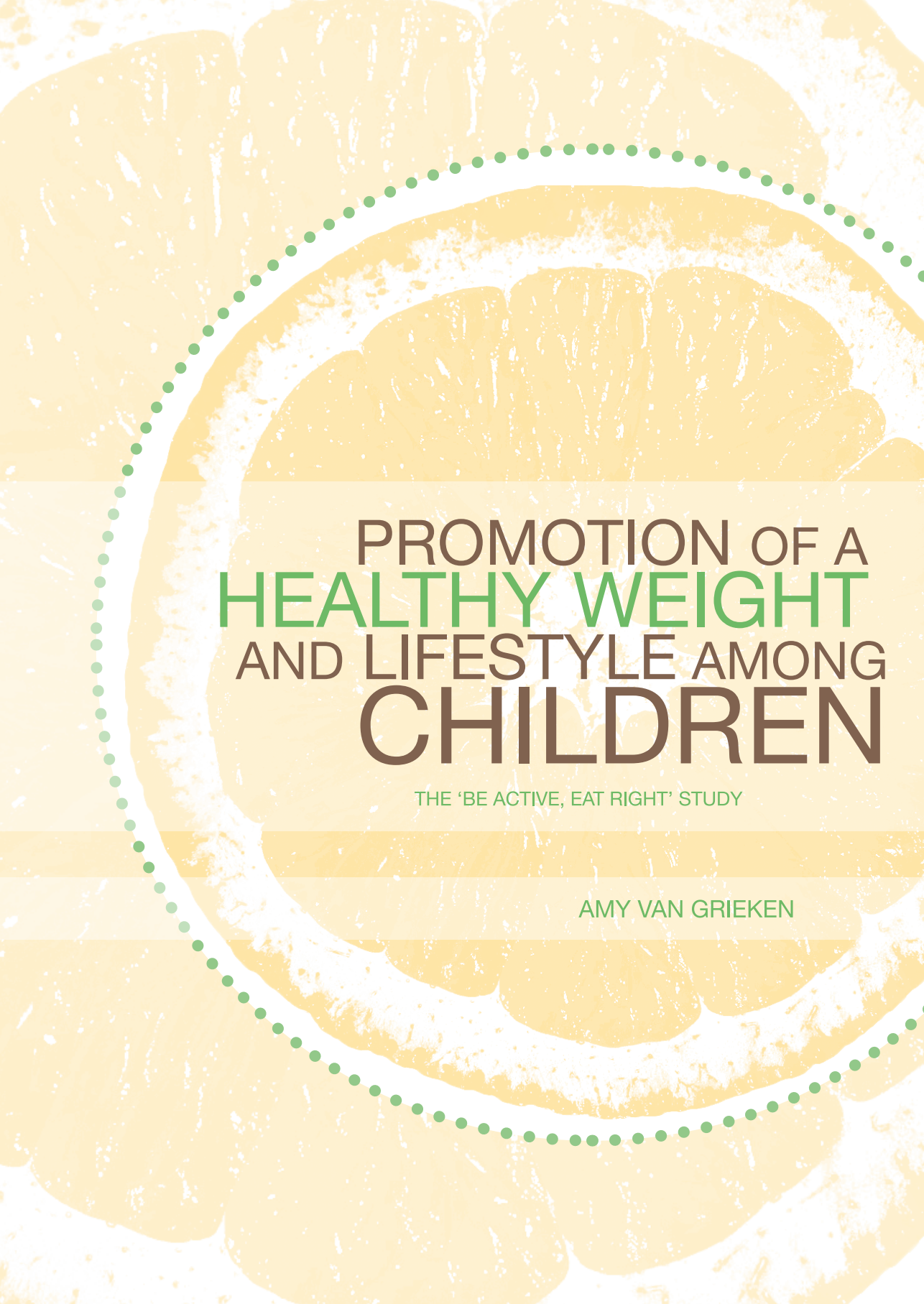

PROMOTION OF A HEALTHY WEIGHT AND LIFESTYLE AMONG CHILDREN

THE 'BE ACTIVE, EAT RIGHT' STUDY

AMY VAN GRIEKEN

Promotion of a healthy weight and lifestyle among children

the 'Be active, eat right' study

Amy van Grieken

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Promotion of a Healthy Weight and Lifestyle among Children: The 'Be Active, Eat Right' Study

Bevorderen van een gezond gewicht
en een gezonde leefstijl van kinderen:
het 'Lekker bewegen, goed eten' onderzoek

Proefschrift

ter verkrijging van de graad van doctor aan de
Erasmus Universiteit Rotterdam
op gezag van de
rector magnificus

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1

General introduction

The first chapter gives a short overview on prevalence, consequences and causes of childhood overweight and interventions promoting a healthy lifestyle. The contribution of youth health care to the prevention of childhood overweight and obesity in the Netherlands is described. At the end of the chapter the study questions are presented.

