cognitive determinants of EBRB [112, 113]. As the environment of the modern society have changed in favour of unhealthy eating and activity behaviours [41, 95, 114], attention has been changed into acknowledging environmental determinants of health behaviours rather than the pure focus on individual determinants [10, 109]. Thus, current health related theories are mainly focused on the interrelation of individual and environmental factors to determine behaviour [109, 115].

This has led to a public health approach of ecological models in order to understand factors influencing obesity [52, 111]. In accordance to ecological models, multiple environmental levels might influence health [115]. An ecological model explains health behaviours through interaction between an individual and the surrounding interpersonal, institutional, community and public policy environments [116, 117] (Figure 1). More proximal interpersonal and institutional influences of where people meet and gather (e.g. homes, schools and neighbourhoods) can be referred to as the micro environment, and broader community and political infrastructures (e.g. town planning, transport and health system) are more distal environments that can be referred to as the macro level [52]. Individuals are thought to interact in a variety of micro environments that in turn are influenced by the larger macro environments [10]. Hence, these models can be used as an approach to disease prevention and health promotion by indentifying the influence of factors at different levels and the interactions between them [117, 118].

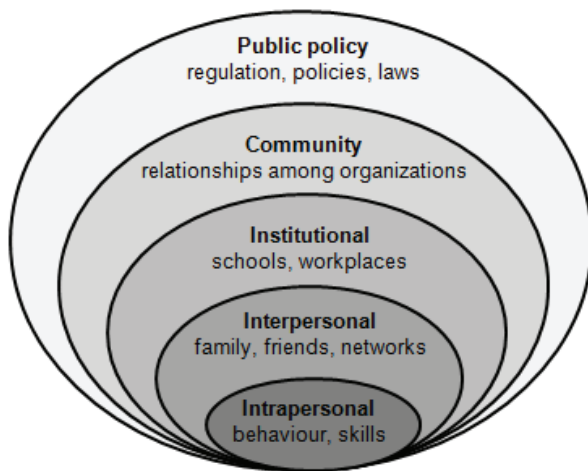


Figure 1 An ecological model, modified from McLeroy et. al. [116]

The Environmental Research framework for weight Gain prevention (EnRG) suggests that different environmental levels could influence EBRB both directly and indirectly through individual determinants [55] (Figure 2). This framework thus represent a dual-process view of how environment may influence behaviour [55], where each level of the environment is characterized by physical, sociocultural, economic and political domains as previously explained in a framework linked to dissecting obesity environments (ANGELO) [52]. The physical environment represents the availability of opportunities for healthy and unhealthy

choices, the sociocultural environment refers to social and cultural influences and norms, the economic environment represents cost related to healthy and unhealthy choices, and the political environment refers to the formal and informal rules related to healthy and unhealthy choices [52]. The direct influence indicates the automatic and unconscious effect of the environmental determinants on behaviour, and the indirect influence reflects the mediating role of individual cognitive factors in the effect of the environmental determinants on behaviour [55]. Various factors (e.g. gender) are furthermore suggested to moderate the relation either between environmental determinants and behaviour, or between the cognitive factors and behaviour [55].

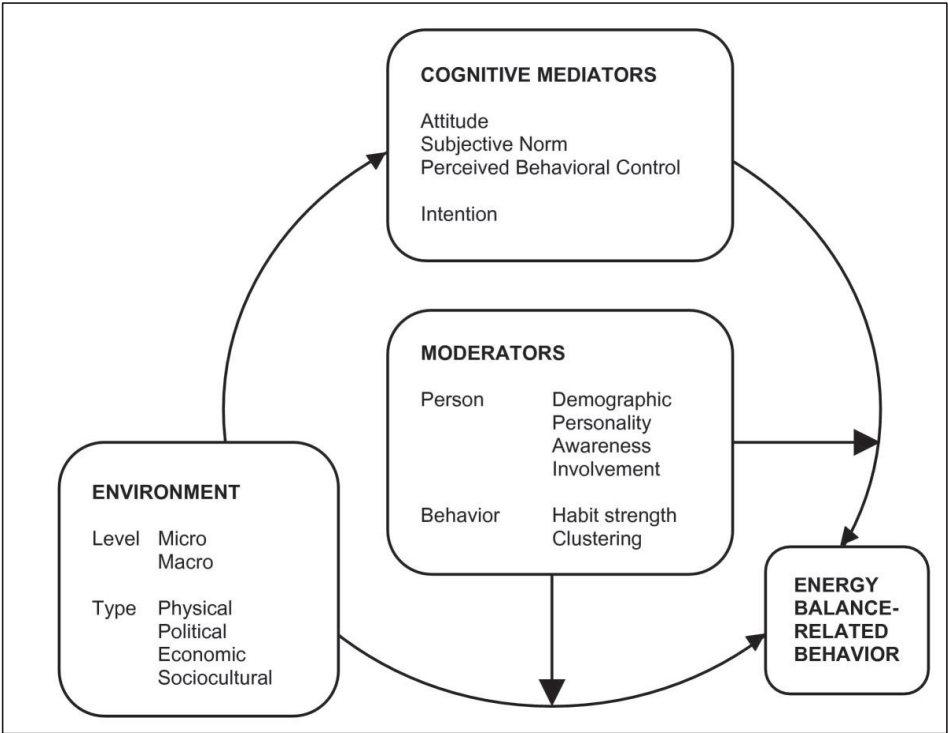


Figure 2 The Environmental Research framework for weight Gain prevention (EnRG) as proposed by Kremers et. al. [55]¹.

For children and adolescents the micro environmental levels are believed to have the most influence on behaviour, such as family, school and peer influences [6, 10]. The home and family environment is the most important setting of children and adolescents’ EBRB [10,

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119]. However, schools provide good opportunities to promote children and adolescents' health behaviours [10, 120]. Even though the importance of environmental influences on eating and activity behaviours have been recognized, specific areas such as consumption of energy rich foods and sedentary behaviours in the home are lacking empirical evidence [111]. Moreover, little research on EBRB is done with multivariate analyses, allowing for the adjustment of other potential individual or environmental correlates [109]. Thus, there is a need for studies to explore possible mediating and moderating pathways to improve the environmental research in obesity prevention [121].

1.3.1 Home environmental influences of behaviour

Parents play a crucial role in creating healthy home environments to influence the behaviours of their children [7, 10, 119, 122]. More research is needed to investigate parent's role in adolescents' EBRB [119, 123]. Longitudinal studies are needed to examine the relationship between the home environment and adolescents' dietary and sedentary behaviours [122, 124, 125]. Moreover, it is important to identify target determinants that may eliminate social inequalities in such behaviours [122].

Rosenkranz and Dzewaltowski's [119] model of the home food environment pertaining to childhood obesity proposes that the home food environment includes elements within all environmental domains. That is the political and economic level such as family SES, the physical (built and natural) level such as equipment, availability and accessibility, and sociocultural environments such as family traditions, practices and rules. All domains are suggested to influence children's dietary intake possibly through individual mediators and moderators of the child. Similarly, the conceptual model by Gattshall et. al. [123] focuses on the importance of the home environment through availability, accessibility, parental role modelling, and parental policies, in influencing children's healthy eating and physical activity.

Socioeconomic status

Socioeconomic conditions can be measured in several ways, such as by social class, socioeconomic position and SES. Socioeconomic position is a wider concept, commonly used in social epidemiology research [126], whereas SES is mainly based on the quantification of family income, parental occupational status, and parental education among children and

adolescents [127]. Income relates directly to the material conditions that may influence health, and occupation is the link between income and education that contributes to the structure of social roles [126]. Education reflects the knowledge of available resources that may influence health, and is shown to be associated with both occupation and income [128]. Level of education is considered to be the most important indicator of SES when investigating health related lifestyles in the Nordic countries [129].

SES has been investigated as a determinant of children and adolescents' dietary and sedentary behaviours, however inconsistent results were observed. A review investigating determinants of children and adolescents fruit and vegetable consumption reported that higher SES was associated with increased intake [130]. Whereas another review found positive associations between parental occupation and adolescents' fruit consumption [122], inconsistent results were reported between fruit and vegetable consumption and parental education by others [75, 110, 131]. A recent review further found household income and parental employment status inversely associated with adolescents soft drink consumption [122]. Inconsistent results were reported in regards to differences in soft drink and snacks intake by parental education [75, 110]. Reviewed evidence also revealed inconsistent associations between SES and sedentary behaviours [96, 122, 132]. The available evidence is mainly limited to cross-sectional findings [96]. Although, a negative association was found between parental education and television viewing among children and adolescents [96, 133], and between maternal education and computer use among young children [132].

Physical determinants

Parents are considered as important gatekeepers in controlling the home food environment by determining what, when and how foods are prepared in the home [10, 108]. Reviews of children and adolescents' fruit and vegetable consumption found availability and accessibility in the home to be important physical environmental correlates positively related to intake [110, 130, 134]. Although studies were limited with regards to adolescents [110], this was supported by a recent cross-sectional European study [135] and a recent prospective study [89] among adolescents. A recent review furthermore reported that availability of soft drinks at home was positively associated with adolescents' soft drink intake [122]. Availability and accessibility of soft drinks in the home, as well as drinking soft drinks with meals were suggested to be positively related to adolescents' soft drink intake in recent cross-sectional studies [136-138]. Another cross-sectional study found that access to unhealthy foods was

related to a higher intake of unhealthy foods in general [139]. A recent prospective study further reported home availability of energy dense foods to be positively associated with change in energy dense snack consumption among adolescents [89]. There is limited evidence on predictors of change in adolescents' dietary behaviours, and further studies are needed [89]. The availability of electronic forms of entertainment is one of the most profound changes in the developed societies in the world during the last decades [90]. Recent reviews report that physical environmental correlates of children and adolescents' screen time are related to availability of televisions [90, 132] and computers [90] in the home, as well as availability of television in the bedroom [90, 93, 132]. Prospective studies are needed in order to investigate these relationships longitudinally [125].

Sociocultural determinants

Reviews reported parental intake/modelling to be the most important sociocultural home environmental factor of children and adolescents' dietary intake [122, 130, 131]. A positive relationship of parental intake was reported for the intake of fruits and vegetables [130, 131], as well as an authoritative parenting style and family connectedness were positively associated with intake among adolescents [110]. A recent review furthermore reported that parental soft drink consumption and a permissive parenting style were positively associated with adolescents' soft drink intake, while parental limits and having family dinners were found to be inversely associated [122]. A cross-sectional study recently conducted in eight European countries furthermore suggested parental modelling, family consumption, parental permissiveness, monitoring and parental self-efficacy to be positively associated with an increase in adolescents' soft drink consumption [138]. There is little knowledge on correlates of children and adolescents' intake of energy dense snacks [110], and no consistent associations have been found.

A recent review concluded that parental rules/regulation were the most important correlate of adolescents' screen time, and that the relationship was inverse [122]. This was supported by other reviews [90, 132], which also found parental television viewing/modelling [90, 93, 133] and single-parent/guardian families [133] to be positively related to children and adolescents' screen time. However, recent evidence is reported as scarce [132], and more studies are needed to support these findings [90, 96]. Moreover, information is needed to identify correlates of different types of screen time behaviours as these may differ between television time and other screen time activities [93-95].

Parent-child gender dyads

Bandura [112] states that children's behaviours at home in general are more related to gender specific behaviours of parents with the same sex than the opposite, when growing older. However, gender related modelling is influenced by social contexts, such as gender conception of the behaviour, and may vary at different periods in life [112]. According to family system theories, each family member is shaping and being shaped by other family members' actions [140]. Parents in many Western societies today share time and responsibility for the daily care of their children more equally than in past generations [141]. Today fathers participate more in the daily care of children, and Scandinavian countries are quite modern societies in this respect. The child's gender identification with their same sex parent may therefore be influenced, and contribute to complex family relationships over time [141]. Associations of mother-daughter, mother-son, father-daughter and father-son are therefore interesting in an obesity prevention perspective [142].

Mothers' and father's parenting practices, support and modelling of dietary and sedentary behaviours are associated with adolescents' weight development [143]. Daughters with higher BMI were found among fathers who did not model or encourage healthy behaviours, and sons with higher BMI were found when both parents did not model healthy behaviours [143]. Differences between mothers' and fathers' parenting practices and modelling of healthy eating have furthermore been suggested to play a role in adolescents' weight development [143]. Also, overweight mothers have been shown to more often have sedentary daughters than normal weight mothers [144]. However, the role of parent-child relationships in adolescents' dietary and sedentary behaviours has been less studied.

Reviewed evidence on gender differences of children and adolescents' intake of fruits and vegetables generally found a higher intake among girls [130], which is supported by a recent prospective study [89]. An increased soft drink intake among adolescents were in cross-sectional studies associated with boys [136, 137, 145], which is also reported for the intake of energy dense snacks by both cross-sectional [145] and longitudinal [89] studies. Inconsistent results with regards to gender differences in adolescents' sedentary behaviours and screen time have been reported in reviews [90, 132, 133].

1.4 Aims

Due to the enormous public health consequences of overweight and obesity, and the documented gaps in international research literature regarding longitudinal studies of EBRB in children and adolescents, this study aimed to investigate the changes and tracking in children's dietary behaviours during the transition into adolescence. By studying the tracking of dietary behaviours, it will be possible to identify the critical age of which the onset of unhealthy dietary behaviours occur, which further may indicate when prevention efforts are of importance. Moreover, longitudinal studies are needed in order to identify possible determinants of adolescents' EBRB. As adolescents' EBRB are highly influenced by their home environment, this study aimed to investigate how the home environment influences young adolescents' obesity inducing dietary and screen time behaviours longitudinally. This study further aimed to examine the possible occurrence of multiple effects of home environmental determinants concurrently. By identifying potential modifiable mediators of adolescents' EBRB future interventions may be improved.

Based on the conceptual model of the HHealth In Adolescents (HEIA) study [146], a model was formed to visualize possible relationships between the home environment and adolescents' dietary and sedentary behaviours (Figure 3). The model was also inspired by previous conceptual models developed to investigate home environmental relationships [119, 123]. The proposed model further implies that the relationship between parental education and adolescents' dietary and sedentary behaviours may be mediated through other factors in the home food environment.

1.4.1 Research questions

The specific research questions proposed for the present thesis are listed as followed.

- 1) Do adolescents' dietary behaviours of fruits, vegetables, snacks, soft drinks and squash change between the ages of 11 and 13 years, and how does the intake track during adolescence? (Paper I)
- 2) What is the prospective relationship between parental education and adolescents' dietary and screen time behaviours? (Papers I, II & III)

- 3) Do home environmental determinants of availability, accessibility, parental modelling and/or regulation mediate the relationship between parental education and adolescents' prospective soft drink consumption or screen time at the age of 13 years? (Papers II & III)
- 4) Are there any gender relationships in dyads of parents' and adolescents' screen time? (Paper III)

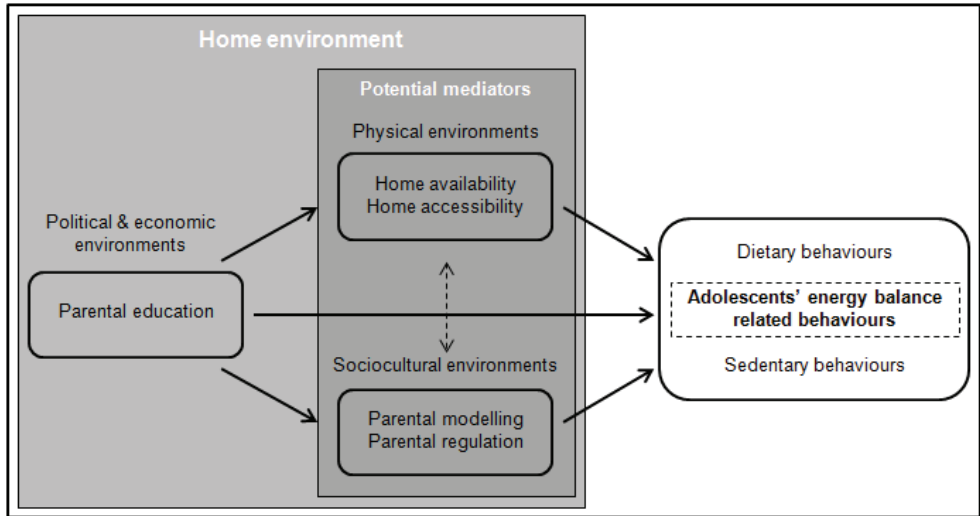


Figure 3 Model of the influence of the home food environment on adolescents' energy balance related behaviours.

2 METHOD

The HEIA study was a 20 month school-based intervention study carried out among pupils in 6th through 7th grade in 2007 to 2009, as a collaboration between the University of Oslo and Norwegian School of Sport Sciences. The overall aim was to promote healthy weight development in school children through dietary behaviours and physical activity. Seven counties in the south-eastern part of Norway were targeted, and 177 schools with a minimum of 40 enrolled pupils in 6th grade were identified and invited to participate. A total of 37 schools agreed to take part in the HEIA study, and these were randomly assigned into 12 intervention schools and 25 control schools with a cluster-randomized controlled design. Approval for the study was obtained from the Regional Committees for Medical Research Ethics and the Norwegian Social Science Data Service. Participation in the study was voluntary at all times. The papers suggested for this thesis is based on the HEIA cohort study, which include data collected from all participants in the 25 control schools of the HEIA study. The design and methodology of the intervention study is described in detail elsewhere [146].

2.1 Subjects and study design

All 6th graders and their parents/legal guardians (hereafter referred to as parents) from the 25 control schools were invited to participate, resulting in 1381 eligible adolescents for the HEIA cohort (Figure 4). Parent signed informed consent forms were obtained from 1014 (73%) of the adolescents, and data was collected at three time points. The baseline survey (T0) was carried out in September 2007 with 975 (71 %) participating adolescents. In May 2008 the first follow-up (T1) was conducted including the attendance of 970 (70 %) adolescents, and 20 months after T0 a second follow-up (T2) was conducted during May 2009. There were 945 (68 %) adolescents participating at T2, and altogether 885 (64%) of the adolescents attended all there time points of data collection. Parental participation among included adolescents was 738 (76%) mothers and 630 (65%) fathers at T0.

At all time points adolescents answered Internet-based questionnaires assessing dietary, physical activity and sedentary behaviours and their determinants. The questionnaires consisted of mostly pre-coded answer categories, and were distributed during school hours. Adolescents' spent about one school hour (45 minutes) in order to complete the questionnaire, and project workers were available during data collection sessions. The dietary behaviours

investigated were intake of fruits, vegetables, snacks and beverages. Physical activity was investigated by school- and leisure time activity and active transport, and sedentary behaviours by television and video viewing (TV/DVD), and computer and electronic game use (PC/game). Anthropometrics were measured among adolescents by project workers at T0 and T2, and separate forms were filled in assessing puberty status. Moreover, physical activity was objectively measured by accelerometers in five consecutive days, including two weekend days.

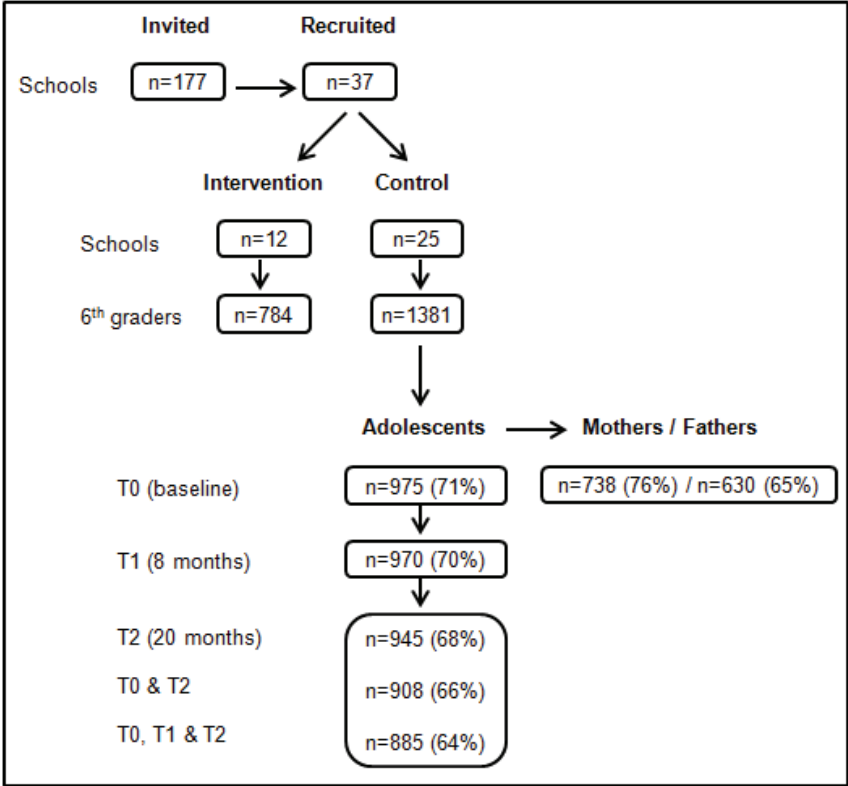


Figure 4 The HEIA cohort study, flowchart of participation

Adolescents brought home scan-able questionnaires for both their parents to fill in at T0 and T2. These were to be sealed in envelopes, returned to schools and then picked up by project workers. Mothers and fathers were asked to answer similar pre-coded questions as their adolescents assessing dietary, physical activity and sedentary behaviours, their determinants, as well as determinants related to their child’s behaviours. Parents self-reported height, weight, hip and waist circumferences were collected through their questionnaires. A separate

home food inventory questionnaire was answered by mothers at T0 and by either mothers or fathers at T2, assessing the availability of foods and drinks in the home at a specific time point.

A separate test-retest study was conducted among 114 6th graders from four schools sampled in the same area as the main study. The mothers' (n=43), fathers' (n=35) and children's questionnaires and anthropometric measurements of the child were measured with two weeks apart [146]. Spearman's rank correlation coefficient was used to assess the two week test-retest reliability of measurements presented in the papers (Table 1). The HEIA questionnaires were not validated by themselves. However, most of the questions were adopted from previously validated instruments (Appendix 1 and 2), as described in the following section.

2.2 Assessment of variables

All variables included in this thesis were assessed by the questionnaires measuring adolescents at T0, T1 and T2, and both parents at T0. The questions included in the current analyses are summarized in Appendix 1 and 2.

2.2.1 Demographics

Parental education for both caregivers was assessed through the adolescents' consent forms by the question "What is your highest level of education?" The answer categories were based on levels proposed by statistics Norway: less than 7 years, elementary school (7-9 years), high school/comprehensive school (10-12 years), lower college/university (1-4 years) or higher college/university (>4 years). For the purpose of the present analyses, level of parental education was either divided into three categories of low (≤ 12 years), medium (lower college/university) and high (higher college/university) education, or dichotomously into low (≤ 12 years) and high (college/university attendance) education. Living status of the adolescents were measured by the question "Which adults are you living with at the moment?" with the answer categories: living with my mother and father, my mother only, my father only, fifty/fifty with my mother or my father, my mother and her partner, my father and his partner, with foster parents or with other adults, please specify. In the present analyses, living status was dichotomously divided into living in two-parent families (including parents and step-parents) and living in other families.

2.2.2 Anthropometrics

Adolescents' height was measured by same-sex project workers to the nearest 0.1 cm on a wall-mounted measuring tape with the adolescents standing up against the wall and without shoes. Weight was measured on light clothed adolescents to the nearest 0.1 kg by a Tanita scale. More details of the anthropometric measurements are described elsewhere [147]. BMI was calculated as $\text{weight}/(\text{height}^2)$, and age- and gender specific cut-off values developed by the IOTF were used to categorize the adolescents into non-overweight or overweight/obese [18].

2.2.3 Behaviours

The intake of foods were measured by frequency for the following items; fresh fruits, raw and cooked vegetables, chocolates and sweets, salty snacks, sweet biscuits, cakes and buns [146]. Consumption of beverages were measured by frequency and amount for the following items; sugar sweetened and diet soft drinks and squash, ice tea, fruit juices, fruit drinks, flavoured milk products and water [146]. The questions used were based on already existing questionnaires [69, 148], and modified to suit to the HEIA study. The original questionnaires were previously validated among Norwegian adolescents, and satisfactory correlations between the questionnaires and the reference methods were obtained in these validation studies [149, 150]. The food items included in the present study were intake of fresh fruits (further referred to as fruits), raw and cooked vegetables (further referred to as vegetables), chocolates, sweets and salty snacks (further referred to as snacks), carbonated sugar sweetened soft drinks (further referred to as soft drinks) and sugar sweetened squash (further referred to as squash). The food items of sweet biscuits, cakes and buns, ice tea and flavoured milk products were excluded in the current analyses, since they were only measured among adolescents at T0 and T2. Other beverages than soft drinks and squash were not included in this thesis, as these were the most interesting beverages in an EBRB perspective. Moreover, determinants were not measured for other beverages than soft drinks and squash. Test-retest correlation coefficients from the HEIA reliability study showed acceptable consistency over two weeks, ranging from 0.5 to 0.8, for adolescents intake of the included dietary items (Table 1).

Table 1 Test-retest correlation coefficients of included behaviours and determinants

Variables	Values	Adolescents		Mothers		Fathers	
		n	Sr	n	Sr	n	Sr
<i>Behaviours</i>							
Fruits	frequency/week	111	0.78				
Vegetables	frequency/week	106	0.77				
Snacks	frequency/week	106	0.50				
Soft drinks	dl/week	95	0.73				
Squash	dl/week	84	0.73				
TV/DVD	hours/week	107	0.72	44	0.83	35	0.91
PC/games	hours/week	105	0.71	44	0.51	34	0.81
<i>Determinants</i>							
Availability soft drinks	yes/no			41	0.61		
Accessibility soft drinks	6 point scale	111	0.67	43	0.71	34	0.65
Regulation TV/DVD	5 point scale			44	0.32	35	0.39
Regulation PC/games	5 point scale			44	0.69	35	0.52

Sr: Spearman's rank correlation coefficient

Sedentary behaviours were measured as frequency and amount of time spent on TV/DVD and PC/games. The question on TV/DVD time was modified from the PEACH study that included 10-11 year old British children [151]. For the purpose of the present study, time used during weekday and weekend days were distinguished during assessment, as suggested by the HBSC study [152]. Time spent on PC/games was not included in the PEACH study, and subsequently the authors composed a similar question to assess the usual time spent on PC/games during spare time. Acceptable correlations of 0.7 among adolescents and 0.5 to 0.9 among parents, were found in the HEIA reliability study when measuring screen time behaviours (Table 1).

2.2.4 Determinants

Perceived accessibility of soft drinks at home was measured among adolescents, mothers and fathers. The questions were modified from the Norwegian Fruit and Vegetables Make the Marks study, that was conducted among Norwegian 6th and 7th graders and their parents [136, 153]. Availability of soft drinks in the home was measured among mothers through the home food inventory questionnaire. The questionnaire was previously validated in an American study including families of 10-17 year old students, obtaining satisfactory validity among the parents of which 76% were mothers [154]. Test-retest reliability scores from the HEIA study

showed acceptable correlations of 0.7 among adolescents and 0.6-0.7 among parents, for measurements of perceived accessibility and availability in the home (Table 1).

Parental regulation of adolescents' time spent on TV/DVD and PC/games was measured among mothers and fathers. The question on regulation of TV/DVD time was derived from a previously reliability tested and published instrument [155], whereas the question on regulation of PC/games was composed based on this question. The original construct measured parental regulation of TV/DVD based on a six items scale. However, in order to keep as many parents as possible in the analyses of the present thesis, only the question directly related to parental regulation of television viewing was included. The answer categories were measured on a five point Likert scale. A variety of correlation coefficients, ranging from 0.3 to 0.7, were obtained in mothers' and fathers' test-retest measurements of parental regulation (Table 1). The weakest correlations were found in both parents regulation of TV/DVD, whereas acceptable correlations were found in parents' regulation of PC/games.

2.3 Statistical analyses

Demographics were presented by means and 95% confidence intervals (CI) unless otherwise stated. The significance level was set to $p < 0.05$, and all statistical analyses were performed by IBM® SPSS® Statistics, version 18.0 (IBM Corp., Somers, New York, USA). Differences in continuous variables were investigated by t-test or analysis of variance (ANOVA), and chi-squared test was used for categorical data. Pearson's correlation coefficient was performed to investigate parametric associations of continuous variables, and Spearman's rank correlation coefficient was used for non-parametric associations. Both parametric and non-parametric tests were tested when the distribution of data were questionable, and presented with parametric tests when the results were similar and number of cases were high. Bonferroni correction was used when adjusting for multiple testing.

2.3.1 Clustering effect by school

The cluster effect of the behavioural variables was tested by using Linear Mixed Models, as the participants were invited through schools. Individuals within a defined group are thought to be more similar than those of other groups. The intraclass correlation (ICC) was used to quantify the degree of clustering of individuals at the school level. However, if the ICC is

small there is no meaningful difference among groups, and the data may be analyzed at the individual level with disregards to the clustering effect [156, 157]. Moreover, the HEIA study found adolescents' dietary behaviours to be independent of school-level [158], as supported by a recent review stating that intrapersonal factors play a more important role [75]. Little is known about the influence of school on adolescents' sedentary behaviours [122]. However, the HEIA study reported a low unexplained variance of the included screen-time behaviours at the school level [159], and therefore multilevel analyses were not performed.

2.3.2 Tracking

Tracking can be defined as the relative stability of behaviour over time [58], or to maintain the relative position in rank within a group over time [160]. The present study used several methods in order to describe the magnitude of tracking in adolescents' intake of fruits, vegetables, snacks, soft drinks and squash over 20 months. First, tracking of variables was illustrated by tracking patterns at T0, T1 and T2 based on groups of consumption at T0. Second, stability was shown by the percentage of individuals remaining in the same group of consumption at T0 and T2, and change was presented by percentages of decrease or increase in consumption between the time points. Third, Cohen's weighted kappa was used as tracking coefficients to test the agreement between each individual's relative position in rank from T0 to T2. The Kappa values were weighted in order to take into account the distance of movement between groups, based on the squared distance between categories as suggested by Fleiss and Cohen [161]. The available command syntax for SPSS (IBM Corp., SPSS Statistics 2010, Somers, New York, USA) was used, in order to calculate Cohen's weighted kappa. Finally, multinomial logistic regression was used to investigate possible associations between level of parental education and the tracking of each of the dietary variables from T0 to T2.

2.3.3 Mediation

Mediators are defined as modifiable determinants that transmit the effect of an independent variable (X) on a dependent variable (Y) [106, 162]. A conceptual model of single mediation is shown in Figure 5, based on the model proposed by MacKinnon, Fairchild and Fritz [106]. The total effect of X on Y is represented by the c-path. The a-path represents the relationship between X and the mediator (M), and the b-path represents the relationship between M and Y when adjusted for X. The direct effect of X on Y, when adjusted for M is represented by the

c'-path [106]. The mediation effect is calculated either by the a-path multiplied by the b-path ($a*b$) or by subtracting the c'-path from the c-path ($c-c'$) [106, 163]. The single mediation model may be extended to include multiple independent variables, mediators or outcomes allowing for multilevel analyses, subgroup analyses and analyses of longitudinal data [106].

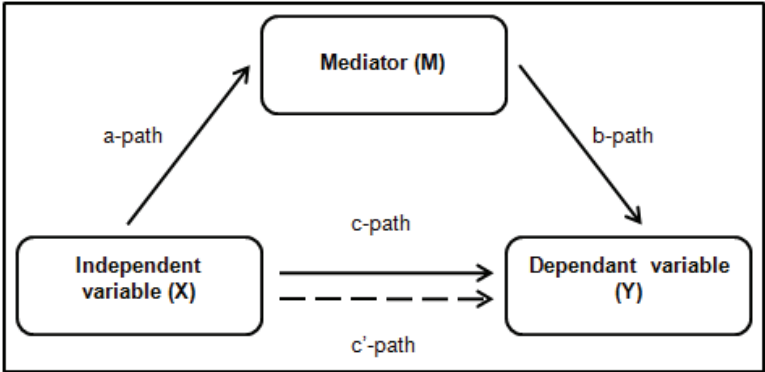


Figure 5 Mediation analysis

There are several assumptions related to single mediation analysis [106]. However, to statistically test all assumptions of mediation is not feasible, and so proof of mediation may be counted as impossible without taking proper evidence from previous research into account [106]. Statistical assumptions for mediation analyses were examined by testing normality of residuals, with Probability plots and Scatter plots. Moreover, outliers were checked for by Mahalanobis and Cook's distance tests. Durbin-Watson statistics and Dot plots were computed in order to check for independence between the residuals. Coefficients of collinearity were used to look for correlation between the independent variables, and possible interactions of $X*M$ were investigated.

The statistical assumptions for the mediation analyses included in the present thesis were considered acceptable. The distribution of residuals was satisfactory and no extreme outliers were detected. Furthermore, independence of the a-path and b-path residuals were confirmed, and no interaction between X and M were detected. Finally, the causal order of the model was assumed to not exceed the proposed directions. Mediation was then investigated by linear regression using the available SPSS script proposed by Preacher & Hayes [163]. Confidence intervals and level of significance were obtained by bias-corrected bootstrapping of 1000 independent samples [163], which is recommended as the most powerful method to obtain power estimates of 0.8 in mediation analyses with smaller samples [164].

3 RESULTS

3.1 Paper I – Tracking of dietary behaviours in adolescents

This paper investigated the tracking and change in intake of fruits, vegetables, snacks, soft drinks and squash between the ages of 11 and 13 years, and possible differences by parental education. A total of 885 adolescents attended all time points of data collection, with 53% participating boys. The mean age was 11 years at T0, 12 years at T1 and 13 years at T2 in both genders. No significant changes were seen in the adolescents' intake of any of the dietary behaviours investigated between T0 and T1. However, the intake of soft drinks increased significantly over time by 0.9 and 0.7 dl/week in boys and girls, respectively, from T0 to T2.

The results further indicated that boys and girls generally maintained their relative position in rank for their intake of fruits, vegetables, snacks, soft drinks and squash between the ages of 11 to 13 years, when grouped by baseline consumption. The highest proportion of stability was observed for the intake of squash in both genders. Tracking coefficients indicated fair tracking of fruits, vegetables, snacks and soft drinks among boys, and of vegetables and snacks among girls from T0 to T2. Moderate tracking coefficients were observed for boys' intake of squash and girls intake of fruits, soft drinks and squash.

An inverse association was found in both genders between level of parental education and tracking in adolescents' soft drink and squash consumption during the 20 months of assessment. Boys and girls with parents of high education had higher odds of a stable low intake of soft drinks and squash, when compared to those with parents of low education (OR=2.6-3.9). No significant associations were seen between level of parental education and tracking of fruits, vegetables or snacks between the ages of 11 to 13 years.

3.2 Paper II – Adolescents’ prospective intake of soft drinks

The prospective relationship between parental education and adolescents’ soft drink intake from the age of 11 to 13 years was investigated in this paper by the prediction and change in the behaviour over 20 months. Moreover, possible mediating effects of availability and perceived accessibility of soft drinks at home were examined. Data were obtained from the 908 adolescents attending T0 and T2, and 866 of these were meeting the analytical criteria of having valid data on parental education at T0 and soft drink consumption at T2. Additionally, mothers (n=738) and fathers (n=630) with parental reports at T0 were included in the analyses. A total of 31% of the adolescents had parents with lower education, compared to having parents that attended university/collage. Adolescents with parents of low education consumed significantly more soft drinks at both time points, than those of parents with high education. Moreover, a significant relationship were observed between a lower level of parental education and a higher perceived accessibility of soft drinks as measured by adolescents, by mothers and by fathers at T0. No difference by parental education was seen for the availability of soft drinks at home.

Mediation analyses consistently found a lower level of parental education to predict a higher intake of soft drinks among adolescents at the age of 13 years (c-path). Perceived accessibility of soft drinks reported by adolescents and mothers partly mediated this relationship by explaining 39% of the total effect. Furthermore, perceived accessibility reported by adolescents, mothers and fathers and availability at home were significant predictors of adolescents’ soft drink intake between the ages of 11 and 13 years (b-path). No relationship was observed between parental education and the change in adolescents’ intake of soft drinks during the 20 months, and no mediation effects of perceived accessibility reported by adolescents, mothers or fathers or availability at home were observed.

3.3 Paper III – Parental influence on adolescents' prospective screen time

The purpose of this paper was to investigate the influence of parental modelling and regulation on adolescents' prospective TV/DVD and PC/game time between the ages of 11 to 13 years, in parent-child gender relationships and as mediators of differences by parental education. The 908 adolescents attending T0 and T2 were included in the present analyses, as well as their participating mothers (n=738) and fathers (n=630) at T0. Adolescents and parents reported similar time spent on TV/DVD at T0, but time spent on PC/games differed between adolescents' and parents' reports. Significant associations were furthermore observed in gender dyads of parents and adolescents time spent on TV/DVD at the age of 11 and 13 years. Associations between mothers and sons and between fathers and daughters were also observed in time spent on PC/games at the age of 11 years.

Mediation analyses showed a lower level of parental education to predict more time spent on PC/games among adolescents at the age of 13 years (c-path), but no such relationship was observed for adolescents' prospective TV/DVD time. Maternal and paternal modelling was, however, found to mediate the prospective relationship of parental education predicting adolescents' TV/DVD time at the age of 13 years. Both maternal and paternal modelling were furthermore positively associated with adolescents' time spent on TV/DVD between the ages of 11 and 13 years, while maternal and paternal regulation were inversely related (b-path). No mediating effects were observed for maternal or paternal modelling or regulation of adolescents' prospective PC/game time. Although, paternal modelling were found to be positively associated with adolescents' time spent on PC/games between the ages of 11 to 13 years (b-path).

4 DISCUSSION

Ecological models emphasize the importance of environmental factors in adolescents' health behaviours. Thus, behaviours that influence children's weight status occur within a context that is both complex and highly interactive. Children's weight status is thought to be influenced by environmental factors both proximal and distal to the child [119]. However, the home environment is considered as most important in preventing children's weight related problems [119].

This thesis highlights the importance of the home environment for young adolescents' dietary and screen time behaviours. Methodological aspects influencing the results will be considered, followed by a discussion of the results.

4.1 Methodological considerations

There are several strengths of the present study, first the longitudinal study design based on a relatively large sample size at a narrow age range. Second, the rate of subject retention was very high. Third, the multiple EBRB investigated rendered the possibility of looking at different aspects of the adolescents' lifestyles. Fourth, the included questions assessing dietary and screen time behaviours among adolescents obtained acceptable test-retest correlations, indicating reliability of the measures. Fifth, parental reports of parental characteristics are considered to give more reliable measurements than when collected from the adolescents themselves. Sixth, the study included both parents, giving the opportunity of studying mothers' and fathers' reports separately. Finally, multiple methods were used in order to investigate longitudinal relationships of adolescents' dietary and screen time behaviours.

4.1.1 Generalizability

The schools invited to participate in the HEIA study were situated in the largest towns/municipalities in the eastern part of Norway. Thus the results cannot be generalized as national representative. A weakness of the study further includes a low response rate of schools initially invited to participate, with a potential selection bias. While the participation rate of sampled schools was only 21 %, attrition analyses showed that there was no significant difference in terms of the number of students in the sixth grade and overall size between

schools that participated in the study and schools that declined participation [158]. Moreover, schools were included from all seven counties targeted in the HEIA study. Due to ethical considerations, reason for non-participation was not enquired. However, some schools (n=50) provided a reason for non-participation, with the most common reason being participation in other similar studies [158]. In addition, weighing of children is continuously debated in the Norwegian media, and may have affected the willingness of participation among schools. The prevalence of BMI within the total HEIA sample of 1485 participating adolescents was comparable with national data [28], thus indicating representativeness among this age group.

Data on SES characteristics are unfortunately not nationally registered at the school level in Norway, and thus SES of the 37 participating schools compared with the 177 invited schools are not available [165]. However, data on parental education was collected among 1527 adolescents in the total HEIA sample, corresponding with 71% of those invited to participate. When comparing the parental educational level of the total HEIA sample with the national educational level reported among 30-49 year olds by Statistics Norway, the proportion of the lowest educated parents (≤ 12 years) was about halved among the HEIA parents [165]. This means that the representativeness of the parents based on their education level can be questioned. Although a contributing factor might be that level of parental education is somewhat higher among those living in the eastern region of Norway [165], because there is a higher concentration of education institutions in this area. Overall, the generalizability of our findings is limited to represent highly educated people from the semi-urban areas surrounding the south-eastern region of Norway.

Attrition occurs due to drop-out in follow-up data collections, and poses threats to the generalizability of the result. The proportion of participating adolescents' lost to follow up was small in the present study, and thus not a big concern for the results. However, missing values appeared as a potential problem when including parental reports in the analyses. Attrition analyses was therefore conducted in each paper, comparing baseline data from the included participants with participants lost due to missing in parental reports. The differences between these samples were generally small, and did not seem to pose severe threats to the validity of the conclusions of this thesis. However, a higher level of parental education, living in two-parent families, a normal weight status and less time spent on PC/game were observed among adolescents in the subsample included in paper III when compared to the baseline sample of 975 adolescents. Analyses were thus adjusted for living status and weight status,

however differences by parental education may have been underestimated. The subsample analyses including parental reports may generally be skewed towards a more health conscious population, as the included parents might represent more interested and persistent than the parents that did not participate.

4.1.2 Reliability and validity of research instruments

Data collection of adolescents' dietary and screen-time behaviours was based on self-reported measures of frequency questionnaires, which may raise possible challenges due to measurement error. Children older than eight years have generally a higher ability to self-report than younger children, and cognitive abilities of reports are expected to be fully developed among adolescents [166]. However, issues of motivation and body-image may influence willingness to report on dietary intakes during adolescence [166], as well as issues of social expectations and norms in relation to the reporting of screen time behaviours [167]. A recent review concluded that the reliability and validity of self-reported food frequency questionnaires are generally acceptable among children and adolescents [168]. Self-reported measurements of screen time behaviours were in a recent review also found to provide reliable estimates among children and adolescents, although validity is largely untested [169]. Thus, caution should be made when interpreting the results of such instruments, and multiple studies are needed to be able to conclude. Finally, the questionnaire assessing adolescents' behaviours was in the present study Internet-based. However, mode of administration of questionnaires, computer or paper, have not been found to have significant effect on responses from adolescents on the majority of lifestyle behaviours [170].