CHILDHOOD OVERWEIGHT: A PUBLIC HEALTH CHALLENGE

Childhood overweight and obesity has become a public health challenge [1-2]. In developed countries around the world the prevalence of overweight and obesity among children has been rising the past years [3-4]. In the Netherlands a two to three fold increase in overweight prevalence and a four to six fold increase in obesity prevalence has been observed since 1980 [3, 5-6]. The Dutch national growth study performed in 2009 estimated an overweight prevalence of 13-15% and an obesity prevalence of 2% for children between 2-21 years [5]. The prevalence of overweight, excluding obesity was 12.8% for 5-year-old boys and 18.1% for girls; obesity prevalence was 2.0% and 3.3% respectively [5]. The International Obesity Task Force recommends the use of the by Cole and colleagues presented international age- and gender specific cut-off values to define overweight and obesity in children below 18 years of age [6-7].

Childhood overweight and obesity is related to many physical health conditions (e.g. wheezing, headaches, sleep disturbances, high blood pressure, type 2 diabetes) and psychosocial health conditions (e.g. lower self-esteem, depression), which may affect the quality of life of the children [8-10]. Moreover, overweight and obesity tends to track from childhood into adulthood and may therefore imply an increased risk for associated morbidity [11-12]. Childhood overweight and especially obesity has been associated with an increased risk of cardiovascular disease, type 2 diabetes, strokes and hypertension in adulthood [10, 13].

Overweight and obesity develop due to uneven energy intake and energy expenditure [2]. Energy intake is for the most part determined by dietary behavior and energy output by physical activity behaviors.

With regard to energy intake, dietary behaviors that have an unfavorable association with childhood overweight are not having daily breakfast and sweet beverage consumption [14-16].

The level of physically active and non-active behaviors determines energy expenditure. Active behaviors contribute to higher energy expenditure and range from daily activities such as playing outside, to organized sports activities [17]. Non-active behaviors, sedentary behaviors, do not contribute to energy expenditure. The amount of time spent in non-active behaviors (e.g. TV-viewing, surfing the Internet) has been increasing due to modern technology. In addition, non-active behaviors may also contribute to energy intake as, for example, during these behaviors the child consumes unhealthy foods and drinks [18-19].

National guidelines, following the recommendations made by the World Health Organization, have been developed to assist health care professionals in advising parents and children [1, 20]. Recommendations are to limit child television time to 2 hours a day and to stimulate children being active for at least 1 hour a day [1, 17, 19, 21]. With regard to dietary intake the advice is to stimulate children having a daily healthy breakfast and to limit the child's intake of sweet beverages [14, 16-17, 22].

In order to change health behavior insight in determinants of behavior is needed [23]. Theories of behavior change suggest that both individual and environmental determinants influence the behavior a person performs [24-26]. Specifically, an individual determinant, a belief or attitude towards healthy behavior (e.g. it is healthy for my child not to drink sweet beverages) can be challenged by an environmental determinant; a person therefore may not act according to their belief (e.g. sweet beverages may be on sale in the supermarket and therefore the parent will still buy them). In order for children to develop a healthy weight and lifestyle, the family environment may be of particular importance [27-28]. Parents provide a role model for their children, but also determine which foods, drinks and physical activity opportunities are available or accessible to their children [28]. In addition, they set rules and thus create a parenting environment [28]. Furthermore, the day-care, school and the neighborhood environment all influence the behavior parents and children perform.

It is recommended to promote and develop a healthy lifestyle during childhood to prevent the development of habitual unhealthy behaviors [16]. Several settings can be used to implement lifestyle interventions aimed at children [29]. Interventions are often implemented at children's schools or at neighborhood level; these interventions can reach many children. However, in these settings it may be more challenging to implement tailored interventions; potential stigmatization or discrimination may occur when children would be selected to receive an additional or different type of intervention [30]. Tailored interventions may be more effective because it fits to the persons' specific situation and habits [31].