As previously shown (Table 1), acceptable test-retest correlations of adolescents' reports were observed among adolescents participating in the present study, indicating reliability of the results. Although, this does not account for the possibility of information bias among the adolescents' reports if this was done consistently at both time points. The questions measuring adolescents' behaviours were mostly based on previously validated questionnaires within this age group. The intakes of fruits, vegetables, soft drinks and squash was furthermore compared between the 13 year olds in the HEIA cohort study (T2) with nationally representative data among 13 year olds in the year of 2000. Frequency of intakes of fruits and vegetables in the present study was thus calculated into grams/times/day as suggested by the corresponding validation study [149]. Although, the intake of fruits was higher and the intake of soft drinks and squash was lower in the HEIA cohort study than what was reported in the year of 2000,

recent trend studies consistently suggest such changes in frequency of intakes since the year of 2001 [80, 87]. Time spent on TV/DVD and PC/games among 11 year olds in the HEIA cohort study (T0) is comparable with nationally representative data among 9 year olds in 2011. Thus we believe a relative accuracy of the measurements used assessing dietary and screen time behaviours in the present thesis.

The use of parental education as an indicator of the adolescents' family SES has both advantages and drawbacks. Parental education is a hierarchic indicator of a persons SES, and the advantages include that education is easy to report and that few members of the population are excluded [126, 128, 171]. Moreover, level of education among adults undergoes small changes over the years, is considered available in both genders, and self reported measurements are considered to be reliable [126, 171]. Drawbacks are related to comparison with other countries, as well as across a larger time span and generations [126, 171]. However, such drawbacks are not considered as an issue in the HEIA study. The parental education variable used in the present analyses included information from the parent with the highest educational level, or else the one available. This was chosen in order to account for the highest educational level within the family, as mothers and fathers in the Western societies today are believed to share time and responsibility for the daily care of their children [141]. By using this variable, the parental educational level of the included adolescents may appear artificially high. However, as data is longitudinally measured among the same individuals, the level of parental education will still represent these adolescents' behaviours prospectively.

Measurements of home availability and accessibility are diverse, which are confusing and make comparisons between studies difficult [154, 172]. The availability of foods have previously been defined as whether foods are present in an environment, and accessibility as whether these foods are available in any form [172, 173]. Several validated measures of the availability of fruits and vegetables have been proposed [172, 174], and good validity and reliability are generally reported among adults for the self-report of food availability in the home through home food inventories [123, 154, 174]. However, few instruments provide comprehensive assessments of food availability in the home [154, 174], and few validated measures were found for the availability and accessibility of unhealthy foods such as SSB in the home [123]. Presumed accessibility of soft drinks was in the present study measured by adolescents and parent with the question: "When soft drinks with sugar are available at home,

can you (your child) serve yourself (him-/herself) as you (he/she) please(s)??". Hence, when asked among parents the question did not only measure presumed accessibility of soft drinks in the home, but to some extent also imply rules of consumption. However, no studies were identified to investigate parental regulation of adolescents' soft drink consumption by parental reports, and thereby data on validation testing of such measurements were not available. The current results should therefore be considered as preliminary in this field, and methodological studies are needed to establish good measurement of the presumed accessibility of foods in the home, as measured by adolescents and by parents.

Single items were predominately used to measure determinants of behaviour in the present study. This was a consequence of keeping the questionnaire within a reasonable extent, when addressing both multiple behaviours and their related determinants simultaneously [165]. The use of single items to assess determinants of behaviour may be less reliable and valid due to measurement error and greater score variation, than using multiple-item measures as proposed in psychometrics [175]. However, a single measurement may be sufficient when measuring a context not directly linked to an individual characteristic [175], such as availability in the home. Multiple items measuring parental regulation of TV/DVD time and PC/game time were available in the HEIA study. However, in order to keep as many parents as possible in the present study only single item measurements were included in the analyses. This was because missing appeared as a problem across the items, even when allowing for missing in one of the construct items. Thus all facets of parental regulation may not be captured, that may be a limitation in the present analyses. As few studies are available to make comparisons of the results, future studies should possibly include the use of multiple-item scales in order to verify the present analyses. Moreover, parental regulation of TV/DVD time obtained low test-retest correlation coefficients, indicating less reliability of these measurements. However, the larger sample size the larger tolerance of a less reliable instrument [176], and thus we believe the reliability of these measurements to be acceptable for the present analyses.

4.1.3 Evaluating the magnitude of tracking

Several methods can be used to evaluate the magnitude of tracking, which make comparison of tracking difficult [59]. For the tracking of continuous variables, Pearson and Spearman's rank correlation coefficient have been widely used [177]. However, significance testing of a tracking coefficient does not provide information about the magnitude of tracking, but rather

that tracking are significantly different from zero [59]. Continuous outcome variables can be divided into percentile groups or into groups according to pre-determined cut-off points [177]. By introducing cut-offs on continuous variables, it is important to notice that some information will be lost when the outcome variables are grouped [177]. For dichotomous and categorical variables a predictive value and relative probability can be calculated [177]. However, it is important to take into consideration that the higher possibility of tracking in extreme groups simply may be caused by statistical property when interpreting the proportion of tracking [59]. Thus tracking can only be concluded when the tracking proportion is significantly different between groups [59]. A commonly used measurement is also tracking by Cohen's Kappa [59]. As this method is weighing movement between groups equally [58], Cohen [178] further developed a correlation coefficient of weighted Kappa accounting for distances of movements over time.

More methodologies are available in order to measure tracking of several longitudinal time points [177]. As the present study conducted the first follow-up already after eight months, small changes were expected between T0 and T1. Nevertheless, the transition period between children and adolescence is a critical period during which rapid changes are expected to occur [1]. As tracking is influenced by the duration of follow-up it is important to take into account that a high tracking coefficient during a short period of time does not necessarily indicate more tracking than a modest tracking coefficient during a longer time span, when comparing the results [59]. Tracking patterns can illustrate evidence of tracking by investigating changes in mean group behaviours over several time points as the maintenance of a relative position in rank [160]. However, a tendency of regression towards the mean will necessarily occur in such analyses, and needs to be accounted for when interpreting the results. This phenomena is a result of the higher statistical probability of an extreme value at one time point being more likely to become less extreme on the next occasion when there is a non-perfect correlation among the two variables, which means almost all of the time [179].

4.1.4 Approaches to mediation analyses

The assessment of mediation is conducted by a series of regression analyses, and different approaches are proposed to statistical mediation analyses [106, 162, 163, 180]. Baron and Kenny's casual step approach from 1986 [162], is the most widely used method for mediation analyses [106, 181]. However, lately several limitations of this approach have been discussed,

especially in regards to the requirement of a significant association in the total effect (c-path) for mediation to occur [106, 163, 181, 182]. The product of coefficients approach to mediation analyses is thus recommended, because it can establish mediation even with the absence of a total effect [181, 183], and is therefore more suitable of detecting mediation in smaller samples [163, 184]. As stated by Shrout and Bolger [182], when a casual process becomes more distal the effect size normally gets smaller because of possible intermediate effects on the relationship. Finally, it is argued that results of mediation analyses should be reported even in the presence of null findings since they have the potential to extend our understanding of behaviour change [181].

In order to test for significance of the mediation effect a 95% confidence interval is needed, which can be obtained by using the Sobel's test that are suggested to be accurate in models with more than one mediator if the sample size exceeds 100-200 [106, 163]. However, this approach assume that both the a-path and the b-path follow a multivariate normal distribution as well as a normal distribution of total and mediation effects, which is rarely true [163]. By using bootstrapping methods, with preferably resampling of 1000 independent samples, the distribution will be examined empirically and thus this problem will be avoided [182]. Percentile bootstrap confidence intervals is then calculated, which reduces the problems with Type 1 errors and power when used in hypothesis testing [163]. Bias-corrected bootstrap tests are furthermore recommended in order to increase the power of the analyses [163, 164].

4.2 Interpretation of results

The main findings of this thesis will be discussed in light of the methodological aspects considered. Firstly the tracking of dietary behaviours will be addressed, followed by social differences by parental education in adolescents' prospective intake of SSB and screen time behaviours. Subsequently possible mediating effects of the home environment on the relationship between parental education and adolescents' prospective intake of soft drinks and screen time behaviours will be presented. Finally, gender related parent-child relationships of screen time will be assessed.

4.2.1 Tracking of dietary behaviours (Paper I)

Childhood and adolescence are key periods in life for the development of long-lasting dietary behaviours [5, 70, 72]. Moreover, adolescence is a period of rapid behavioural, psychological

and biological development that may influence such behaviours [5]. Studying the tracking of dietary behaviours during this age may help determine the proper timing of interventions to target behaviour changes, and thus establish good opportunities for a healthy diet in the future.

The present study found fair to moderate tracking of fruits and vegetables between the ages of 11 and 13 years. The findings is in line with previous studies [65, 185-187], although comparability between tracking studies is complicated due to differences in methods used and duration of follow-up [59]. The results indicate that low consumers of fruits and vegetables are likely to remain low consumers during this age, and that interventions aiming to increase intake should be aimed at even younger children. An Australian study investigating the tracking of fruit and vegetables in younger children, indicated high stability from the age of six years with follow-up after three and five years [186]. These findings may suggest that adolescents' dietary behaviours of fruit and vegetable intake are established even before the age of six. However, more studies are needed to investigate the critical age of when such dietary habits are initiated.

Results from the present study further add to the limited knowledge regarding tracking patterns of unhealthy dietary behaviours, by consumption of snacks, soft drinks and squash in children during the transition into adolescence. Fair tracking of snacks was observed from the age of 11 to 13 years, based on two questions measuring the usual consumption of chocolates/sweets and salty snacks. Previous findings are inconsistent [185, 186, 188], however the definition of snacks varied between studies. A recent Australian study reported moderate to high stability of the intake of sweet and sour energy dense snacks among both six year olds and 11 year olds when followed up after three and five years [186]. The intake of snacks were then measured by 13 items consumed during the last week [186]. Tracking depends on the categorical grouping of variables [177], which may have influenced the results of the present study where tracking groups were based on quite narrow intervals. However, corresponding correlation coefficients were obtained when looking at snacking as a grouped variable by Cohen's weighted Kappa and as a continuous variable by Spearman's rank correlation (Cohen's $\kappa_w=0.3$, Spearman's $r_s=0.3$). Thus the present results are through multiple analyses believed to reflect the tracking of chocolates, sweets and salty snacks among these adolescents between the ages of 11 and 13 years.

Fair to moderate tracking were observed for the consumption of soft drinks and squash between the ages of 11 to 13 years. Previous findings among Swedish nine year olds reported low tracking of SSB over six years [185]. Inconsistency in results may be due to the existing methodological differences in defining variables, as well as methodological differences as data was collected through a 24 hour recall [185]. Importantly, the age span of which adolescents were measured differed between studies, as well as the time period investigated. Hence, more studies are needed in order to investigate the magnitude of tracking of energy dense snacks and SSB among children during transition into adolescence.

The overall small changes and the fair to moderate tracking observed in dietary behaviours from the age of 11 to 13 years in the present study may be anticipated, because in general we expect small changes during such a short time period. However, rapid changes are expected to occur in children during transition into adolescents, and a significant increase in the intake of soft drinks was observed during the 20 months of assessment. Thus, the adolescents may be more independent in their preferences at the age of 13 years, and the amount of pocket money may have increased allowing the adolescents to buy what they want. Further understanding of determinants influencing adolescents' prospective soft drink intake is therefore important during this age, to be able to prevent negative behaviour changes to occur, and further influence future health. However, few studies have examined determinants of adolescents' intake of SSB longitudinally [89, 189].

4.2.2 Social inequalities by parental education (Paper I - III)

Social inequalities are consistently observed in adolescents' health behaviours, and parental education is an important indicator of such differences [190, 191]. However, inconsistent findings have been reported for the relationship between parental education and unhealthy dietary behaviours [75] and screen time [122] among adolescents. Few studies have investigated such relationships longitudinally.

Sugar sweetened beverages (SSB)

The present study found the consumption of soft drinks to significantly increase among boys and girls between the ages of 11 to 13 years. Significant differences were furthermore found between level of parental education and adolescents' soft drink intake at both ages, where a higher level of education was associated with a lower consumption. Regression analyses

confirmed that parental education predicted the intake of soft drinks among 13 year olds, when adjusting for gender. However, by investigating change in behaviour over time, no such relationship was observed between parental education and the change in adolescents' soft drink intake between the ages of 11 and 13 years, when adjusting for gender and weight status. The results may indicate that differences by parental education in adolescents' soft drink intake may already be established before the age of 11 years, and that these differences do not necessarily increase between the ages of 11 and 13 years. Other studies investigating prospective relationships between parental education and adolescents' soft drink consumption were not found, and more longitudinal studies are needed in order to conclude on such relationships.

The present study further reported differences by parental education in adolescents' tracking of soft drinks and squash during the 20 months of assessment. Adolescents having parents with a high education level had higher odds of consuming a stable low than a stable high intake of soft drinks and squash between the ages of 11 to 13 years, when compared to participants having parents of a lower level of education. Tracking in dietary intakes among Chinese children aged 6-13 years, and followed-up after six years, indicated that mothers' nutritional knowledge, health consciousness and exposure to media may be more important than maternal education in predicting dietary tracking [65]. However, the results are hardly comparable to the present results due to the study population from a developing country undergoing rapid social and economic transitions [65]. The results of the present thesis imply that differences by parental education were important in adolescents' maintenance of soft drink and squash consumption among these semi-urban adolescents' of highly educated parents. Hence, it is important to investigate possible modifiable factors of parental education on adolescents' prospective intake of SSB, in order to identify target variables to include in future interventions aimed at reducing social inequalities in consumption.

Screen time behaviours

Previous findings from the HEIA cohort study investigating screen time behaviours among adolescents, reported no significant associations between parental education and total screen time (total of TV/DVD and PC/games) at the age of 11 years [159]. However, parental education was found to predict girls' total screen time among 13 year olds, with an inverse relationship [159]. By investigating TV/DVD and PC/games as separate behaviours, the present study concurrently observed no cross-sectional differences by parental education in

adolescents' time spent on TV/DVD or PC/games at the age of 11 years. Although, significant differences were found between level of parental education and adolescents' TV/DVD and PC/game time at the age of 13 years. Such relationships were further examined by regression analyses, when adjusting for adolescents' gender, weight status and living status. The results showed that parental education predicted time spent on PC/games among adolescents at the age of 13 years. However, a relationship was no longer observed in adolescents' prospective time spent on TV/DVD. A previous study reported inconsistent results on the prospective relationship between parental education at the age of 13 years and girls' television viewing and videogame playing after six months [192], and no relationships were reported between parental education level at the age of 9-12 years and adolescents' television viewing, playing video games or computer use at the age of 14 years and older [193].

The lack of influence from parental education on adolescents' prospective TV/DVD time in the present study may be caused by the fact that social differences in adolescents' prospective TV/DVD time were less important in this group of 11-13 year olds. Although, the findings may indicate that such differences may become more predominant by age. A recent cross sectional study among Norwegian 6-15 year olds reported that children of parents with higher education were associated with less screen time as well as a lower frequency of television in the child's bedroom [194]. Other factors in the home environment are consistently shown to be important correlates of adolescents' television viewing, such as such as parental modelling, regulation, availability and accessibility of televisions in the home [90, 122]. Hence, other determinants in the home may be stronger in influencing the adolescents' prospective behaviour during adolescence than the highest level of education among parents. However, the level of parental education was high in this group of 11 year olds, and analyses were based on a binominal variable which may not capture all gradients of parental education. More research is needed in order to investigate the prospective relationship between parental education and different screen time behaviours during adolescence.

Tracking of adolescents' screen time behaviours have furthermore been investigated in the HEIA cohort study, implying fair to moderate tracking between the ages of 11 to 13 years [159]. However, parental education was not found to be associated with tracking of adolescents' total screen time between the ages of 11 and 13 years [159]. A significant increase in adolescents' TV/DVD and PC/game time was observed during the 20 months of assessment, and the study concluded that variables from other domains may be more

important than sociodemographic factors in influencing the maintenance of total screen time in adolescents of this age [159]. There is thus a need to look into possible modifiable determinants of screen time in children during transition into adolescence.

4.2.3 Mediating effects of the home environment (Paper II and III)

The relationship between parental education and dietary and sedentary behaviours may be explained through determinants in the home environment [75, 122], but this has not been much studied. There is furthermore a lack of longitudinal studies and studies that investigate multiple determinants concurrently [111], which is strongly needed to take into account the complex interaction of influences of the home from different environmental levels [119, 123].

Accessibility and availability of soft drinks in the home

The present study observed a significant mediation effect of perceived accessibility of soft drinks measured by adolescents and mothers. The mediators explained the relationship of parental education predicting adolescents' soft drink consumption at the age of 13 years. The results indicate that a lower level of education was related to a higher accessibility of soft drinks, which was further predicting a higher soft drink intake between the ages of 11 and 13 years. A significant direct effect was furthermore found between parental education and the prediction of adolescents' soft drink intake (c'-path), indicating that this relationship still existed after adjusting for the possible mediating effects (partial mediation). Availability of soft drinks at home was not found to mediate such relationship, because no significant difference by parental education was observed. Perceived accessibility of soft drinks measured by fathers was no longer found to be a significant mediator after adjusting for adolescents' and mothers' reports. This was due to a weaker relationship between paternal perceived accessibility and adolescents' prospective soft drink intake, and may indicate that mothers are more attentive in regards to the accessibility of soft drinks at home. However, a moderate correlation was found between parental reports of perceived accessibility ($r=0.47$), and caution should therefore be made before disregarding the importance of perceived accessibility of soft drinks reported by fathers.

The results imply that perceived accessibility measured by adolescents and parents may be important determinants to consider in interventions aiming to reduce differences by parental education in adolescents' soft drink consumption, and should be further investigated. Previous

findings are scarce, however a recent cross-sectional study among preschool children in Belgium found the relationship between parental education and consumption of soft drinks to be almost entirely mediated by accessibility at the dinner table, availability in the home and permissiveness [195]. Another cross-sectional study suggested perceived accessibility at home and modelling (descriptive norms from important others) among Norwegian 16 year olds to partly mediate the relationship between adolescents' future educational plans and soft drink consumption [196]. Furthermore, cross-sectional analyses indicated that the relationship between home environmental variables of availability, accessibility, parental modelling and parental rules, as measured by 14 year olds, and adolescents' soft drink consumption was partly mediated by habit strength and intention to consume soft drinks within the next six months [197]. Other factors in the adolescents' home environment may be involved in explaining the relationship between parental education and adolescents' prospective soft drink intake, and caution should therefore be taken before a conclusion can be made. As the present measurement of perceived accessibility among parents may have been influenced by parental rules, the results may indicate a possible influence of parental education on parental house rules that further affect adolescents' soft drink intake over time. Future mediation analyses investigating possible mediating effects of the home environment in the relationship between parental education and adolescents' soft drink consumption should include both sociocultural and physical environmental variables as well as examine possible moderating individual determinants.

Parental modelling and regulation of screen time

A significant mediation effect of maternal and paternal modelling of adolescents' TV/DVD time was observed in the present analyses. The mediators were found to explain the relationship of parental education predicting adolescents' TV/DVD time at the age of 13 years. Indicating that a lower level of parental education was related to more parental TV/DVD time, which was further predicting more TV/DVD time between the ages of 11 and 13 years. However, no total or direct effect of parental education on adolescents' TV/DVD time was observed. The level of parental education was high in the included sample of participants, as well as measured by the educational level of the parent with the highest educational level. This may have underestimated the differences by parental education in this sample of participants, as the participating parents may be seen as more health conscious than the parents that did not participate.

The results indicate that the relationship between parental education and adolescents' prospective time spent on TV/DVD is explained through parental modelling in this sample of 11 to 13 year olds. Thus, parental modelling of TV/DVD time may be important to consider when intervening on adolescents' TV/DVD time across social groups. However, no mediation by parental regulation of adolescents' prospective TV/DVD time was observed, as differences in regulation by parental education were not found. The findings are supported by a recent cross-sectional study indicating that restrictions of children's television viewing seemed less important as a mediator between maternal education and 11 year old children's television viewing than among six year olds television viewing [198]. It is important to notice that the present study questioned the reliability of measuring parental TV/DVD regulation as a single construct. Although, the lack of test-retest reliability among parents may be somewhat explained by less established rules related to adolescents' TV/DVD time than for PC/game time. Thus, further studies should investigate the role of parental regulation in the casual relationship between parental education and adolescents' TV/DVD time. A recent cross-sectional study further found number and placement of television in the home to be the strongest mediators of the relationship between maternal education and 11 year old children's television viewing [198]. Further studies should additionally investigate other possible influences of the home food environment on adolescents' TV/DVD time, such as the availability and accessibility in the home.

The present study did neither find parental modelling nor regulation to mediate the relationship of parental education on adolescents' prospective PC/game time. These results imply that parental modelling is less important as an intermediate variable when explaining differences by parental education in adolescents' prospective PC/game time. Few studies are found to investigate associations of the home environment on adolescents' time spent on PC/games [122]. The results may be reflect by the larger differences in time spent on PC/games between parents and adolescents, than what was observed for TV/DVD time. Hence, adolescents' may be more independent in their time spent on PC/games, which can be more influenced through social contexts with siblings and friends rather than with parents. Other factors in the home environment may be more important mediators of adolescents' time spent on PC/games by parental education, and thus availability and accessibility of computers in the home, presence and interaction with siblings and friends should be a matter for further investigation.

4.2.4 Parent-child gender relationships (Paper III)

Previously reviewed research on parent-child relationships indicate that mothers invest more time and are more involved in parenting during adolescence compared to fathers, and are thus considered closer to adolescents of both genders [199]. However, while mothers are more engaged in care giving, the fathers tend to be more involved in leisure activities [199]. The HEIA study previously reported gender relationships of overweight and weight circumference between both parents with their sons and between mothers and daughters at the age of 11 years [147]. The same gender relationships were found among 11 year old adolescents' consumption of SSB, but such findings were less consistent for the intake of fruits and vegetables [200].

The present study found correlations between mothers' and fathers' TV/DVD time with boys and girls TV/DVD time at both ages of 11 and 13 years, and the associations seemed to become stronger by age. A steady increase of time spent watching television in gender dyads of parents and adolescents has been reported from the age of 9-10 years to the age of 15-17 years [45]. Previous findings have furthermore reported that parents spend less time with their children in other social contexts as they grow older [45]. The present findings may suggest that adolescents spend more time on TV/DVD with their parents as a shared activity when they grow older, probably as a result of spending time together as a family and due to prolonged waking hours.

The present study furthermore observed cross-sectional associations between mothers and their sons PC/game time and fathers and their daughters PC/game time at the age of 11 years. The evidence on gender relationships of adolescents' use of computer and electronic games is limited, but a previous cross-sectional study among Portuguese 7 to 10 year olds consistently showed that paternal television viewing was significantly related to their daughters' PC and electronic game time during weekends [201]. Correlations in gender dyads of parents' and adolescents' time spent on PC/games were no longer observed at the age of 13 years. The results may reflect the fact that time spent on PC/games is less of a shared activity among parents and adolescents, and thus less influenced by parental behaviours when adolescents grow older.

These results indicate that the fathers are more important in the adolescents screen time habits in both genders, than what was observed for these adolescents' dietary behaviours by Bjelland

et. al. [200]. It is important to notice that most previous research has been focusing on the mother as a representative of parents' and excluded the role of fathers in the home environment [141]. Hence, important cross gender relationships between parents and adolescents may exist within the different EBRB. More research is needed in order to identify possible prospective gender specific influences of parental modelling on children's screen time when growing into adolescence.

5 CONCLUSION

This thesis suggests that promotion of healthy dietary behaviours at an early age is important to prevent the establishment of unfavourable dietary behaviours later in adolescence. Fair to moderate tracking of the dietary intake of fruits, vegetables, snacks, soft drinks and squash was observed among boys and girls between the ages of 11 and 13 years. The intake of soft drinks furthermore increased significantly between these ages. Availability and perceived accessibility of soft drinks at home, as measured by adolescents, mothers and fathers, were found to predict an increased intake between the ages of 11 and 13 years. These results indicate that early adolescence is a critical phase for the onset of soft drink consumption. Availability and perceived accessibility of soft drinks at home may be important determinants to consider preventing an increase in intake over time, and positively influencing future health.

An inverse association was found in both genders between level of parental education and level of tracking in adolescents' soft drink and squash consumption, as higher odds of consuming a stable low than a stable high intake was observed among those with a higher level of parental education. The results imply that inequalities by parental education in adolescents' consumption of soft drink and squash were maintained from the age of 11 to 13 years. A higher level of parental education furthermore predicted a lower intake of soft drinks among 13 year olds. However, no association was seen between parental education and the change in adolescents' soft drink intake between the ages of 11 and 13 years, indicating that differences by parental education were already established before the age of 11 years. Moreover, perceived accessibility of soft drinks at home, as measured by adolescents and mothers, was found to be important mediators in the relationship of parental education predicting adolescents' soft drink intake, by increasing the consumption from age 11 to age 13. Thus, these may be important target variables in order to reduce adolescents' prospective soft drink intake across social groups.

Results from the present thesis showed cross-sectional and longitudinal relationships in gender dyads of parents and adolescents' screen time. Both parents' TV/DVD time was associated with adolescents' TV/DVD time among boys and girls at the age of 11 and 13 years. Opposite gender dyads were observed for PC/game time at the age of 11 years, but the association was not seen in either gender at the age of 13 years. These findings may suggest

that adolescents spend more time on TV/DVD with their parents as a shared activity, while time spent on PC/games is less of a shared activity among parents' and adolescents when they grow older.

Parental modelling of TV/DVD time further predicted more time spent on TV/DVD and parental regulation predicted less time spent on TV/DVD between the ages of 11 and 13 years, while a higher level of parental education predicted less time spent on PC/games among adolescents. Suggesting that these may be important home environmental determinants to consider when aiming to reduce adolescents' prospective TV/DVD and PC/game time. However, other factors in the home environment may influence adolescents' prospective screen time and should be included in future studies, such as the availability and accessibility of screens in the home. Parental modelling may further be an important target variable in reducing adolescents' prospective TV/DVD time across social groups, as both maternal and paternal modelling was found to be important mediators of the relationship between parental education and adolescents' prospective TV/DVD time among 13 year olds.

5.1 Implications for further research

Changes in energy balance-related behaviours may occur during key life stages such as children growing into adolescence. There is limited evidence in regards to the tracking of dietary behaviours between childhood and adolescence. The present findings indicated tracking of dietary behaviours between the ages of 11 and 13 years, and thus highlight the importance of starting before the age of 11 years to prevent the establishment of unfavourable dietary behaviours later in adolescence. Hence, the tracking of dietary behaviours among children should be further investigated. Moreover, few studies have investigated changes in intake of energy dense and sugary foods among adolescents over time, and thus more longitudinal studies should be conducted.

Relatively few studies have included variables in the home environment as measured by parents. Even less evidence is found including both mothers and fathers reports as most previous research has been focusing on the mother as a representative of parents, and thus excluded the role of fathers in the home environment. The present study found novel cross-sectional and longitudinal relationships of different screen time behaviours in gender dyads of parents and adolescents, indicating that mothers and fathers may influence their children

differently. Hence, important parent-child relationships may exist in adolescents' EBRB that are currently not understood, indicating a need for further studies.

The present study is furthermore among the first to investigate the prospective relationship between parental education and adolescents dietary and screen time behaviours. More studies are needed in order to conclude on the association between parental education and tracking of dietary behaviours in children during the transition into adolescence. Moreover, few studies have investigated the prospective relationship of parental education on adolescents' soft drink consumption as well as screen time during adolescence. Hence, more evidence is needed in order to draw a conclusion. Important determinants in the home environment were found to influence adolescents' prospective intake of soft drinks and time spent on TV/DVD and PC/games. Both availability and accessibility in the home, as well as parental modelling and regulation seems to be important factors that should be included in further analyses.

5.2 Implications for health promotion

In 2010 the Norwegian Directorate of Health presented the "National guidelines for prevention, assessment and treatment of overweight and obesity in children and adolescents" [50]. These guidelines aimed to prevent the onset of overweight among children and adolescents by establishing a healthy lifestyle at an early age, as well as to identify children and adolescents at risk of an unhealthy weight development. The importance of involving the family and surroundings of the child in collaboration with the primary school health service is highlighted, to be able to influence their daily dietary and activity habits. The present thesis contributes with knowledge in regards to the parental role in young adolescents' dietary and screen time behaviours, which further may influence weight status. Furthermore, important gender relationships between parents' and adolescents' behaviours are highlighted. Even though mothers are found to be important providers and role models for their children, fathers seem to have a great role in adolescents' health behaviours that has previously been less highlighted, probably due to lack of such data. Involving both parents in prevention strategies of an unhealthy lifestyle among adolescents might be of importance in regards to adolescents' weight status. By increasing parental awareness of the importance of determinants in the home, such as availability and accessibility of soft drinks, modelling and regulation of TV/DVD time, parents may to a larger degree contribute in reducing adolescents' intake of soft drinks and time spent on TV/DVD, respectively. Raising awareness of these

determinants, resulting in a healthier lifestyle, may further have implications for adolescents' prospective behaviours, and thus influence future health.

The Norwegian white paper "National strategy to reduce social inequalities in health 2006-07" argues that to reduce social inequality in health it is important to reduce inequality in diet, physical activity, smoking and other health-related behaviours, and to focus the efforts on structural causes of these behaviours [49]. This thesis contributes to the National strategy by highlighting the importance of parental education in dietary and screen time behaviours during adolescence, of which differences in adolescents' prospective soft drink consumption and PC/game time in particular should be emphasized. Moreover, the mediating effect of home environmental variables in explaining the relationship between parental education and adolescents' health behaviours was observed longitudinally. Thus, factors in the home environment were found to be related to adolescents' dietary and screen time behaviours, and may furthermore be important determinants to target in interventions aiming to reduce social differences in such behaviours among Norwegian 11 to 13 year olds. By targeting the accessibility of soft drinks at home, adolescents' soft drink intake can be reduced across level of parental education. Subsequently, targeting parental modelling of time spent on TV/DVD may be an important target variable to consider in interventions aiming to reduce TV/DVD time across social groups of parental education. This may be done by involving the family and surroundings of the adolescents in collaboration with the primary school health service.

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Does tracking of dietary behaviours differ by parental education in children during the transition into adolescence?

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Abstract

Objective: The present study investigates the changes and tracking of dietary behaviours in Norwegian 11-year-olds and examines the association between parental education and dietary tracking over a time period of 20 months.

Design: Longitudinal data from the Norwegian HEalth In Adolescents (HEIA) cohort study followed up at three time points (2007–2009).

Setting: Intakes of fruits, vegetables and snacks were assessed by frequency and intakes of sugar-sweetened soft drinks and squash were assessed by frequency and amount. Tracking of dietary behaviours was assessed by adolescents' relative position in rank over time and Cohen's kappa was used to measure tracking coefficients. Multinomial logistic regression analyses were performed to assess the association between parental education and the tracking of dietary behaviours.

Subjects: In total, 885 adolescents from the HEIA cohort study participated by answering Internet-based questionnaires at three time points.

Results: The results indicated that boys and girls maintained their relative position in rank of dietary intake over time, when grouped by baseline consumption. Fair to moderate tracking coefficients of dietary variables were observed. An inverse association was found between parental education and stability of soft drink and squash consumption during the 20 months.

Conclusions: The observed tracking pattern indicates the importance of promoting healthy dietary behaviours at an even earlier age. Furthermore, interventions should focus particularly on adolescents from families with low parental education and their consumption of sugar-sweetened beverages.

Keywords

Adolescents
Children
Socio-economic status
Stability
Dietary behaviour

Diet is an important factor in order to maintain good health throughout the life course⁽¹⁾. Knowledge on healthy dietary behaviours and other lifestyle factors related to the development of obesity is needed to understand the prevalence of obesity and other non-communicable diseases^(2,3). Establishing healthy eating habits is of importance during adolescence, given that these behaviours tend to be continued into adulthood^(4–8). Promotion of fruits and vegetables, and reducing the intake of energy-dense and sugary foods, are recommended in order to prevent non-communicable diseases^(1,9).

Changes in an individual's eating habits may occur between childhood and adolescence due to physiological changes and social interactions influenced by the adolescent's development and environment^(8,10,11). Investigating eating behaviours in children longitudinally during the transition into adolescence is recommended in order to provide important information on when, how and why dietary changes occur^(2,6,12,13). This will in turn enable the

development of strategies for interventions^(14,15) and then further influence future health.

The concept of tracking is used in epidemiology literature to describe the longitudinal development of variables⁽¹⁶⁾ and is generally used to indicate the risk of future diseases in subjects at an early age⁽¹⁷⁾. Dietary tracking can be defined as the relative stability of dietary habits over time⁽⁷⁾ or the maintenance of relative position in rank of dietary behaviours over time⁽⁴⁾. The existence of dietary tracking from adolescence to adulthood has been reported in several studies^(5,14,18–20), but relatively few previous longitudinal studies have reported on dietary tracking in children during the transition into adolescence^(8,21,22). Wang *et al.*⁽⁸⁾ found tracking of fruits and vegetables in Chinese children with a mean age of 9 years at baseline and followed up after 6 years. Patterson *et al.*⁽²²⁾ showed slight tracking coefficients for most food groups in Swedish children of average age 10 years at baseline and followed up 6 years later. However, the

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intake data were based on one 24 h recall at each time point, which may influence foods that are not consumed on a daily basis. There are limited studies focusing on the tracking of energy-dense and sugary foods over time⁽²³⁾.

Parents play an important role in shaping the dietary habits of their children by determining what foods are available and how foods are prepared in the home^(24,25). Moreover, socio-economic status (SES) has been shown to be a strong determinant of children's and adolescents' dietary intake^(26–28). Little research has investigated home environmental factors that may influence changes or predict the tracking of dietary behaviours from childhood to adolescence^(8,10,29). Social inequalities related to the tracking of adolescents' health behaviours are of importance in order to investigate unequal distributions of health, but few studies have investigated the influence of SES on tracking of dietary behaviours in adolescence⁽¹¹⁾. Wang *et al.*⁽⁸⁾ indicated that urban–rural residence, family income and mother's education were important predictors of dietary tracking among Chinese children and adolescents.

The purpose of the present study was to investigate changes and tracking of dietary behaviours in a group of Norwegian 11-year-olds over a time period of 20 months. Moreover, the aim was to examine the associations between parental education and dietary tracking in children during the transition into adolescence.

Materials and methods

Participants and study design

The HEIA In Adolescents (HEIA) study is a school-based group-randomized controlled survey, designed to promote healthy weight development through dietary behaviours and physical activity. A total of 177 public schools were invited to take part in the HEIA study, resulting in thirty-seven participating schools situated in seven counties surrounding Oslo, Norway. Approval for the study was obtained from the Regional Committees for Medical Research Ethics and the Norwegian Social Science Data Service. The design and methodology are described in detail elsewhere⁽³⁰⁾.

The HEIA cohort study consists of data collected from twenty-five control schools in the HEIA study. All 6th graders from the control schools were invited to participate, resulting in a HEIA cohort of 1381 adolescents. At the baseline survey (T0) in September 2007, 975 (71%) of these adolescents participated. In May 2008, 970 (70%) participants attended the first follow-up (T1), and 20 months after attendance at T0, 945 (68%) adolescents participated at the second follow-up (T2), during May 2009. For the purpose of the present paper, only participants attending all three time points were included in the analyses, resulting in a total sample of 885 (64%) adolescents with the mean age of 11.2 (sd 0.3) years at T0.

Data collection

Informed consents were collected from parents or legal guardians (hereafter called 'parents') and included questions on parents' education. Internet-based questionnaires were filled in during school hours at three time points, taking about 45 min to complete. The questionnaires assessed dietary and physical activity behaviours and their determinants by mostly pre-coded answer categories; the dietary variables investigated were fruits, vegetables, snacks and the intake of beverages. Trained staff was available during all data collection sessions, collecting anthropometric measurements at T0 and T2.

Variables

Intake of fruits was assessed by one question and intakes of raw and cooked vegetables were assessed by two questions asking for frequency of usual intake. Frequencies were measured by eight categories; from never/seldom to three or more times daily. Sweet (candies and chocolate) and salty (chips and popcorn) snacks was assessed by two questions asking for frequency of usual intake, measured by seven categories; from never/seldom to two or more times daily. All variables were recoded into frequency of intake per week by using the midpoints of categories (i.e. making 1–2 times/week equal 1.5 times/week). Intake of vegetables was calculated from the sum of raw and cooked vegetables, and intake of snacks was calculated from the sum of sweet and salty snacks.

Usual consumption of sugar-sweetened beverages (SSB), as carbonated sugar-sweetened soft drinks (hereafter called 'soft drinks') and squash (defined as sugar-sweetened concentrates of fruit and berries), was calculated as decilitres per week from the sum of five weekdays and two weekend days. During weekdays the consumption of soft drinks and squash was assessed by frequency (six categories; from never/seldom to every weekday) and amount in glasses for each occasion (four categories; from one glass to four glasses or more). For weekends the consumption was measured by the total number of glasses over both days (eight categories; from never/seldom to seven glasses or more). It was stated in the questionnaire that 0.5 litre of beverage equalled three glasses, making one glass equal to 1.67 dl.

Parental education was categorized into three levels: low (≤ 12 years), medium (13–16 years) and high (> 16 years), based on categories from Statistics Norway. Values from the parent with the longest education level were used, or else from the one available. Both parents' education levels were reported for 81% of these adolescents. BMI was calculated from anthropometric measurements of height and weight.

A separate test–retest study among 6th graders (n 114) from the same sampling area as the main study was conducted prior to baseline data collection. The self-reported measures for fruits, vegetables, snacks, soft drinks and squash obtained acceptable to good values (Spearman's $\rho = 0.49–0.78$; data not shown).



Data analysis

All statistical analyses were performed using the statistical software package IBM® SPSS® Statistics version 18.0 (IBM Corp.). Mean differences in characteristics at T0 between participants and drop-outs were tested with the independent-sample *t* test for demographic variables and dietary behaviours. The cluster effect for each of the behavioural variables was tested by using linear mixed models. Only 0.3–5.6% of the unexplained variance in the behaviours was shown to be at the group level, and therefore multilevel analyses were not performed⁽³¹⁾. One-way ANOVA was used to investigate the difference between dietary behaviours and level of parental education at T0. Significant differences in dietary intake between time points were assessed using one-way repeated-measures ANOVA with Bonferroni correction of multiple testing.

Several methods were used to describe the tracking of dietary behaviours over time. First, tracking patterns were illustrated as consumers' relative position in rank by mean dietary intakes at T0, T1 and T2 in groups of low, medium and high consumption at T0. Intakes of fruits and vegetables were categorized as low (<5), medium (5–13) or high (≥ 14) consumption in times per week. Snack intake was similarly categorized into low (≤ 2), medium (3) or high (≥ 4) consumption in times per week. Soft drinks and squash were categorized based on intake in decilitres per week, into low (0), medium (≤ 7 but > 0) or high (> 7) consumption. Grouping of variables was based on weekly intake and the Norwegian dietary guidelines. Between-group differences at each time point were calculated using one-way ANOVA with Bonferroni correction of multiple testing. Second, stability and change in dietary behaviours from T0 to T2 was assessed from cross-tabulation of intake patterns at T0 and T2. Stability was shown by the percentage of individuals remaining in the same group of consumption at both time points and change was presented by percentages of decrease or increase in consumption over time. Third, Cohen's kappa was used as tracking coefficients to test the agreement between each individual's relative position in rank from T0 to T2. Kappa values were weighted (κ_w) to take into account their squared position of concordance between groups⁽³²⁾. Because this command was currently unavailable in SPSS, the available command syntax for SPSS from the IBM® webpage was used⁽³³⁾. Cut-offs suggested by Landis and Koch⁽³⁴⁾ were used for the interpretation of kappa values.

Multinomial logistic regression analyses were performed to assess the association between level of parental education and the tracking of each of the dietary variables from T0 to T2. For the purpose of these analyses differences between stable high consumers and stable low consumers were of interest, hence a variable of four tracking groups was made. Tracking groups indicating stability were split into those who maintained a stable low (low and medium consumption groups) or a stable high

(high consumption group) intake at both T0 and T2. Tracking groups indicating change were kept as participants who either increased or decreased their consumption between these time points. A stable high intake was the reference category for the dependent variable, and a low level of education was the reference category for the independent variable.

Results

Mean age of participating boys (*n* 466) and girls (*n* 419) was 11.2, 11.9 and 12.9 years for both genders at T0, T1 and T2, respectively. Attrition analysis showed no significant differences in the demographic variables gender, age, BMI and parental education, or in dietary behaviours at T0, between the sample of adolescents included in the present paper and those excluded (*n* 90) due to lack of participation at all three time points (data not shown).

Changes in dietary intake

The intake of soft drinks increased significantly over time, by 0.9 and 0.7 dl/week among boys and girls, respectively, from T0 to T2 (Table 1). No significant changes were seen for the intake of soft drinks between T0 and T1, or for the intake of fruits, vegetables, snacks or squash between T0 and T1 or between T0 and T2.

Tracking patterns and stability

Adolescents kept their relative position in rank over time when grouped by dietary intake at T0, except for girls' intake of fruits and boys' intake of snacks (Fig. 1(a) to (j)). Low and medium consumers of fruits among girls at T2 were no longer statistically different, neither were low and medium consumers of snacks among boys at T1 or T2. A tendency of regression towards the mean was generally observed, as group means seemed to converge towards the distribution of the middle group.

Tables 2 and 3 present the proportion of stability in dietary behaviours between T0 and T2, based on groups of low, medium and high consumption, for boys and girls, respectively. The highest proportion of stability was seen for the intake of squash in both genders. The largest changes were seen for the intake of fruits among boys and snacks among boys and girls, where more than 50% changed their dietary behaviour by either decreasing or increasing intake over time.