CONTRIBUTION OF YOUTH HEALTH CARE TO OVERWEIGHT PREVENTION

In the Netherlands, youth health care sees all children regularly on set ages monitoring health, growth and development from birth until the child is 18 years old. In the first five years of the child's life, 16 well-child visits are planned for youth health care. Specifically the visits in the first 4 to 5 years of the child's life are well attended (attendance rate 90-100%) [32-34]. The youth health care professional, most often a youth health care physician or (school-) nurse, performs measurements of height and weight of the child each visit to monitor growth and development. During these visits there is an opportunity to provide tailored advice to parents. Youth health care has successfully contributed to, for example, the prevention of

Sudden Infant Death Syndrome (SIDS) and a high vaccination rate [35-36]. The youth health care program is offered free of charge to the parents and their children.

Between 1980 and 1997 the prevalence of overweight and obesity among children in the Netherlands rose [5]. Youth health care professionals also noticed this increase in daily practice. Until 2002, there were no instruments available for the youth health care professionals to uniformly detect overweight and obesity and offer appropriate care after detection. Because of the rising prevalence of overweight and obesity among children an instrument that could be implemented on short term was needed.

In 2004, the detection protocol was developed to detect overweight and obesity among children visiting youth health care [37]. The detection protocol was designed to promote uniform detection of overweight and obesity among children and enhance possibilities for international comparisons by using the International Obesity Task Force age- and gender-specific cut-offs [6-7, 37]. Youth health care professionals can show parents on charts how the child is growing relative to other children; which may increase parental awareness of the child's weight status [37-38].

After the youth health care professional had detected a child who was overweight, a subsequent intervention was needed to give parents the opportunity to change health behavior. In 2004-2005, a transitional plan was developed for the youth health care professionals describing a set of activities for individual prevention: the prevention protocol [20]. When a child is detected with overweight (not obesity) the activities described in the prevention protocol can be offered to parents and their child. The prevention protocol recommends that normal-weight children receive regular care and that obese children are referred to the general practitioner for further management and diagnosis [20]. In the Netherlands the general practitioner is the gatekeeper for referral of the child to the pediatrician or other professionals.

When a child with overweight is detected, youth health care professionals explore child health behavior and assess the stage of change of parents with regard to health behavior change [39-40]. The youth health care professionals are trained to use a non-directive guiding style and motivational interviewing techniques to motivate parents and promote health behavior change. The prevention protocol describes having breakfast daily, playing outside, watching less television and drinking less sweet beverages as health behaviors that can be promoted. For infants, the promotion of breastfeeding is also described in the prevention protocol. The prevention protocol suggests youth health care professionals to choose, in collaboration with the parents, one or two health behaviors most feasible to change, to focus on during the counseling. Due to the time limits of the regular well-child visit, up to three additional counseling sessions may be offered in the next six months to change health behavior. Parents create, assisted by the youth health care professional, feasible action plans and set goals for their family. Youth health care professionals can use diaries to be completed by parents to increase awareness of behavior and assist in behavior change. Overall with the

prevention protocol parents are supported and motivated to promote healthy behavior of their child using structure, rules and active involvement.

Development of the prevention protocol

The development of the prevention protocol for use in youth health care can more or less be related to the model for planned health education and promotion (see Figure 1) [20]. This model describes six steps to develop, evaluate and adjust interventions [41]. Step one is an analysis of the health of the population under study and step two describes an analysis of behavior and environmental risk factors for the health problem. In step three an analysis of determinants of risk behaviors is performed. Thereafter, in three subsequent steps, an intervention can be developed, implemented and evaluated. After evaluation, the intervention can be adjusted following the steps from the model again [41].

The prevention protocol was developed in four subsequent phases carried out in 2004-2005. First, a literature search was performed in international and national databases to identify dietary and physical activity behaviors associated with overweight and obesity. Also, determinants of these behaviors and associated environmental risk factors were explored (e.g. rules parents have at home, availability of products in the home environment). Secondly, experts from both overweight prevention and youth health care were consulted to complement the relevant information gathered by the literature study. Based on the literature study and the expert consultations the most promising health behaviors for intervention with the prevention protocol were determined. Determinants of these health behaviors were evaluated and described in the prevention protocol (e.g. structure and rules at home). These most promising health behaviors were the promotion of daily breakfast and playing outside, and