Tracking coefficients

Tracking coefficients measured by Cohen's kappa indicated fair tracking of fruits, vegetables, snacks and soft drinks, and moderate tracking of squash, in boys (Table 2). Fair tracking coefficients of vegetables and snacks and moderate tracking coefficients of fruits, soft drinks and squash were seen in girls (Table 3). The lowest tracking coefficient was observed for the intake of snacks and the

Table 1 Means and changes of dietary behaviours according to gender in Norwegian 11-year-olds, HHealth In Adolescents (HEIA) cohort study

Dietary consumption	n	T0 (baseline)		T1 (8 months)			T2 (20 months)		
		Mean	95% CI	Mean	95% CI	P†	Mean	95% CI	P†
Boys									
Fruits (times/week)	466	9.5	8.8, 10.1	9.6	8.9, 10.2	1.00	9.0	8.3, 9.6	0.43
Vegetables (times/week)	441	10.7	9.8, 11.6	11.0	10.1, 11.9	1.00	10.2	9.4, 11.1	0.93
Snacks‡ (times/week)	438	3.3	3.0, 3.5	3.3	3.0, 3.6	1.00	3.5	3.2, 3.8	0.47
Soft drinks§ (dl/week)	415	6.0	5.4, 6.6	6.5	5.8, 7.2	0.43	6.9	6.2, 7.5	0.04*
Squash§ (dl/week)	395	6.2	5.4, 7.0	5.9	5.1, 6.7	1.00	5.8	5.0, 6.6	1.00
Girls									
Fruits (times/week)	415	10.1	9.5, 10.8	10.4	9.8, 11.1	1.00	10.0	9.4, 10.7	1.00
Vegetables (times/week)	405	11.5	10.6, 12.4	11.2	10.4, 12.1	1.00	10.7	9.9, 11.6	0.50
Snacks‡ (times/week)	398	2.9	2.6, 3.3	3.0	2.7, 3.3	1.00	3.3	3.0, 3.6	0.08
Soft drinks§ (dl/week)	405	4.6	4.1, 5.1	4.5	4.1, 5.0	1.00	5.3	4.7, 5.8	0.05*
Squash§ (dl/week)	378	4.6	3.9, 5.3	4.2	3.5, 4.8	0.50	4.0	3.3, 4.6	0.15

* $P < 0.05$.

†P value for the significance of the difference from T0 by one-way repeated-measures ANOVA.

‡Sweet candies and chocolate, salty chips and popcorn snacks.

§Carbonated soft drinks with sugar, non-carbonated squash with sugar.

highest tracking coefficient was observed for the intake of squash, in both genders.

Parental education and adolescents' dietary tracking

Parental education was given by 865 (98%) of the parents at T0, of whom 30% were categorized at the low level, 35% at the medium level and 32% at the high level of parental education (data not shown). At T0 significant negative differences were observed between level of parental education and the intake of soft drinks ($P < 0.01$ in boys and girls) and squash ($P = 0.01$ in boys and $P = 0.02$ in girls). However, no such differences were seen for the intake of fruits, vegetables or snacks (data not shown).

Boys and girls with parents of high education had higher odds of a stable low intake of soft drinks (OR = 3.92, 95% CI 1.80, 8.53, $P < 0.01$ in boys and OR = 2.64, 95% CI 1.11, 6.29, $P < 0.05$ in girls) and squash (OR = 3.00, 95% CI 1.35, 6.64, $P < 0.01$ in boys and OR = 2.95, 95% CI 1.13, 7.69, $P < 0.05$ in girls), when compared with those with parents of low education (Table 4). Boys of parents with a medium level of education had higher odds of a stable low intake of soft drinks (OR = 2.24, 95% CI 1.12, 4.51, $P = 0.02$) when compared with those having parents with a low parental education level (data not shown). No significant associations were seen between parental education level and adolescents' tracking of fruits, vegetables or snacks.

Discussion

Childhood and adolescence are key periods in life for the development of long-lasting dietary behaviours. The current study adds to the limited knowledge regarding tracking patterns of snacks, soft drinks and squash in children during the transition into adolescence. The study

found associations between having parents of a high education level and consuming a stable low intake of soft drinks and squash between the ages of 11 to 13 years, when compared with participants having parents of a lower level of education.

Our findings showed a non-significant decrease in the intake of fruits and vegetables between ages 11 and 13 years. These results are comparable with other studies published on young adolescents' intake of fruits and vegetables over time^(3,29). Tracking coefficients of fruits and vegetables indicated that adolescents maintained fair to moderate tracking of fruits and vegetables from T0 to T2. Similar stability was shown for the consumption of vegetables at dinner in Norwegian 12-year-olds, measured over a time period of 3 years⁽³⁵⁾. Slight to fair tracking coefficients have been reported previously for the intake of fruits and vegetables in adolescents of this age^(8,22). Overall, a larger proportion of females than of males maintained a stable intake of fruits of ≥ 14 times/week.

No significant changes were seen for the mean weekly intake of snacks among boys and girls during the period of 20 months. This has also been observed by others^(3,6,29), although comparisons in the intake of snacks were challenging because of the differences in definitions between studies. Tracking patterns of snack intake showed that girls kept their relative position in rank over time, when grouped by consumption level at T0. There were no significant differences between low and medium consumption groups among boys at T1 and T2, indicating that boys did not keep their relative position in rank for the intake of snacks over time. Tracking coefficients of adolescents' snack intake showed fair tracking in both genders from T0 to T2. Earlier findings on the tracking of snacks in adolescents of this age group were inconsistent^(21,22). In our study narrow confidence intervals were generally seen between consumption groups, indicating consistent results

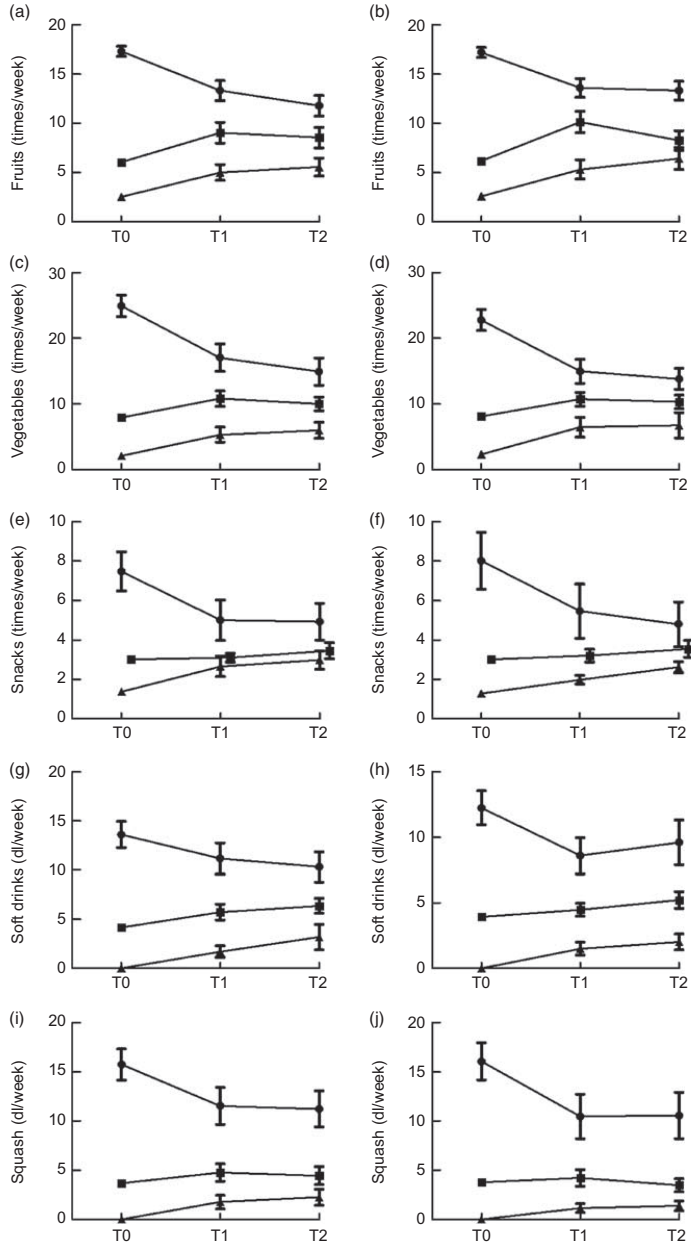


Fig. 1 Tracking patterns in Norwegian 11-year-olds, HHealth In Adolescents (HEIA) cohort study. Mean dietary intakes, with their 95% confidence intervals represented by vertical bars, in consumption groups (—●—, high; —■—, medium; —▲—, low) at baseline (T0), followed up after 8 months (T1) and 20 months (T2): (a) boys (*n* 456); (b) girls (*n* 415); (c) boys (*n* 441); (d) girls (*n* 405); (e) boys (*n* 438); (f) girls (*n* 398); (g) boys (*n* 415); (h) girls (*n* 405); (i) boys (*n* 395); (j) girls (*n* 378). Intake categories (times/week) for fruits and vegetables: high, ≥ 14 ; medium, 5–13; low, < 5 . Intake categories (times/week) for snacks: high, ≥ 4 ; medium, 3; low, ≤ 2 . Intake categories (dl/week) for soft drinks and squash: high, > 7 ; medium, ≤ 7 but > 0 ; low, 0

**Table 2** Proportion of stability and tracking coefficients in Norwegian 11-year-old boys (*n* 466), HHealth In Adolescents (HEIA) cohort study

Dietary behaviour	T0 (baseline)		T2 (20 months)			Cohen's κ_w [§]
	<i>n</i>	%	Decreaset	Stability‡	Increase‡	
			%	%	%	
Fruits (times/week)	456		29.4	46.3	24.3	0.38
Low (<5)	133	29	nc	54.9	45.1	
Medium (5–13)	143	31	33.6	30.8	35.7	
High (≥ 14)	180	39	47.8	52.2	nc	
Vegetables (times/week)	441		22.0	54.2	23.8	0.39
Low (<5)	115	26	nc	49.6	50.4	
Medium (5–13)	214	49	16.8	61.2	22.0	
High (≥ 14)	112	25	54.5	45.5	nc	
Snacks (times week)	438		20.1	47.7	32.2	0.31
Low (≤ 2)	183	42	nc	45.4	54.6	
Medium (3)	165	38	25.5	49.7	24.8	
High (≥ 4)	90	21	51.1	48.9	nc	
Soft drinks* [¶] (dl/week)	415		19.3	55.7	25.1	0.38
Low (0)	79	19	nc	54.4	45.6	
Medium (≤ 7 but > 0)	222	53	13.1	56.3	30.6	
High (> 7)	114	27	44.7	55.3	nc	
Squash* [¶] (dl/week)	395		25.1	57.5	17.5	0.46
Low (0)	127	32	nc	67.7	32.3	
Medium (≤ 7 but > 0)	146	37	30.8	50.0	19.2	
High (> 7)	122	31	44.3	55.7	nc	

nc, no changes as increase/decrease of behaviour possible.

†Proportion of individuals' behavioural change as decreased or increased dietary intake from T0 to T2.

‡Proportion of individuals' unchanged behaviour as stable dietary intake from T0 to T2.

§Tracking coefficient of weighted Cohen's kappa.

¶Sweet candies and chocolate, salty chips and popcorn snacks.

*Carbonated soft drinks with sugar, non-carbonated squash with sugar.

Table 3 Proportion of stability and tracking coefficients in Norwegian 11-year-old girls (*n* 419), HHealth In Adolescents (HEIA) cohort study

Dietary behaviour	T0 (baseline)		T2 (20 months)			Cohen's κ_w [§]
	<i>n</i>	%	Decreaset	Stability‡	Increase‡	
			%	%	%	
Fruits (times/week)	415		24.3	52.8	22.9	0.43
Low (<5)	108	26	nc	46.3	53.7	
Medium (5–13)	124	30	29.0	41.1	29.8	
High (≥ 14)	183	44	35.5	64.5	nc	
Vegetables (times/week)	405		25.7	53.3	21.0	0.37
Low (<5)	71	18	nc	46.5	53.5	
Medium (5–13)	213	53	15.5	62.4	22.1	
High (≥ 14)	121	30	58.7	41.3	nc	
Snacks (times week)	398		19.3	45.5	35.2	0.27
Low (≤ 2)	181	45	nc	47.5	52.5	
Medium (3)	160	40	30.0	41.9	28.1	
High (≥ 4)	57	14	50.9	49.1	nc	
Soft drinks* [¶] (dl/week)	405		21.0	53.8	25.2	0.40
Low (0)	109	27	nc	55.0	45.0	
Medium (≤ 7 but > 0)	212	52	20.3	54.7	25.0	
High (> 7)	84	21	50.0	50.0	nc	
Squash* [¶] (dl/week)	378		22.8	59.0	18.3	0.49
Low (0)	152	40	nc	69.7	30.3	
Medium (≤ 7 but > 0)	154	41	33.8	51.3	14.9	
High (> 7)	72	19	47.2	52.8	nc	

nc, no changes as increase/decrease of behaviour possible.

†Proportion of individuals' behavioural change as decreased or increased dietary intake from T0 to T2.

‡Proportion of individuals' unchanged behaviour as stable dietary intake from T0 to T2.

§Tracking coefficient of weighted Cohen's kappa.

¶Sweet candies and chocolate, salty chips and popcorn snacks.

*Carbonated soft drinks with sugar, non-carbonated squash with sugar.

for the intake of snacks over time. In relation to tracking, this may further have increased the possibility of changes between groups.

A significant increase in mean soft drink consumption was observed among boys and girls from T0 to T2, simultaneously with a non-significant decline in the



Table 4 Associations between 20 months of dietary tracking and level of parental education (PE) according to gender in Norwegian 11-year-olds, HHealth In Adolescents (HEIA) cohort study

Dietary tracking	Boys (n 466)			Girls (n 419)		
	n	PE high v. PE low†		n	PE high v. PE low†	
		OR‡	95% CI		OR‡	95% CI
Fruits	443			408		
Decrease§	131	1.43	0.72, 2.83	99	0.86	0.45, 1.65
Increase§	108	1.10	0.55, 2.21	92	0.84	0.43, 1.62
Stable low	111	0.95	0.47, 1.92	100	0.86	0.44, 1.69
Stable high †	93	1.00		117	1.00	
Vegetables	428			399		
Decrease§	92	0.72	0.30, 1.73	104	0.94	0.42, 2.10
Increase§	100	0.82	0.34, 2.01	83	0.93	0.41, 2.12
Stable low	185	0.85	0.38, 1.90	163	1.22	0.59, 2.57
Stable high †	51	1.00		49	1.00	
Snacks¶	425			391		
Decrease§	82	1.35	0.56, 3.27	76	1.00	0.35, 2.82
Increase§	137	0.96	0.43, 2.16	139	0.96	0.37, 2.51
Stable low	162	1.36	0.62, 3.00	149	1.04	0.40, 2.75
Stable high †	44	1.00		27	1.00	
Soft drinks††	403			398		
Decrease§	74	1.99	0.83, 4.77	84	1.15	0.44, 3.00
Increase§	102	1.64	0.71, 3.78	101	1.48	0.59, 3.67
Stable low	165	3.92**	1.80, 8.53	172	2.64*	1.11, 6.29
Stable high †	62	1.00		41	1.00	
Squash††	385			372		
Decrease§	98	2.02	0.87, 4.69	82	2.37	0.85, 6.62
Increase§	66	2.21	0.85, 5.74	68	1.92	0.67, 5.55
Stable low	156	3.00**	1.35, 6.64	184	2.95*	1.13, 7.69
Stable high †	65	1.00		38	1.00	

*P < 0.05, **P < 0.01.

†Reference group.

‡OR and 95% CI obtained by multinomial logistic regression.

§Proportion of individuals' behavioural change as decreased or increased dietary intake from T0 to T2.

||Proportion of individuals' unchanged behaviour as stable low or high dietary intake from T0 to T2.

¶Sweet candies and chocolate, salty chips and popcorn snacks.

††Carbonated soft drinks with sugar, non-carbonated squash with sugar.

intake of squash. There are few longitudinal studies reporting on the trends of soft drink and squash consumption separately, which makes it difficult to conclude on intake patterns based on earlier findings. However, Lytle *et al.*⁽⁶⁾ found a significant increase in the consumption of soft drinks and fruit drinks among students going from 5th to 8th grade. A significant increase in adolescents' soft drink intake was reported by others^(3,36), although the definition of soft drinks varies between studies. Tracking coefficients for the intake of soft drinks and squash indicated that adolescents maintained fair to moderate tracking over a period of 20 months. Stability was seen among 56% of soft drink consumers and 58% of squash consumers in boys; for girls stability was seen among 54% and 59%, respectively. The one study found to report on tracking of SSB in adolescents of this age found slight tracking ($\kappa_w = 0.07$) for the consumption of sweetened drinks during a period of 6 years⁽²²⁾, although results were obtained with methodological differences. Our results suggest that the intakes of soft drinks and squash track well in this age group, and interventions that reduce intake are therefore encouraged to start at an early age.

The overall small changes and the fair to moderate tracking observed in dietary behaviours from the age of

11 to 13 years in the present study may be anticipated, because in general we expect small changes in the home or school environment during this time period. However, a significant increase in the intake of soft drinks was observed, and this could be due to, for instance, personal maturation and higher accessibility to money. The adolescents may be more independent in their preferences at the age of 13 years, and the amount of pocket money may have increased allowing the adolescents to buy what they want.

Adolescents with lower levels of SES have been found to have poorer diets than adolescents with higher levels of SES^(26,37). However, such relationships have not conclusively been demonstrated among younger children⁽¹⁵⁾. In our study, significant differences were seen between level of parental education and the intakes of soft drinks and squash at T0. No such differences were observed for the intake of fruits or vegetables, as already reported and discussed in the HEIA intervention study⁽²⁸⁾, neither for the intake of snacks. Adolescents having parents with a higher level of education had higher odds of consuming a stable low intake of soft drinks and squash, when compared with having parents with a low level of education. The results imply that inequalities in parental education were maintained in adolescents' consumption of soft drinks



and squash from the age of 11 to 13 years. No such associations were seen between level of parental education and adolescents' tracking of fruits, vegetables or snacks. Inconsistent results were shown earlier by Wang *et al.*⁽⁸⁾, who found that mothers with a higher education level predicted a stable high intake of fruit and vegetables in Chinese children and adolescents. More studies are needed in order to conclude on the association between parental education and tracking of dietary behaviours in children during the transition into adolescence.

Changes in energy balance-related behaviours may occur during key life stages such as children growing into adolescence. Knowledge about the determinants of such change is important in the prevention of non-communicable diseases⁽³⁸⁾; however, few studies have examined the determinants of change in adolescents' dietary behaviours longitudinally^(29,39). Previous studies show that availability/accessibility, parental intake/modelling and preferences all seem to be strong determinants of children's and adolescents' consumption of SSB^(28,40–42). Further studies should investigate the determinants of adolescents' change in soft drink intake longitudinally.

There are some general methodological aspects to be aware of when doing tracking analysis. Our results of dietary tracking patterns showed that most adolescents kept their relative position in rank over time, when grouped on consumption level at T0. By introducing cut-offs on continuous variables, it is however important to notice that some information will be lost when the outcome variables are grouped⁽⁴³⁾. A tendency of regression towards the mean was observed in these analyses, which may partially be caused by changes in extreme values when repeating observations, as well as by individual changes over time. Moreover, tracking coefficients indicated fair to moderate tracking of dietary behaviours during this period of 20 months. As reported by Twisk⁽¹⁷⁾, it is important to take into account the fact that a high tracking coefficient during a short period of time does not necessarily indicate more tracking than a modest tracking coefficient during a long time span, when comparing the results.

These results should be viewed in light of some limitations. While the participation rate of sampled schools was 21% in the present study, the participation rate among invited adolescents in the participating schools was high across time points. Furthermore, participating schools were from all counties targeted by the HEIA study. Thus we do not believe that adolescents' dietary tracking patterns were influenced by low participation at the school level. Data collection was based on self-reported measures of FFQ, which may raise possible challenges due to misreporting of dietary intake. However, the questionnaire obtained moderate to high test-retest correlations, indicating reliability of the results. The questions on dietary behaviours used in the HEIA questionnaire have previously been validated in another study within the same age group⁽⁴⁴⁾. Dietary behaviours

only measuring intake by frequencies may be a limitation to the study, but an earlier validation study showed that increasing frequency of intake corresponded with increasing amount of intake measured by a pre-coded food diary⁽⁴⁴⁾. Finally, tracking is influenced by the duration of follow-up, and differences in parental education are not necessarily disclosed in the context of dietary tracking during 20 months. Nevertheless, the transition period between childhood and adolescence is a critical period during which rapid changes are expected to occur.

Strengths of the present study were the longitudinal study design based on a relatively large sample size at a narrow age range, with a high participation rate over time. Furthermore, drop-out analysis showed that individuals lost to follow-up did not differ significantly from the included participants in demographic variables or dietary intakes. Additional strengths were the use of multiple methods to describe tracking patterns over time. Parental education was collected for this purpose from the parents of the adolescents, which reduced both the problem of measurement error and the tendency of missing data. In our study both healthy and unhealthy dietary behaviours were investigated, giving the possibility to look at diverse dietary behaviours of children during the transition into adolescence.

Conclusion

The study showed that a number of dietary behaviours in this population of Norwegian schoolchildren track between the ages of 11 and 13 years. Promotion of healthy dietary behaviours at an earlier age is important in order to prevent the establishment of unfavourable dietary behaviours later in adolescence. Our study indicated that interventions should have a particular focus on adolescents from families with low parental education and their consumption of SSB.