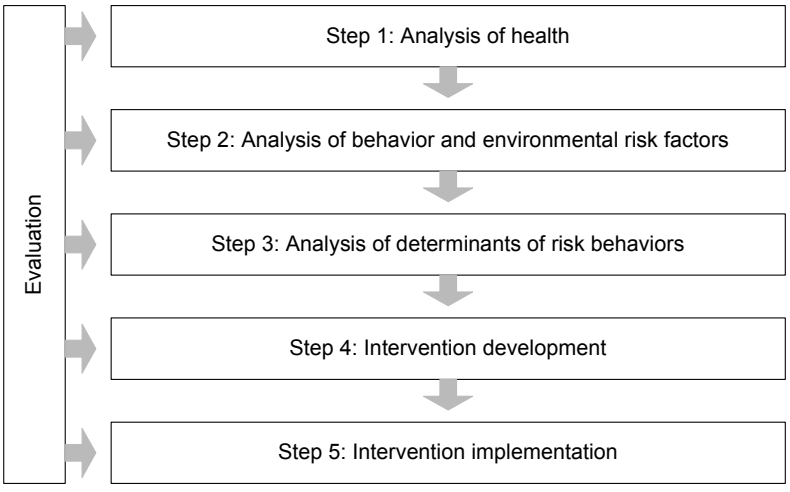

Figure 1 Model for planned health education and promotion[41]

limiting sweet beverage consumption and television viewing. For infants the promotion of breastfeeding was selected.

Thirdly, to further define the protocol, the best way to implement and use the protocol in youth health care was discussed during expert meetings. Professionals from youth health care attended these meetings. The meetings also served to create commitment among the youth health care professionals.

The fourth phase was to evaluate the applicability of the prevention protocol in the daily practice of the youth health care [20]. A pilot study was performed to evaluate feasibility, usability and experiences of youth health care professionals [42]. The results from the pilot study indicated that the prevention protocol was implementable in daily youth health care practice and rated positively by the youth health care professionals [42].

To evaluate the use and the effectiveness of the prevention protocol the 'Be active, eat right' study was set up [43]. This thesis is guided by the six steps of the model for planned health education and promotion. In the first part the intervention is evaluated: the prevention protocol. In the second part, step 1 of the model is reviewed; psychosocial and physical health outcomes related to overweight and obesity are analyzed. And in the third part determinants of sweet beverage consumption are evaluated (step 3).

THE 'BE ACTIVE, EAT RIGHT' STUDY

The 'Be active, eat right' study is a cluster randomized controlled trial evaluating the use and effectiveness of the prevention protocol used in youth health care among 5-year-old children and their parents. In addition, the data collected in the 'Be active, eat right' study is used to evaluate health, growth and development of children 5 to 7 years. More details on the 'Be active, eat right' study have been published by Veldhuis and colleagues [43].

In short, in 2007, all youth health care centers in the Netherlands were invited to participate in the study. Youth health care often works in teams, consisting of a youth health care physician, (school-) nurse and an assistant. Each team serves families living in a certain area of the youth health care center. Nine of the 37 youth health care centers in the Netherlands agreed to participate. All parents and their 5-year-old children visiting the participating youth health care centers were invited to participate in the study by mail. Although interventions may preferably start even earlier in the child's life, the 5-year visit is the first regular visit for which all parents and children are invited at elementary school. A total of 13,638 parents were invited to participate and 64.4% provided written informed consent (n= 8,784) to participate in the two-year study.

With regard to the evaluation of the prevention protocol, the teams within each center were randomized in intervention and control condition. The teams allocated to the intervention condition offered parents the prevention protocol when a child was detected with over-

weight (not obesity), following the detection protocol, during the regular well-child visit. Children and parents visiting a youth health care team allocated to the control condition received usual care.

Data was collected during the two-year study period. During the regular well-child visit of the 5-year-old child height, weight and waist circumference measures were taken according to standardized protocols. Together the invitation for the regular visit parents received a questionnaire concerning socio-demographic characteristics and health behaviors, which they were requested to return by mail.

The first and second year after the regular well-child visit parents received follow-up questionnaires that they could return by mail or via the Internet. After two years youth health care professionals or research assistants performed the child's body measurements again. All studies presented in this thesis, except for the systematic review and meta-analysis, are based on data collected with the 'Be active, eat right' study.