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The relationship between parental education and adolescents' soft drink intake from the age of 11–13 years, and possible mediating effects of availability and accessibility

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Abstract

The present study examined the prospective relationship between parental education and adolescents' soft drink intake over 20 months, and possible mediating effects of adolescents' availability and accessibility of soft drinks at home. A total of 866 adolescents, with data on two time points in the Norwegian HEalth In Adolescents (HEIA) cohort study (2007–9), were included in the analyses. Data on intake and determinants of soft drinks were collected from adolescents and both parents by questionnaires. Mediation analyses using linear regression investigated the total and direct effects of parental education on adolescents' soft drink intake from the age of 11–13 years. In order to investigate prospective relationships, two models were set up to measure the (1) prediction and (2) change in consumption over 20 months. Possible mediation effects of availability and perceived accessibility at home were further examined in both models. The results showed that a lower level of parental education predicted a higher intake of soft drinks among adolescents after 20 months, and that higher perceived accessibility of soft drinks reported by adolescents and mothers explained 39% of the total effect. No relationship was observed between parental education and the change in adolescents' intake of soft drinks over 20 months. Interventions aimed at families with low parental education should target the perceived accessibility of soft drinks at home in order to diminish social differences in adolescents' soft drink consumption.

Key words: Sugar-sweetened beverages: Socio-economic position: Parental education: Adolescents: Mediation

Sugar-sweetened beverage consumption contributes to a considerable proportion of adolescents' energy intake^(1–4), and is one of the energy balance-related behaviours associated with overweight and weight gain among children and adolescents^(5–9). The consumption of soft drinks is shown to track from childhood to adolescence⁽¹⁰⁾ and further into adulthood^(11,12). In order to support a healthy weight development, it is essential to identify factors in the environment that may influence energy balance-related behaviours^(12–14). Longitudinal studies are currently needed in order to identify possible environmental determinants^(15,16).

The home food environment is considered to be of importance in the development of children's and adolescents' dietary behaviours^(7,12,17,18). Parents are found to play an important role in shaping the dietary behaviours of their children by determining which foods are available and how foods are prepared in the home^(7,12). Parental education is one aspect of the

home environment, and a lower level of parental education has been found to be associated with poorer diets^(12,19), and with an increased prevalence of overweight and obesity^(12,20) among adolescents. Cross-sectional studies have furthermore reported an inverse association between parental education and adolescents' soft drink consumption^(21–25); however, no studies have to our knowledge investigated this relationship longitudinally.

The relationship between parental education and dietary behaviours (e.g. consumption of soft drinks) may be explained through determinants in the home environment⁽²⁴⁾, but this has not been much studied. Parental education has been inversely associated with children's and adolescents' availability and accessibility of soft drinks at home^(23,25,26). Moreover, a recent review reported a positive relationship between the availability of soft drinks at home and consumption among adolescents aged 10–12 years⁽²⁷⁾, but

Abbreviations: HEIA, HEalth In Adolescents; M₁, availability; M₂, perceived accessibility by adolescents; M₃, perceived accessibility by mothers; M₄, perceived accessibility by fathers; T₀, baseline survey; T₂, 20 months' follow-up.

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only one study was found to investigate this relationship longitudinally⁽²⁸⁾. Less is known about the association between the accessibility of soft drinks at home and adolescents' intake⁽¹⁸⁾.

Further understanding of whether availability and accessibility influence the prospective relationship between parental education and adolescents' soft drink consumption through mediating pathways is important to be able to modify this behaviour. The present study hypothesised that lower parental education is associated with an increased intake of soft drinks among adolescents from the age of 11–13 years, and that this relationship is mediated by higher availability and perceived accessibility of soft drinks at home.

Methods

Subjects and study design

Data were obtained from the HEalth In Adolescents (HEIA) cohort study, consisting of participants from the twenty-five control schools included in the HEIA intervention study. The design and methodology have been described in detail elsewhere⁽²⁹⁾. All sixth graders were invited to take part in the study, resulting in a HEIA cohort of 1381 adolescents. At the baseline survey (T0) in September 2007, 975 (71%) adolescents participated. In May 2008, 970 (70%) participants attended the first follow-up, and 945 (68%) adolescents participated in the 20 months' follow-up (T2) during May 2009. Parents or legal guardians (hereafter called parents) of the adolescents were also asked to participate in the study at T0 and T2. For the purpose of the present study, only participants attending T0 and T2, with data on parental education at T0 and adolescents' soft drink intake at T2, were included, resulting in 89% of the adolescents participating at T0 (866/975).

The present study was conducted according to the guidelines laid down in the Declaration of Helsinki, and all procedures were approved by the Regional Committee for Medical Research Ethics and the Norwegian Social Science Data Service. Written informed consent was obtained from the parents of all participants.

Data collection

Information on the educational level of both parents was collected from the parents through the consent forms for their child. Internet-based questionnaires were filled in by the adolescents during school hours at all time points, taking about 45 min to complete. The questionnaires assessed dietary, sedentary and physical activity behaviours and their determinants. Trained staff was available during data collection, collecting anthropometric measurements at T0 and T2. Adolescents brought home paper questionnaires to each of the parents, who returned them through their adolescents and the school to the HEIA project workers. Mothers and fathers answered the same questions assessing dietary, sedentary and physical activity behaviours, their determinants and presumed determinants of their child's dietary and physical activity behaviours at T0 and T2. Additional questions on

availability of foods in the home were measured at T0 among mothers only. All questionnaires consisted of mostly pre-coded answer categories.

Dietary behaviour

Usual consumption of carbonated sugar-sweetened soft drinks (hereafter called soft drinks) was reported by the adolescents, by frequency per weekday in six categories ranging from never/seldom to every weekday, and amount in glasses for each occasion in four categories ranging from one glass to four glasses or more. For weekends, the consumption was measured by the total number of glasses over both days in eight categories ranging from never/seldom to seven glasses or more. Instructions in the questionnaire specified that 5 dl beverage equalled three glasses, making one glass 1.67 dl. The intake of soft drinks was therefore calculated into dl/week from the sum of five weekdays and two weekend days. A separate test–retest study among 114 sixth graders, from the same sampling area as the main study, was conducted before baseline data collection^(23,29). The self-reported measures of soft drinks obtained good test–retest reliability (Spearman's ρ : 0.73, data not shown).

Determinants

Parental education was dichotomised into categories of 12 years or less and 13 years or more (university or college attendance). Educational level of the parent with the longest education was used, or else the one available. Age- and sex-specific BMI cut-off values, as proposed by the International Obesity Task Force⁽³⁰⁾, were used to categorise the adolescents into normal weight or overweight/obese based on objectively measured height and weight.

Home availability of soft drinks was determined by mothers with the question 'Do you have soft drinks available in your house at this moment?', with answer categories yes or no. Adolescents' perceived accessibility of soft drinks in the home was determined by adolescents and each parent with the question: 'When soft drinks with sugar are available at home, can you (your child) serve yourself (him-/herself) as you (he/she) please(s)?' The six pre-coded answer categories were as follows: always, most days, sometimes, seldom or never serve as pleased and not available at home. Measures of adolescents' availability and perceived accessibility of soft drinks obtained good test–retest reliability (Spearman's ρ : 0.61–0.71, data not shown).

Data analysis

All statistical analyses were performed by IBM® SPSS® Statistics, version 19.0 (IBM Corporation). Attrition analysis was calculated between participants in the included sample (n 866) and those lost to follow-up between T0 and T2 (n 109), using independent-samples t tests for continuous variables and Pearson's χ^2 tests for categorical variables. Additional missing values appeared when data from adolescents, mothers and fathers were combined in the

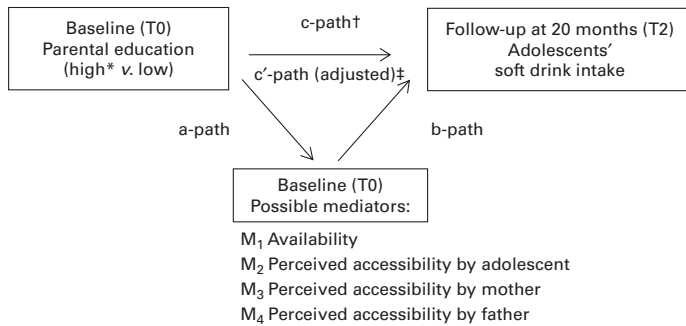


Fig. 1. Prediction of parental education on adolescents' soft drink intake after 20 months (model 1). * Reference group. † Adjusted for sex. ‡ Adjusted for sex and potential mediator(s).

mediation analyses. Attrition analysis was for this reason also conducted on the differences between the mediation sample ($n = 557$) and those with incomplete data ($n = 418$). Independent-samples t tests and Pearson's χ^2 tests were further used to investigate differences in adolescents' intake, availability and perceived accessibility of soft drinks by parental education at both time points. Pearson's correlation coefficients were obtained in order to investigate correlations between possible mediating variables of home availability and perceived accessibility measured by adolescents, mothers and fathers.

In order to examine prospective relationships, two models were set up to measure the influence of parental education on adolescents' soft drink intake over a time period of 20 months (Figs. 1 and 2). Model 1 (Fig. 1) investigated the prediction of parental education at T0 on adolescents' soft drink intake at T2. Model 2 (Fig. 2) investigated the relationship between parental education at T0 and the change in adolescents' soft drink intake over 20 months. Change in adolescents' soft drink intake between the time points was calculated by absolute change scores. Absolute change scores measure unconditional changes over time^(31,32), and are calculated by the difference score between the time points ($T2 - T0$)⁽³¹⁻³³⁾.

According to MacKinnon *et al.*⁽³⁴⁾, a mediator is a variable that transmits the effect of an independent variable on a dependent variable. Adolescents' availability (M_1) and perceived accessibility of soft drinks measured by adolescents (M_2), mothers (M_3) and fathers (M_4) at T0 were examined as possible mediating variables in both models. All analyses were adjusted for sex. Adolescents' weight status was found to be a confounder of the results in model 2, and was therefore adjusted for in this model. The possible clustering by schools was tested using linear mixed model analyses. Only 4% of the unexplained variance of adolescents' soft drink intake was found at the school level in model 1 and 1% was found in model 2 (data not shown), and therefore multi-level analyses were not performed⁽³⁵⁾. Mediation analyses were performed using linear regression, and unstandardised β coefficients are presented. Assumptions for the mediation analyses were met in both models.

Single mediation analyses were calculated by three steps: (1) the c-path measures the total effect of parental education on adolescents' prospective soft drink intake (model 1) and the change in adolescents' soft drink intake over 20 months (model 2); (2) the a-path measures the relationship of parental education with each of the possible mediators (M_1-M_4) in

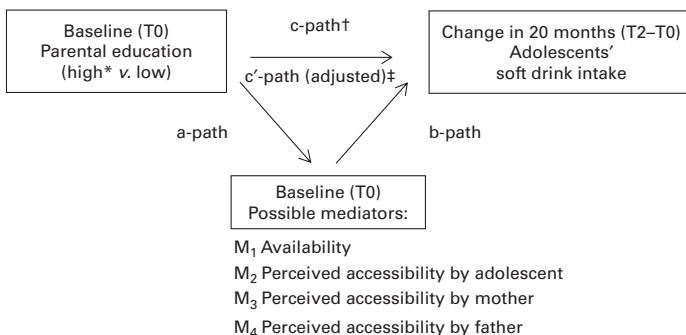


Fig. 2. Relationship between parental education on the change in adolescents' soft drink intake over 20 months (model 2). * Reference group. † Adjusted for sex and weight status (based on the International Obesity Task Force cut-off points). ‡ Adjusted for sex, weight status and potential mediator(s).

Table 1. Participant characteristics at baseline and attrition analyses of the included sample (*n* 866) and the mediation sample (*n* 557) (Mean values and standard deviations)

Measurements	Total sample						<i>P</i> *	Mediation sample						
	Included			Excluded				Included			Missing			
	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD		<i>n</i>	Mean	SD	<i>n</i>	Mean	SD	
Sex	866			109			0.485	557			418			0.118
% Boys		51.5			55.0				54.8			49.7		
Parental education†	866			79			0.015	557			388			<0.001
% Low		30.9			44.3				26.0			40.7		
Age (years)	866	11.2	0.3	109	11.2	0.3	0.758	557	11.2	0.3	418	11.2	0.3	0.243
Soft drink intake (dl/week)	839	5.3	5.8	103	5.6	5.8	0.522	557	5.2	5.9	385	5.5	5.8	0.406
Availability	702			73			0.337	557			218			0.049
% No		61.4			67.1				59.8			67.4		
Perceived accessibility by adolescents‡	862	1.9	1.1	107	1.9	1.2	0.553	557	1.8	1.2	412	1.9	1.1	0.441
Perceived accessibility by mothers‡	708	1.5	1.1	72	1.7	1.2	0.394	557	1.5	1.1	223	1.6	1.1	0.195
Perceived accessibility by fathers‡	603	1.8	1.1	54	1.6	1.4	0.503	557	1.8	1.1	100	1.8	1.2	0.945

* Attrition analysis by independent-samples *t* test/Pearson's χ^2 test.

† Parental education as low *v.* high (university/college).

‡ Perceived accessibility measured by six answer categories; from not available at home (recoded as 0) to always served as pleased (recoded as 5).

both models; (3) the *b*-path measures the relationship between each of the possible mediators (M_1 – M_4) on adolescents' prospective soft drink intake (model 1) and the change in adolescents' soft drink intake over 20 months (model 2), when adjusted for parental education^(34,36) (Figs. 1 and 2). The mediation effect (*a* × *b*) with 95% CI and statistical significance was obtained from bootstrapping, calculated by resampling of 1000 independent samples using the SPSS script described by Preacher & Hayes⁽³⁶⁾. A multiple mediation analysis was finally conducted for each model, by calculating the *a*-path and *b*-path when adjusted for all significant mediating variables of availability and perceived accessibility from the single mediation analyses. A fourth step was then calculated: (4) the *c'*-path measures the direct effect of parental education on adolescents' prospective soft drink intake (model 1) and the change in adolescents' soft drink intake over 20 months (model 2), when adjusted for all significant mediating variables of availability and perceived accessibility from the single mediation analyses^(34,36).

Mediation effects with 95% CI and statistical significance by bootstrapping were finally conducted⁽³⁶⁾.

Results

Of the 866 participants included in these analyses, 51.5% were boys and the mean age was 11.2 years at T0 (Table 1). A total of 30.9% of the adolescents had parents with lower education, which was significantly less than among those lost to follow-up (*n* 109; Table 1). No other significant differences in adolescents' sex, age, intake of soft drinks or availability and perceived accessibility of soft drinks were found in the attrition analysis of participants lost to follow-up. Similar findings were seen in the attrition analysis of the adolescents with complete data in the mediation analysis *v.* those with incomplete data (*n* 418; Table 1).

The mean intake, availability and perceived accessibility of soft drinks at T0 and T2 by parental education are shown in Table 2. Adolescents with parents of low education consumed significantly more soft drinks at both time points than those of

Table 2. Adolescents' intake, availability and perceived accessibility of soft drinks (dl/week) at age 11 (T0) and age 13 (T2) years by parental education (Mean values and standard deviations)

Adolescents' measurements	T0							T2						
	Parental education*						<i>P</i> †	Parental education*						
	Low			High				Low			High			
	<i>n</i>	Mean	SD	<i>n</i>	Mean	SD		<i>n</i>	Mean	SD	<i>n</i>	Mean	SD	<i>P</i> †
Soft drink intake by adolescents	258	6.7	7.0	581	4.6	5.1	<0.001	268	7.6	7.4	598	5.4	5.8	<0.001
Availability	203	0.4	0.5	499	0.4	0.5	0.455	177	0.5	0.5	433	0.4	0.5	0.055
Perceived accessibility by adolescents‡	265	2.1	1.1	597	1.8	1.1	<0.001	267	2.3	2.3	598	1.9	1.3	<0.001
Perceived accessibility by mothers‡	202	1.7	1.2	506	1.5	1.1	0.003	184	1.8	1.1	438	1.6	1.1	0.062
Perceived accessibility by fathers‡	163	2.0	1.1	440	1.7	1.1	<0.001	133	2.2	1.3	383	1.9	1.2	0.027

* Parental education as low *v.* high (university/college).

† Difference between the groups of parental education with independent-samples *t* test/Pearson's χ^2 test.

‡ Perceived accessibility measured by six answer categories; from not available at home (recoded as 0) to always served as pleased (recoded as 5).

Table 3. Correlations between the measures of adolescents' availability and perceived accessibility of soft drinks as reported by 11-year-olds and their parents

	<i>n</i>	<i>M</i> ₁	<i>M</i> ₂	<i>M</i> ₃	<i>M</i> ₄
<i>M</i> ₁	702	1			
<i>M</i> ₂	862	0.11*	1		
<i>M</i> ₃	708	0.28*	0.35*	1	
<i>M</i> ₄	603	0.25*	0.25*	0.47*	1

*M*₁, availability; *M*₂, perceived accessibility by adolescents; *M*₃, perceived accessibility by mothers; *M*₄, perceived accessibility by fathers.

* Pearson's correlation coefficients were significant ($P < 0.05$).

parents with high education. Perceived accessibility was also significantly higher among adolescents with parents of low education at T0 and T2. However, associations were not found for adolescents' availability of soft drinks (Table 2). Pearson's correlations between the possible mediating variables of availability and perceived accessibility at T0 were < 0.5 (Table 3). The largest correlation ($r = 0.47$) was found between the perceived accessibility of soft drinks reported by mothers and fathers.

Model 1: parental education predicting adolescents' soft drink intake after 20 months

Single mediation analyses showed a significant total effect between parental education and adolescents' soft drink intake after 20 months (c-path), where low parental education at T0 indicated a higher intake of soft drinks at T2 (Table 4). The multiple mediation analysis additionally showed a significant direct effect (c'-path) of parental education on adolescents' soft drink intake after 20 months, indicating that this relationship was still present after adjusting for significant mediators of the relationship.

Single mediation analyses found significant mediation effects of adolescents' perceived accessibility of soft drinks reported by adolescents, mothers and fathers on the relationship between parental education at T0 and soft drink intake at T2. No mediation effect was found for the availability of soft drinks in the home. The multiple mediation analysis showed significant mediation effects of adolescents' perceived

accessibility of soft drinks reported by adolescents and mothers by explaining 39% of the total effect, but a mediation effect was no longer found for perceived accessibility reported by fathers.

Strong relationships between parental education and the perceived accessibility of soft drinks measured by adolescents, mothers and fathers were furthermore observed in single mediation analyses (a-path), but this relationship was not significant for the availability of soft drinks at home. Significant associations were furthermore observed for the availability and perceived accessibility of soft drinks at T0 on adolescents' consumption at T2, in single mediation analyses (b-path).

Model 2: parental education predicting the change in adolescents' soft drink intake over 20 months

No significant relationship was found between parental education at T0 and the change in adolescents' soft drink intake over 20 months (T2 – T0) in single mediation analyses (c-path) (Table 5). The multiple mediation analysis was not performed in model 2, because no significant mediating effects of availability or perceived accessibility in the home were detected in the single mediation analyses.

Discussion

The present study found that the level of parental education is inversely associated with adolescents' soft drink intake at both ages of 11 and 13 years. Furthermore, single mediation analyses indicated that parental education predicts adolescents' soft drink intake between the ages of 11 and 13 years (c-path). Other studies investigating the prediction of parental education on adolescents' soft drink consumption were not found; however, the result is consistent with a recent cross-sectional study among Norwegian sixth and seventh graders⁽²²⁾. The multiple mediation analysis furthermore observed a significant direct effect between parental education and adolescents' prospective soft drink intake after 20 months (c'-path). Hence, this relationship does not seem to be fully mediated by the availability or perceived accessibility of soft drinks in the home.

Table 4. Prediction of parental education† on adolescents' soft drink intake after 20 months (T2), and the possible mediating effects of availability and perceived accessibility at baseline (T0) (*n* 557)

Measurements	c-path	SE	a-path	SE	b-path	SE	c'-path	SE	a × b‡	95% CI	a × b/c§
Single mediation models	1.9*	0.6									
<i>M</i> ₁			0.0	0.0	1.6*	0.5			-0.1	-0.2, 0.1	
<i>M</i> ₂			0.4*	0.1	1.6**	0.2			0.6	0.2, 1.1	29%
<i>M</i> ₃			0.3*	0.1	1.4**	0.2			0.4	0.2, 0.9	23%
<i>M</i> ₄			0.4**	0.1	0.7*	0.2			0.3	0.0, 0.5	14%
Multiple mediation model	1.9*	0.6					1.2*	0.6	0.7	0.3, 1.3	39%
<i>M</i> ₂			0.4*	0.1	1.3**	0.2			0.5	0.2, 0.9	24%
<i>M</i> ₃			0.3*	0.1	0.9*	0.3			0.3	0.1, 0.6	15%
<i>M</i> ₄			0.4**	0.1	0.0	0.3			0.0	-0.3, 0.2	

*M*₁, availability; *M*₂, perceived accessibility by adolescents; *M*₃, perceived accessibility by mothers; *M*₄, perceived accessibility by fathers.

Statistical significance: * $P < 0.05$, ** $P < 0.001$.

† Baseline (T0) parental education as high (university/college) v. low.

‡ Mediation effect.

§ Percentage mediation effect.

|| Linear regression analysis, adjusted for sex.