STUDY QUESTIONS ADDRESSED IN THIS THESIS

This thesis aims to describe interventions promoting a healthy weight and lifestyle among children and contribute to insight in elements that may relate to intervention improvement. The following research questions are addressed:

1. What are the effects of interventions promoting a healthy weight and lifestyle among children?
    1.1. Effects of a prevention protocol for parents of overweight children on child BMI, waist circumference and health behaviors (chapter 2 and 3)
    1.2. Effects of interventions aiming to decrease sedentary behavior of children in the general population on child BMI and sedentary behavior (chapter 4)
2. What indicators of psychosocial and physical health are associated with child weight status?
    2.1. Associations between overweight and obesity and health-related quality of life in childhood (chapter 5)
    2.2. Associations between overweight and obesity and psychosocial and physical health outcomes in childhood (chapter 6)
3. What socio-demographic characteristics, parental beliefs and parenting practices are associated with children's sweet beverage consumption? (chapter 7)

Outline of the studies presented in this thesis

In this thesis six studies are described in three subsequent parts, guided by the model of planned health education and promotion. In the first part, the evaluation of the prevention

protocol is described: **chapter 2** and **chapter 3**. The effects of the prevention protocol on child BMI and waist circumference (chapter 2) and the effects on child health behaviors: having daily breakfast, playing outside, drinking sweet beverages and watching television (chapter 3) are described. In **chapter 4**, a systematic review and meta-analysis is presented evaluating the effects of interventions aiming to reduce sedentary behavior. Effects of these interventions on sedentary behavior and BMI among the general population of children are described.

The second part of this thesis evaluates associations between overweight and obesity among children and indicators of psychosocial and physical health outcomes. Research evaluating these associations at younger ages may help health care professionals providing appropriate counseling to parents and children. In **chapter 5,** the cross-sectional associations between overweight, obesity and severe obesity at age 5 years and health-related quality of life are examined. In **chapter 6,** the effects of childhood overweight and obesity on indicators of psychosocial and physical health are evaluated at age 7 years. In the second part of this thesis, chapter 5 and 6, in addition to the subgroups of children with normal-weight, overweight and obesity, the subgroup of children with underweight was evaluated with regard to indicators of psychosocial and physical health. Research with regard to health outcomes of children with underweight is limited. The large study sample of the 'Be active, eat right' study offered the opportunity to include underweight as a distinct group of children and evaluate their health outcomes compared to normal-weight children.

In the third part of this thesis, **chapter 7,** associations between socio-demographic characteristics, parental beliefs, parenting practices and child sweet beverage consumption are evaluated. Sweet beverage consumption has been related to overweight, understanding determinants of sweet beverage consumption may contribute to intervention development and improvement.

In **chapter 8,** the results from the studies are summarized and interpreted alongside the literature. Strengths and limitations of the studies are discussed. Recommendations for future research are made and implications for practice and policy are presented. Finally, an overall conclusion is drawn. Table 1 provides an overview of the studies presented in this thesis.

Table 1 Overview of the studies presented in this thesis

Chapter	Study design	n	Determinants	Main outcomes
2	Cluster- RCT	637	Intervention versus control condition	BMI and waist circumference at age 7 years
3	Cluster- RCT	637	Intervention versus control condition	Health behaviors at age 7 years
4	Systematic review and meta-analysis	34 studies	n/a	Sedentary behavior and BMI
5	Cross-sectional study	3,227	Weight status at age 5 years	Health- related quality of life at age 5 years
6	Cohort study	2,372	Weight status at age 5 years	Indicators of psychosocial and physical health at age 7 years
7	Cohort study	2,047	Socio-demographic characteristics, parental beliefs and parenting practices at age 5 years	Sweet beverage consumption at age 7 years

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Part I

Interventions promoting a healthy lifestyle among children

2

Population-based childhood overweight prevention: outcomes of the 'Be active, eat right' study

Amy van Grieken, Lydian Veldhuis, Carry M Renders, Gerard J Borsboom, Johannes C van der Wouden, Remy A Hirasing, Hein Raat

PLoS ONE 2013; 8(5)

ABSTRACT

Purpose

An overweight prevention protocol was used in the 'Be active, eat right' study; parents of overweight children (5 years old) were offered healthy lifestyle counseling by youth health care professionals. Effects of the protocol on child BMI and waist circumference at age 7 years were evaluated.