Table 5. Relationship between parental education† and the change in adolescents' soft drink intake over 20 months (T2 – T0), and the possible mediating effects of availability and perceived accessibility at baseline (T0) (n 550)

Measurements	c-path	SE	a-path	SE	b-path	SE	a × b‡	95% CI
Single mediation models§	-0.9	0.6						
M ₁			0.0	0.0	-0.2	0.5	0.0	-0.0, 0.2
M ₂			0.4*	0.1	-0.3	0.2	-0.1	-0.4, 0.1
M ₃			0.3*	0.1	0.3	0.2	0.1	-0.1, 0.3
M ₄			0.4**	0.1	0.1	0.2	0.0	-0.2, 0.2

M₁, availability; M₂, perceived accessibility by adolescents; M₃, perceived accessibility by mothers; M₄, perceived accessibility by fathers.

Statistical significance: **P* < 0.05, ***P* < 0.001.

† Baseline (T0) parental education as high (university/college) v. low.

‡ Mediation effect.

§ Linear regression analysis, adjusted for sex and weight status (normal/overweight).

Adolescents' perceived accessibility of soft drinks at the age of 11 years reported by adolescents and mothers partly mediated the prospective relationship between parental education and adolescents' soft drink intake after 20 months, by explaining 39% of the total effect in the multiple mediation analysis. Perceived accessibility of soft drinks reported by fathers was no longer a significant mediator, when adjusted for perceived accessibility measured by adolescents and mothers. A correlation was found between parental reports of perceived accessibility (*r* 0.47), and caution should therefore be made before disregarding the importance of perceived accessibility of soft drinks reported by fathers. Availability of soft drinks in the home was neither a mediator of the total effect between parental education and adolescents' prospective soft drink intake after 20 months, possibly explained by small differences in the availability of soft drinks between the levels of parental education among the 11-year-olds. However, it is important to mention that availability was measured by only one question on whether soft drinks were available in the home or not, which may not capture all dimensions of adolescents' soft drink availability. The results are somewhat consistent with a recent cross-sectional study among pre-school children in Belgium, showing that the relationship between parental education and the consumption of soft drinks was almost entirely mediated by accessibility at the dinner table, availability in the home and permissiveness⁽²⁶⁾. Other personal or environmental mediating variables may also be involved, but this was not tested in the present analyses. Perceived accessibility measured by adolescents and parents may be important determinants to consider in interventions aiming to reduce differences by parental education in adolescents' prospective soft drink consumption.

Single mediation analyses found both availability and perceived accessibility among adolescents and parents to be strong predictors of adolescents' soft drink intake after 20 months, when adjusted for sex and parental education (b-path). Several cross-sectional studies have observed a positive association between adolescents' self-reported home availability of soft drinks and consumption^(37–39), when adjusted for sex⁽³⁸⁾, age⁽³⁷⁾, ethnicity and school level⁽³⁹⁾. Norwegian cross-sectional data have also found perceived accessibility measured by adolescents themselves to be correlated with soft drink intake among nine and tenth graders, when adjusted for sex, educational plans, dieting, grade and school level⁽¹⁸⁾. Correlations between adolescents' and

parents' reports of perceived accessibility were low in the present study, indicating that adolescents' perception of their food environment is not necessarily the same as that of their parents, which has also been reported by others^(13,17,23,40).

No association was seen between parental education and the change in adolescents' soft drink intake over 20 months. This may indicate that differences by parental education in adolescents' soft drink intake were established before this age and did not increase between the ages of 11 and 13 years. Further on, no relationship was observed between parental education and availability or perceived accessibility or between availability or perceived accessibility and the change in soft drink intake over time. Hence, availability of soft drinks did not mediate the effect of parental education on the change in adolescents' soft drink intake from the age of 11–13 years. These findings are not consistent with those of Ezendam *et al.*⁽²⁸⁾, who found that self-reported perceived availability of soft drinks at home was associated with the change in adolescents' soft drink intake over 4 months. The association was partly mediated through adolescents' perceived behaviour control. However, the adolescents were slightly older at baseline (mean age 12.6 years)⁽²⁸⁾, and changes may be more rapid later in adolescence. More studies should therefore investigate this relationship.

These results should be viewed in light of some limitations of the study. Although the participation rate of sampled schools was low (21%), attrition analyses showed that there was no significant difference between schools that participated in the study and schools that declined participation in terms of the number of students in the sixth grade and overall size⁽⁴¹⁾. Attrition analysis disclosed significant differences in the level of parental education between those included and excluded from these analyses. However, no significant differences were seen in the intake or availability of soft drinks at home, thus we believe that the results are representative for this population of 11–13-year-olds. The use of absolute change scores may be a problem because the measure does not take into account the phenomena of regression towards the mean⁽³⁵⁾. Unconditional change over time was measured because differences in adolescents' soft drink intake were observed between the levels of parental education at baseline^(31,32). Furthermore, the correlation between soft drink measurements at T0 and T2 was <0.5 in the present study (data not shown), which is considered to give acceptable reliability of absolute change scores⁽³²⁾.

The strengths of the present study were the longitudinal study design based on a relatively large sample size at a narrow age range, with a high participation rate over time. Moreover, the questionnaire obtained moderate-to-high test–retest correlations, indicating the reliability of the measures⁽²⁹⁾. The question measuring soft drink consumption used in the HEIA questionnaire has previously been validated in another study within the same age group⁽⁴²⁾, although the HEIA study asked for intake on weekdays and weekends separately. Information on parental education was for this purpose collected from the parents through the adolescents' consent forms, which is considered to give more reliable measurements than when collected from the adolescents themselves.

Conclusion

The present study showed that parental education predicts young adolescents' soft drink consumption after 20 months when adjusted for sex, and a significant direct effect was observed after adjusting for mediating variables of home availability and perceived accessibility. Thus, the hypothesis was to a certain extent supported, as we found that perceived accessibility of soft drinks partly mediated this relationship when measured by adolescents and mothers. Interventions aiming at families with low parental education should target both adolescents' and parents' perceived accessibility of soft drinks in order to reduce social differences in adolescents' soft drink consumption. Finally, the availability of soft drinks at home should in general be targeted to prevent the increase in adolescents' prospective intake.

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RESEARCH

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Adolescents' prospective screen time by gender and parental education, the mediation of parental influences

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Abstract

Background: The present study investigated associations in gender dyads of parents' and adolescents' time spent on television and video viewing (TV/DVD), and computer and electronic game use (PC/games) at the ages of 11 and 13 years. Possible mediating effects of parental modelling and parental regulation in the relationship between parental education and adolescents' prospective TV/DVD and PC/game time were further examined.

Methods: A total of 908 adolescents, participating at both ages 11 and 13 years in the Norwegian HHealth In Adolescents (HEIA) cohort study (2007–2009), were included in the analyses. Data on adolescents', mothers' and fathers' self reported time spent on TV/DVD and PC/games were measured at both time points by questionnaires. Correlation coefficients were used to examine gender dyads of parents' and adolescents' reports. Mediation analyses using linear regression investigated possible mediation effects of parental modelling and parental regulation in the prospective relationship between parental education and adolescents' time spent on TV/DVD and PC/games between the ages of 11 and 13 years.

Results: Correlations of screen time behaviours in gender dyads of parents and adolescents showed significant associations in time spent on TV/DVD at the age of 11 and 13 years. Associations between mothers and sons and between fathers and daughters were also observed in time spent on PC/games at the age of 11 years. Maternal and paternal modelling was further found to mediate the relationship between parental education and adolescents' prospective TV/DVD time between the ages of 11 and 13 years. No mediation effect was observed for parental regulation, however a decrease in both maternal and paternal regulation at the age of 11 years significantly predicted more TV/DVD time among adolescents at the age of 13 years.

Conclusion: Cross-sectional and longitudinal relationships were observed in gender dyads of parents' and adolescents' screen time behaviours at the ages of 11 and 13 years, and further studies including both parents and their children should be emphasized. Moreover, maternal and paternal modelling were found to be important target variables in interventions aiming to reduce social differences by parental education in adolescents' prospective time spent on TV/DVD.

Keywords: Television, Computer games, Socioeconomic position, Parental modelling, Parental regulation, Gender dyads

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Background

Sedentary behaviour is one of the energy balance related behaviours found to be associated with body weight, overweight and obesity in children and adolescents [1-8], and is emerging as an important issue in public health [9,10]. Children and adolescents' sedentary behaviours are shown to continue into adulthood [11], and time spent sedentary during childhood is thus associated with several health consequences as adults [12]. The age of 10–11 years is considered to be a key transition phase in a prevention perspective [13], and good opportunities for future health may be established among children growing into adolescence [14].

Sedentary behaviours can be defined as low-energy expenditure activities [5,9,15], and the most common sedentary behaviours are related to desk-based work and education, motorized transport, sitting while socializing and screen time [5,16]. Early adolescence is considered a critical time period for the onset of screen time behaviours [14,17]. European children and adolescents' are in general found to exceed the recommendation of spending less than two hours on screen time a day [18-20]. Several reviews have therefore investigated correlates of sedentary behaviours [4,5,21,22] and screen time [23,24] in young people. However, insufficient evidence was found for prospective determinants of children and adolescents' sedentary behaviours [22], and few investigated other screen time behaviours than television viewing. Reviews of cross-sectional studies found boys, older children, a higher body weight, lower socioeconomic status, lower parental education, non-white ethnicity and children living in one-parent families to be socio-demographic correlates of increased screen time among children and adolescents [5,21,23,24].

A previous cross-sectional study found the family television environment to partly mediate the relationship between maternal education and children's television viewing [25]. Important factors in the home environment related to children's and adolescents' screen time are access to televisions and computers at home [5,26], parental screen time [22,24,26] and parental rules/regulation/limitation [5,26]. Little is known about gender specific relationships between parents and their children's screen time [27]. Two cross-sectional and one longitudinal study were found to investigate the association between adolescents' television viewing and parental television viewing [28-30] and parental rules of television viewing [29] with reports from mothers and fathers separately. Moreover, few cross-sectional and no longitudinal studies were found to specifically investigate the association between adolescents' time spent on computer and electronic games with parental screen time behaviours [31,32] or parental screen time rules [31,33,34]. Longitudinal studies are currently needed to examine the

relationship between the home environment and adolescents' sedentary behaviours [26,27].

In the HEalth In Adolescents (HEIA) cohort study it has previously been reported that time spent on television and video viewing (TV/DVD) and on computer and electronic games (PC/games) increased significantly among boys and girls from the age of 11 to 13 years [35]. Demographic factors related to adolescents' total screen time between the ages 11 to 13 years were lower parental education among girls and not living in two-parent families among boys [35]. Determinants in the home environment may be important target variables to consider in interventions aiming to reduce adolescents' prospective screen time, and thus explain some of the educational differences in adolescents screen time. The purpose of the present paper was to investigate associations in gender dyads of parents' and adolescents' time spent on TV/DVD and PC/games, and to examine whether parental modelling and parental regulation mediate the relationship between parental education and TV/DVD or PC/game time from the age of 11 to 13 years.

Methods

Subjects and study design

The HEIA cohort consists of students from the 25 control schools of the randomized controlled intervention study HEIA. A total of 37 schools participated in the HEIA study, out of 177 schools identified from the largest towns/municipalities in seven counties surrounding the capital of Norway, with at least 40 pupils enrolled in 6th grade. These were randomly selected into 12 intervention schools and 25 control schools. The design and methodology of the HEIA study is described in detail elsewhere [36]. The present study was conducted according to the guidelines laid down in the Declaration of Helsinki and all procedures were approved by the Regional Committee for Medical Research Ethics and the Norwegian Social Science Data Service. Written informed consents were obtained from the parents of the included adolescents, and participation in the study was voluntary among both adolescents and parents at all times.

All 6th graders enrolled in the 25 control schools were invited to participate, resulting in a cohort sample of 1381 adolescents. At the baseline survey (T0) in September 2007, 975 (71%) adolescents participated. In May 2008, 970 (70%) attended the first follow up (T1), and 945 (68%) adolescents participated in the 20 months follow up (T2) during May 2009. Parents or legal guardians (hereafter called parents) of the adolescents were also asked to participate in the study at T0 and T2. For the purpose of the present paper, only participants attending T0 and T2 were included, resulting in 908 (93%) of the adolescents participating at T0. When including mothers' and fathers'

reports at T0, the study sample was reduced to 738 (76%) and 630 (65%) respectively.

Data collection

Information on both parents' education was reported by parents on the adolescents' consent forms. Internet-based questionnaires were filled in by the adolescents during school hours at each time-point, taking about 45 minutes to complete. The questionnaires assessed dietary, sedentary and physical activity behaviours and their determinants. Trained staff was available for questions during data collection at all times, and for measuring adolescents' anthropometrics by height, weight, hip and waist at T0 and T2. Adolescents brought home separate questionnaires for their mothers and fathers. Both parents answered the same questions assessing dietary, sedentary and physical activity behaviours, their determinants as well as determinants related to their child's behaviours at T0 and T2, taking about 45 minutes to complete. The questionnaires were returned to the schools in sealed envelopes by the adolescents, and then collected by the HEIA project workers. All questionnaires consisted of mostly pre-coded answer categories, in addition to some open ended fields with the possibility of specifying the responds.

Outcome measures of screen time

Adolescents' TV/DVD time was measured by a question modified from the PEACH study [37]. For the purpose of the present study, time used at weekdays and weekends were assessed separately, as previously recommended [38]. The question assessing TV/DVD time was phrased: "How many hours do you usually watch television and/or video on a normal weekday?" The same question was asked for a normal weekend day or day off from school. The answer categories were (recoding in brackets): half an hour (0.5), one hour (1), two hours (2), three hours (3), four hours (4), five hours or more (5). A similar question was composed to assess adolescents' usual time spent on PC/games: "How many hours do you usually spend on computer, TV games or other electronic games on a normal weekday?" The same question was asked for a normal weekend day or day off from school. The answer categories were (recoding in brackets): no time (0), half an hour or less (0.5), one hour (1), two hours (2), three hours (3), four hours or more (4). Separate weekly scores for TV/DVD and PC/game time were calculated by summing hours reported for an average weekday (multiplied by five) and average weekend day (multiplied by two). The weekly outcome measures obtained acceptable test-retest correlation (Spearman's $\rho=0.66-0.73$) [35,36].

Parental measures

Parental education was dichotomized into categories of 12 years or less and 13 years or more (equals university

or college attendance). The parent with the longest education was used, or else from the one available. Parental behaviours (parental modelling) were measured by both parents as usual time spent on TV/DVD and PC/games by the same questions and pre-coded answer categories as for adolescents. However, in the parental questionnaires it was stated that the reported PC/game time was to be outside working hours. Parental regulation of TV/DVD was measured by mothers and fathers by a question derived from a previously reliability tested and published instrument [30]: "I restrict how much time my child spends watching TV". A similar question was composed to measure parental regulation of PC/games: "I restrict how much time my child spends on computer and other electronic games". The answer categories were based on a five point Likert scale (recoding in brackets): totally disagree (1), partly disagree (2), neither agree nor disagree (3), partly agree (4), totally agree (5).

Correlates

Adolescents' height and weight were measured objectively by project workers to the nearest 0.1 cm and 0.1 kg [39]. Age and gender specific body mass index cut-off values as proposed by the International Obesity Task Force was used to categorize the adolescents' weight status as normal weight or overweight/obese [40]. Living status was reported by the adolescents and grouped in two categories of those living in two-parent families (including married or cohabitating parents or parent/step-parent), and those living in other families such as with their father or mother alone, equally with their mother and father alone, with foster parents or with other guardians. The study sample consisted of 93.5% ethnical Norwegians, and thus differences by ethnicity was not investigated.

Data analysis

All statistical analyses were performed by IBM® SPSS® Statistics, version 19.0 (IBM Corporation). Descriptive statistics were used to present baseline demographics of adolescents, mothers and fathers. Pearson's correlation coefficients were conducted to investigate associations of TV/DVD and PC/game time in gender dyads of parents and adolescents at T0 and T2. Differences in adolescents screen time by parental education were obtained by independent-samples *t* test. Attrition analyses were calculated at T0 between the sample of adolescents included in mediation analyses ($n=573$) and those missing due to incomplete data from mothers' and/or fathers' reports ($n=402$). Independent-samples *t* test was used for continuous variables and Person's chi-square test was used for categorical variables.

To investigate the mediation of parental modelling and parental regulation, two models were set up to measure

the relationship between parental education and adolescents' prospective screen time separately for TV/DVD time (model 1) and PC/game time (model 2). Figure 1 illustrates the prediction of parental education at T0 on adolescents' TV/DVD time (model 1) and PC/game time (model 2) at T2. The possible mediation of parental modelling by TV/DVD time (model 1) and PC/game time (model 2), as measured at T0 by mothers and by fathers, and parental regulation of adolescents' TV/DVD time (model 1) and PC/game time (model 2), as measured at T0 by mothers and by fathers, was examined.

Cluster effects of adolescents' screen time have previously been measured in the HEIA cohort, and low unexplained variance (1.5 – 2.8%) was found at the school level [35,36]. The analyses were thus not adjusted for clustering effects by school [41]. Mediation analyses were investigated by linear regression, and unstandardized beta coefficients are presented. In order to control for other possible influences associated with adolescents' screen time, adolescents' gender, weight status and living status at T0 were adjusted for in all analyses. To obtain power estimates of 0.8 as recommended in mediation analyses by Fritz and MacKinnon [42], bias-corrected bootstrap analyses were performed using the SPSS script described by Preacher & Hayes [43] with a resampling of 1000 independent samples. Assumptions for the analyses were investigated and considered acceptable.

Single mediation analyses were performed in model 1 and model 2 investigating the total effect of parental education on adolescents' prospective screen time (c-path) (Figure 1). The relationship between parental education and each of the possible mediating variables were examined at T0 (a-path), as well as the relationship between

each of the possible mediating variables and adolescents' prospective screen time at T2, when adjusted for parental education (b-path) [43,44]. The direct effect of parental education on adolescents' prospective screen time was then calculated, when adjusted for each of the possible mediating variables of parental modelling and regulation (c'-path). Finally, the mediation effect (a-path x b-path) for each of the possible mediating variables were investigated [43].

Results

Descriptive statistics of the participants at T0 are shown in Table 1. About 31% of the participants had parents with educational level less than university/college attendance. Adolescents and parents reported similar time spent on TV/DVD, but more time spent on PC/games were generally observed among adolescents than among parents. No significant differences in adolescents' screen time or any of the correlates were found at T0 between the participants attending both time points (n=908) and those lost to follow up at T2 (n=67) [35]. Attrition analyses between adolescents included in mediation analyses (n=573) and those lost due to missing data in parental reports (n=402) consistently showed no differences in adolescents' TV/DVD time, but significant less time spent on PC/games were seen among the included adolescents (p=0.01) (data not shown). In the included sample, there was also a significantly larger proportion of adolescents with high level of parental education, normal weight status and living in two-parent families.

Screen time behaviours in gender dyads

There were significant associations between mothers and fathers TV/DVD time at T0 with boys and girls TV/DVD time at both time points. Stronger correlations were generally observed at T2 than at T0, except for between fathers and sons reports (Table 2). Moreover, mothers and their sons PC/game time and fathers and their daughters PC/game time were significantly correlated at T0, but no such associations were found at T2.

Prediction of adolescents' screen time by parental education

Significant differences were observed between adolescents' TV/DVD time and PC/game time at T2 by level of parental education at T0 (Table 3). Single mediation analyses further showed a significant total effect of parental education at T0 on adolescents' prospective PC/game time at T2 (c-path), where lower parental education was associated with an increase in adolescents PC/game time of 1.4 hours a week (Table 4). A significant direct effect was subsequently observed (p=0.04), after adjusting for either of the possible mediating variables of parental modelling and regulation (c'-path). However, single mediation analyses observed no significant relationship

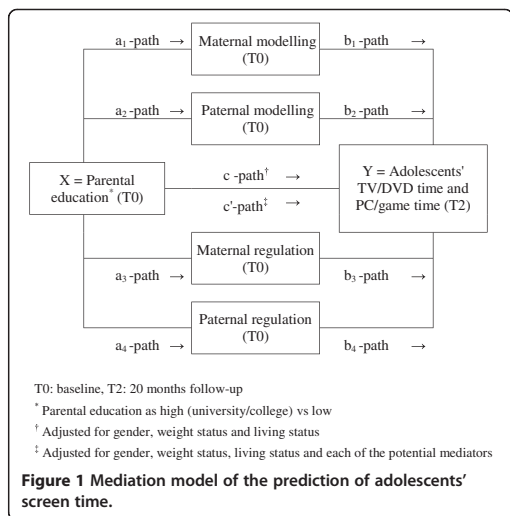


Table 1 Descriptive statistics of adolescents and parents at baseline (T0)

Measure	Value	Boys (n=474)	Girls (n=434)	Mothers (n=738)	Fathers (n=630)
Age	Mean (SD)	11.2 (0.3)	11.2 (0.3)	40.8 (4.8)	43.4 (5.6)
Weight status*	% normal	85.5%	85.4%	-	-
Parental education†	% low	30.2%	32.0%	-	-
Living status‡	% two-parents	79.2%	81.6%	-	-
TV/DVD (hours/week)	Mean (SD)	12.0 (6.9)	11.1 (6.6)	13.0 (6.3)	13.4 (6.6)
PC/games (hours/week)	Mean (SD)	9.8 (6.7)	7.3 (5.8)	2.6 (3.9)	3.7 (4.5)
TV/DVD regulation§	Mean (SD)	-	-	4.1 (1.0)	3.9 (1.0)
PC/game regulation¶	Mean (SD)	-	-	4.0 (1.0)	3.8 (1.1)

Number of participants (n) varies slightly across variables, SD: Standard Deviation.

* Normal weight vs overweight/obese based on the International Obesity Task Force cut off values.

† Parental education as low vs high (university/college) at T0.

‡ Two-parent families vs other families.

§ Measured in a five-point Likert scale (from 1=totally disagree to 5=totally agree).

between parental education and adolescents' prospective TV/DVD time.

Mediation effects of parental modelling and regulation

Significant mediation effects of maternal and paternal modelling at T0 were found on the relationship between parental education at T0 and adolescents' prospective TV/DVD time at T2 (a-path x b-path) (Table 4). Neither maternal nor paternal regulation mediated the relationship between parental education at T0 and TV/DVD time at T2 in either gender. Mediation effects of parental modelling or regulation were not observed in the relationship between parental education and adolescents' PC/game time.

Influence of parental education on parental modelling and regulation

Significant cross-sectional relationships were observed by mediation analyses at T0, between a lower level of

parental education and more maternal and paternal TV/DVD time of 3.6 and 3.3 hours a week respectively (a-path, Table 4). There was no such relationship between parental education and parental regulation of adolescents' TV/DVD time. Cross-sectional relationships were neither found between parental education and parental modelling or regulation of adolescents' PC/game time.

Prediction of adolescents' screen time by parental modelling and regulation

Mediation analyses further found more maternal and paternal TV/DVD time at T0 to be significant predictors of more time spent on TV/DVD among adolescents at T2, when adjusted for parental education (b-path). Furthermore, less maternal and paternal regulation at T0 was found to significantly predict more TV/DVD time among adolescents at T2. Paternal modelling of PC/game time was also found to be a significant predictor of adolescents' time spent on PC/games.

Table 2 Correlation of screen time in gender dyads of parents and adolescents

Adolescents		Mothers (T0)			Fathers (T0)		
Measure	Timepoint	n	TV/DVD	PC/game	n	TV/DVD	PC/game
			Pearson r	Pearson r		Pearson r	Pearson r
TV/DVD (hours/week)							
Boys	Age 11 (T0)	366	0.20***		319	0.15**	
	Age 13 (T2)	369	0.25***		323	0.14*	
Girls	Age 11 (T0)	361	0.18***		304	0.19**	
	Age 13 (T2)	364	0.22***		307	0.30***	
PC/game (hours/week)							
Boys	Age 11 (T0)	362		0.15**	318		0.08
	Age 13 (T2)	367		0.10	321		0.05
Girls	Age 11 (T0)	359		0.09	302		0.12*
	Age 13 (T2)	363		0.08	307		0.10

T0: baseline, T2: 20 months follow-up.

Statistical significance at * p<0.05 ** p<0.01 *** p<0.001.

Table 3 Adolescents' screen time by parental education

Screen time (hours/week)		Parental education [†]				p-value [‡]
		Low		High		
		n	Mean (SD)	n	Mean (SD)	
T0	TV/DVD	267	11.9 (7.4)	604	11.3 (6.3)	0.210
	PC/game	266	9.1 (7.0)	599	8.3 (6.0)	0.125
T2	TV/DVD	274	14.2 (7.5)	607	13.0 (7.0)	0.024
	PC/game	274	11.4 (7.8)	605	10.1 (6.8)	0.015

T0: baseline, T2: 20 months follow-up, SD: Standard Deviation.

[†] Parental education as low vs high (university/college) at T0.

[‡] Difference between groups of parental education with independent-samples t test.

Discussion

As previously reported in the HEIA cohort study, adolescents' time spent on TV/DVD significantly increased by 1.4 hours/week among boys and 2.4 hours/week among girls, between the ages of 11 and 13 years [35]. The respective increase in adolescents' PC/game time was 1.2 and 2.6 hours/week among boys and girls [35]. Significant gender differences were furthermore observed, as boys spent more time on PC/games than girls at both time points [35]. The present study found novel cross-sectional and longitudinal relationships in gender dyads of parents and adolescents' time spent on TV/DVD and PC/games at the ages of 11 and 13 years. Moreover, both maternal and paternal modelling was found to mediate the prospective relationship between parental education and adolescents' time spent on TV/DVD.

Correlations observed in gender dyads of parents' and adolescents' reports of TV/DVD time are consistent with previous cross-sectional findings of children and

adolescents' TV viewing [28,29,32]. The findings indicate that more time spent on TV/DVD among both parents at the age of 11 years may influence more TV/DVD time among adolescents of both genders at the age of 11 and 13 years. However, a previous study investigating the longitudinal relationship between mothers', fathers' and girls' TV viewing from the age of 9 to 11 years reported no such associations [28]. This may correspond with the present findings of stronger correlation coefficients between parents' and adolescents' reports with increasing age. A steady increase of time spent watching TV in gender dyads of parents and adolescents has been reported from the age of 9–10 years to the age of 15–17 years [45]. However, a dip in time was reported between fathers and daughters at the age of 11–12 years [45], which may explain the present findings of a stronger correlation among fathers and daughters' than among fathers and sons' in TV/DVD time between the ages of 11 and 13 years in the present study. Previous findings have furthermore reported that parents spend less time with their children in other social contexts as they grow older [45]. The present findings may suggest that adolescents spend more time on TV/DVD with their parents as a shared activity when they grow older, probably as a result of spending time together as a family and due to prolonged waking hours.

The present study furthermore observed cross-sectional associations across genders in dyads of parents' and adolescents' PC/game time at the age of 11 years, even though parents generally reported less time spent on PC/games than adolescents during leisure time. Differences in gender dyads of PC/game time may be explained due to large gender differences between girls

Table 4 Prediction of adolescents' screen time by single mediation analyses[†]

Measurement	n	c-path (SE)	a-path (SE)	b-path (SE)	ab [‡]	95% CI
TV/DVD (hours/week)						
Parental education [#]	573	0.75 (0.68)				
Maternal modelling			3.63 (0.55)**	0.28 (0.05)**	1.01	0.62, 1.65
Paternal modelling			3.25 (0.60)**	0.23 (0.05)**	0.75	0.38, 1.27
Maternal regulation			-0.06 (0.10)	-1.40 (0.29)**	0.08	-0.16, 0.42
Paternal regulation			-0.11 (0.10)	-0.60 (0.28)*	0.06	-0.02, 0.33
PC/game (hours/week)						
Parental education [#]	570	1.36 (0.65)*				
Maternal modelling			0.24 (0.36)	0.12 (0.08)	0.03	-0.04, 0.34
Paternal modelling			0.30 (0.41)	0.17 (0.07)*	0.05	-0.07, 0.26
Maternal regulation			0.05 (0.10)	-0.04 (0.27)	0.00	-0.09, 0.05
Paternal regulation			0.05 (0.11)	-0.01 (0.26)	0.00	-0.07, 0.07

SE: Standard Error, CI: Confidence Interval.

Statistical significance at *p>0.05 and **p>0.01.

[†] Linear regression analysis, adjusted for adolescents' gender, weight status and living status at baseline.

[‡] Mediation effects calculated as a-path x b-path.

[#] Parental education as high (university/college) vs low at baseline.

and boys, and should be further explored. Moreover, parental work time on computers at home was not measured, that may have influenced the results. The evidence on gender relationships between adolescents' and parents' use of computer and electronic games is limited. Although, a previous cross-sectional study among Portuguese 7 to 10 year olds showed that paternal TV viewing was significantly related to their daughters' PC and electronic game time during weekends [32]. In contrast to these findings, reviewed evidence on parent-child relationships generally indicate that mothers invest more time and are more involved in parenting during adolescence compared to fathers, and are thus considered closer to adolescents of both genders [46]. It is important to notice that most previous research has been focusing on the mother as a representative of parents' and excluded the role of fathers in the home environment [47]. Hence, important relationships may exist between fathers' and adolescents' energy balance related behaviours that are currently not understood. Correlations in gender dyads of parents' and adolescents' time spent on PC/games were no longer observed at the age of 13 years. The results may reflect the fact that time spent on PC/games is less of a shared activity among parents and adolescents, and thus less influenced by parental behaviours when adolescents grow older. More research is needed in order to identify possible prospective gender specific influences of parental modelling on children's screen time when growing into adolescence.

Mediation analyses showed a significant total and direct effect between level of parental education and adolescents' PC/game time from the age of 11 to 13 years, indicating that a lower level of parental education is an important predictor of more time spent on PC/games among adolescents. No prospective relationship was observed in mediation analysis of parental education on adolescents' TV/DVD time between the ages of 11 to 13 years. A previous study reported inconsistent results in the prospective relationship between parental education at the age of 13 years and girls' TV viewing and videogame playing after 6 months [48], and no relationships were reported between parental education level at the age of 9-12 years and adolescents' TV viewing, playing video games or computer use at the age of 14 years and older [49]. The lack of influence from parental education on adolescents' prospective TV/DVD time in the present study may be caused by the fact that social differences in adolescents' prospective TV/DVD time are less important among older adolescents. Hence, other determinants in the home may be stronger in influencing adolescents' prospective behaviour, such as parental modelling, regulation, availability and accessibility of TV in the home as well as presence and interaction with siblings. However, the level of parental education was high

in this group of 11 year olds, and analyses were based on a binomial variable which may not capture all gradients of parental education. More research is needed in order to investigate the prospective relationship between parental education and different screen time behaviours during adolescence.

Maternal and paternal modelling significantly mediated the prospective relationship between parental education and adolescents' TV/DVD time. However, no mediation was found by parental regulation of adolescents' prospective TV/DVD time, as differences in regulation by parental education were not found. A recent cross-sectional study found number and placement of TV in the home to be the strongest mediators to the relationship between maternal education and 11 year old children's TV viewing [25]. Parental behaviour was not investigated as a potential mediator, but restrictions on how much time the child spent on TV viewing was shown to be less important as a mediator among 11 year olds than among 6 year olds [25]. The present study did neither find parental modelling nor regulation to mediate the relationship of parental education on adolescents' prospective PC/game time. These results imply that parental modelling is more important as an intermediate variable when explaining differences by parental education in adolescents' prospective TV/DVD time than in time spent on PC/games. The results may indicate that adolescents' are more independent in their leisure time using PC/games, than what is observed for watching TV/DVD. Moreover, time spent on PC/games may be more reflected by social contexts with siblings and friends rather than with parents. Other factors in the home environment may thus be important mediators of adolescents' time spent on PC/games by parental education. In addition to parental modelling and regulation, determinants such as availability and accessibility of computers in the home, presence and interaction with siblings and friends should be a matter for further investigation. These could be important modifiable determinants to target in interventions aiming to reduce social inequalities in adolescents' PC/game time by parental education.

Both maternal and paternal regulation at the age of 11 years was significantly related to less time spent on TV/DVD among 13 year old adolescents (b-path). The results imply the importance of parental regulation in order to reduce adolescents' prospective TV/DVD time, independently of parental education. This may thus be an important determinant to target in order to reduce adolescents' prospective TV/DVD time. No such relationships were seen for parental regulation of adolescents' PC/game time. A recent review concluded consistently with an inverse cross-sectional association between parental rules and adolescents' screen time,

where most of the studies investigated adolescents' TV viewing [26]. An inverse longitudinal relationship was furthermore reported between perceived presence of family rules and TV viewing among adolescents over 2 years [50]. It is important to notice that parental regulation was only measured with a single question item in the present study, and may therefore not capture all facets of parental rules of TV/DVD and PC/game time.

The results should be viewed in light of some limitations of the study. Although the participation rate of sampled schools was low (21%), there was no significant difference between schools who participated in the study and schools that declined participation in terms of number of students in the 6th grade and overall size [51]. However, socioeconomic characteristics of schools were not measured, as such data is not nationally available in Norway. The outcome measures were self-reported, which are associated with problems of misreporting of adolescents screen time, due to issues of social expectations and norms [52]. Although, adolescents' ability to self-report are considered to be fully developed at this age [53]. The test-retest correlation results of the outcome measures were borderline in the present study, thus the reliability of the results may be questioned. However, the larger sample size the larger tolerance of a less reliable instrument, and thus we believe the reliability of these measurements to be acceptable [54]. Attrition analysis showed no significant differences in adolescents' baseline TV/DVD time between those included and those excluded from the analyses. However, significant differences were observed in adolescents' PC/game time, weight status, living status and level of parental education. This may indicate that the included participants were more health conscious than the rest of the population.

Strengths of the present study were the longitudinal study design based on a relatively large sample size at a narrow age-range, with high participation rate over time. Information on parental education, modelling and regulation was collected through parental reports, which is considered to give more reliable measurements than when reported by the adolescents [55]. Moreover, measurements of multiple screen time behaviours and their determinants were included.

Conclusion

The present study found that both parents' TV/DVD time is associated with adolescents' TV/DVD time in both genders at the age of 11 years, and between the ages of 11 to 13 years. Opposite gender dyads were observed for PC/game time at the age of 11 years, but the association was not seen in either gender between the ages of 11 and 13 years. Further investigations of different screen time behaviours in gender dyads of both

parents and their children should be emphasized. Parental TV/DVD time was further found to mediate the relationship between parental education and adolescents' prospective TV/DVD time across genders. Hence, parental modelling are important to consider in interventions aiming to reduce social differences by parental education in the prevention of adolescents' prospective time spent on TV/DVD. Other factors in the home environment may influence adolescents' prospective screen time and should be included in future studies, such as the availability and accessibility of screens in the home.

Abbreviations

HEIA: The Norwegian HEalth In Adolescents study; TV/DVD: television and video viewing; PC/game: computer and electronic game use.

Competing interests

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Authors' contributions

THT drafted the first manuscript, conducted the statistical analyses and revised the paper based on the comments by the other co-authors. MB, NL, IHB, MG, YO and LFA participated in designing the study, project planning and/or data collection. All authors have critically read and revised the paper, and approved the final manuscript.

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Appendix I

Appendix 1 Included questions from the adolescent questionnaire

Adolescents Behaviours	Source	Measure	Assessment
Fresh fruit	PC	Frequency by 8 categories	Question: How often do you normally consume fresh fruits? Answer: never/seldom; less than 1 time/week; 1-2 times/week; 3-4 times/week; 5-6 times/week; 1 time/day; 2 times/day; 3 times/day or more
Raw vegetables	Modified PC	Frequency by 8 categories	Question: How often do you normally consume raw vegetables? (e.g. carrot, tomato, salad) Answer: never/seldom; less than 1 time/week; 1-2 times/week; 3-4 times/week; 5-6 times/week; 1 time/day; 2 times/day; 3 times/day or more
Cooked vegetables	PC	Frequency by 8 categories	Question: How often do you normally consume cooked vegetables? (potatoes are not included) Answer: never/seldom; less than 1 time/week; 1-2 times/week; 3-4 times/week; 5-6 times/week; 1 time/day; 2 times/day; 3 times/day or more
Chocolate and sweets	Modified Ungkost	Frequency by 7 categories	Question: How often do you normally consume chocolate/sweets? Answer: never/seldom; less than 1 time/week; 1-2 times/week; 3-4 times/week; 5-6 times/week; 1 time/day; 2 times/day or more
Salty snack	Modified Ungkost	Frequency by 7 categories	Question: How often do you normally consume salty snacks? (e.g. potato chips, popcorn) Answer: never/seldom; less than 1 time/week; 1-2 times/week; 3-4 times/week; 5-6 times/week; 1 time/day; 2 times/day or more
Soft drinks (weekday)	Modified Ungkost	Frequency by 6 categories	Question: How often do you normally drink the following beverages on weekdays? (Monday through Friday). Soft drinks with sugar? (e.g. Cola, Solo) Answer: never/seldom; 1 time/week; 2 times/week; 3 times/week; 4 times/week; every weekday
Soft drinks (weekday)	Modified Ungkost	Amount by 4 categories	Question: When you drink soft drinks with sugar on weekdays, how much do you normally consume? (1/2 litre = 3 glasses) Answer: 1 glass; 2 glasses; 3 glasses; 4 glasses or more
Soft drinks (weekend)	Modified Ungkost	Amount by 8 categories	Question: How much of the following beverages do you normally drink during weekends? (Add the consumption for Saturday and Sunday together). Soft drinks with sugar? (e.g. Cola, Solo) Answer: never/seldom; 1 glass; 2 glasses; 3 glasses; 4 glasses; 5 glasses; 6 glasses; 7 glasses or more
Squash (weekday)	Modified Ungkost	Frequency by 6 categories	Question: How often do you normally drink the following beverages on weekdays? Squash with sugar? (e.g. regular or Orange flavoured) Answer: never/seldom; 1 time/week; 2 times/week; 3 times/week; 4 times/week; every weekday
Squash (weekday)	Modified Ungkost	Amount by 4 categories	Question: When you drink squash with sugar on weekdays, how much do you normally consume? (1/2 litre = 3 glasses) Answer: 1 glass; 2 glasses; 3 glasses; 4 glasses or more
Squash (weekend)	Modified Ungkost	Amount by 8 categories	Question: How much of the following beverages do you normally drink during weekends? (Add the consumption for Saturday and Sunday together). Squash with sugar? (e.g. regular or Orange flavoured) Answer: never/seldom; 1 glass; 2 glasses; 3 glasses; 4 glasses; 5 glasses; 6 glasses; 7 glasses or more

Adolescents	Source	Measurement	Assessment
<i>Behaviours cont.</i>			
TV/DVD (weekday)	Modified PEACH	Amount by 6 categories	Question: How many hours do you usually watch television and/or video on a normal weekday? Answer: ca 5 hours or more; ca 4 hours; ca 3 hours; ca 2 hours; ca 1 hour; ca half an hour or less
TV/DVD (weekend)	Modified PEACH	Amount by 6 categories	Question: How many hours do you usually watch television and/or video on a normal weekend or day off? Answer: ca 5 hours or more; ca 4 hours; ca 3 hours; ca 2 hours; ca 1 hour; ca half an hour or less
PC/games (weekday)	Modified PEACH	Amount	Question including TV- and computer games (e.g. surfing the Internet, Messenger, Game boy, Nintendo, Play station): How many hours do you spend on computer, TV games or other electronic games on a normal weekday?
PC/games (weekend)	Modified PEACH	by 6 categories Amount	Answer: ca 4 hours or more; ca 3 hours; ca 2 hours; ca 1 hours; ca half an hour; no time at all Question including TV- and computer games (e.g. surfing the Internet, Messenger, Game boy, Nintendo, Play station): How many hours do you spend on computer, TV games or other electronic games on a normal weekend or day off?
		by 6 categories	Answer: ca 4 hours or more; ca 3 hours; ca 2 hours; ca 1 hours; ca half an hour; no time at all

Determinants

Accessibility soft drinks	Modified FVMM	Scale by 6 categories	Question: When soft drinks with sugar are available at home, can you serve yourself as you please? Answer: always; most days; sometimes; seldom; never served as pleased; not available at home
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PC: Pro Children - De Bourdeaudhuij *et.al.* (2005), Ungkost: Ungkost 2000 - Lillegaard *et. al.* (2012),

PEACH: Personal and Environmental Associations with Children's Health - Page *et. al.* (2010), FVMM: Fruit and Vegetables Makes the Marks - Bere *et. al.* (2008)

Appendix II

Appendix 2 Included questions from the parents' questionnaires

Mothers/Fathers Behaviours	Source	Measurement	Assessment
TV/DVD (weekday)	Modified PEACH	Amount by 6 categories	How many hours do you usually watch television and/or video on a normal weekday? Answer: ca 5 hours or more; ca 4 hours; ca 3 hours; ca 2 hours; ca 1 hour; ca half an hour or less
TV/DVD (weekend)	Modified PEACH	Amount by 6 categories	How many hours do you usually watch television and/or video on a normal weekend? Answer: ca 5 hours or more; ca 4 hours; ca 3 hours; ca 2 hours; ca 1 hour; ca half an hour or less
PC/games (weekday)	Modified PEACH	Amount by 6 categories	How many hours do you spend on computer, TV games or other electronic games on a normal weekday (except for working hours)? Answer: ca 4 hours or more; ca 3 hours; ca 2 hours; ca 1 hour; no time at all
PC/games (weekend)	Modified PEACH	Amount by 6 categories	How many hours do you spend on computer, TV games or other electronic games on a normal weekend or day off? Answer: ca 4 hours or more; ca 3 hours; ca 2 hours; ca 1 hour; ca half an hour; no time at all
Determinants			
Availability	HFI	Dummy by 2 categories	Question: Which foods and drinks do you have available in your home at the moment? Soft drinks with sugar? (e.g. Cola, Solo) Answer: yes; no
Accessibility soft drinks	Modified FVMM	Scale by 6 categories	Question: When soft drinks with sugar are available at home, can your child serve him-/herself as (s)he pleases? Answer: always; most days; sometimes; seldom; never served as pleased; not available at home
TV/DVD regulation	Nepean	Scale by 5 categories	Question: I restrict how much time my child spends watching TV Answer: totally disagree; partly disagree; neither agree nor disagree; partly agree; totally agree
PC/game regulation	Modified Nepean	Scale by 5 categories	Question: I restrict how much time my child spend on computer and other electronic games Answer: totally disagree; partly disagree; neither agree nor disagree; partly agree; totally agree
PEACH: Personal and Environmental Associations with Children's Health - Page et al. (2010), HFI: Home Food Inventory - Fulkerson et al. (2008), FVMM: Fruit and Vegetables Makes the Marks - Bere et al. (2008), Nepean: The Nepean study - Hardy et al. (2006)			