Methods

A cluster RCT was conducted among nine youth health care centers in the Netherlands. Parents of overweight, not obese, children received lifestyle counseling and motivational interviewing according to the overweight prevention protocol in the intervention condition (n= 349) and usual care in the control condition (n= 288). Measurements were made of child height, weight and waist circumference at baseline and at a two-year follow-up; parents completed questionnaires regarding demographic characteristics. Linear mixed models were applied; interaction terms were explored.

Results

The analyzed population consisted of 38.1% boys; mean age 5.7 (SD 0.4) years; mean BMI 18.1 (SD 0.6), the median number of counseling sessions in the intervention condition was 2. The regression model showed no significant difference in BMI increase between the research conditions at follow-up (beta -0.16, 95% CI -0.60 to 0.27, p= 0.463). There was a significant interaction between baseline BMI and research condition; children with a baseline BMI of 17.25 and 17.50 had a smaller increase in BMI at follow-up when allocated to the intervention condition compared to control condition (estimated adjusted mean difference -0.67 (se: 0.30) and -0.52 (se: 0.36)).

Conclusion

Mildly overweight children (baseline BMI 17.25 and 17.50) in the intervention condition showed a significantly smaller increase in BMI at follow-up compared to the control condition; there was no overall difference between intervention and control condition. Future research may explore and evaluate improvements of the prevention protocol.

INTRODUCTION

The prevalence of childhood overweight and obesity has been increasing for several years [1]. In the Netherlands in 2009, the prevalence of overweight among boys was estimated at 12.8% and obesity at 1.8%, while for girls the figures were 14.8% and 2.2%, respectively (2-21 years) [2]. Several consequences are associated with overweight, and especially obesity, in childhood (e.g., type 2 diabetes, heart disease) [3-4]. Worldwide, interventions aimed at preventing overweight and obesity among children are being developed and evaluated [5-6]. It has been shown that parental involvement may contribute to improving healthy behavior in children and preventing the development of overweight and obesity [7-9].

In the Netherlands, growth, development and health of all children (0-19 years) is monitored in a nationwide program with regular well-child visits at set ages by providers of preventive Youth Health Care (YHC). In each Dutch region YHC providers, mainly youth health care physicians and school-nurses, work in teams at YHC centers or schools to execute this nationwide program [10-11]. The nationwide program is offered free of charge by the government; participation is voluntary (attendance rate 90-100%) [12]. Several successful preventive measures have been implemented through the YHC, for example the national immunization program and the prevention of Sudden Infant Death Syndrome (SIDS) [13-14]. The YHC setting with the regular visits, measurement of height and weight and also the collaboration between YHC providers and local care providers, creates an opportunity for tailored prevention and promotion of healthy child development.

In 2004, a practiced-based protocol was developed to help detect overweight and obesity among children attending a well-child visit [15-16]. Children were by means of this protocol classified into weight categories using the international age-and-gender Body Mass Index (BMI) cut-off values [17]. In 2005, a transitional plan, the prevention protocol, was developed based on the international literature and theory, to be used in daily practice to prevent overweight children from developing obesity [18]. This intervention offers additional healthy lifestyle counseling to parents of overweight, not obese children [18]. During a well-child visit, parents are informed about the overweight of their child and motivated to change health behavior. In addition, up to three structured healthy lifestyle counseling sessions to promote overweight-prevention behaviors can be offered. The YHC professionals are trained in using motivational interviewing to motivate parents to change health behavior, taking into account the parents' current stage of change [18].

The prevention protocol was launched as a transitional plan in 2005. The 'Be active eat right' study was set up to assess the effectiveness of this practice-based prevention protocol among 5-year-old children who are overweight (not obese) [19]. We hypothesized that the children who are overweight (not obese) visiting YHC teams allocated to the intervention condition, selected to perform the prevention protocol, would have a lower BMI and waist circumference at follow-up compared to overweight children visiting YHC teams allocated to the control condition, performing usual care.

METHODS

The 'Be active, eat right' study (trial registration Current Controlled Trials ISRCTN04965410) is a cluster randomized controlled trial described in detail elsewhere [19]. In 2007 all YHC centers in the Netherlands (n= 37) were invited to participate in the study. Nine services were eligible (i.e. a control condition could be created) and agreed to participate with a total of 44 YHC teams [19]. Within each center, YHC teams were randomized for allocation to intervention or control condition by means of a computer-generated random number list. All parents and children are invited for a well-child visit in the year the child turns five years old. Between September 2007 and October 2008 all parents invited to attend the well-child visit of their five-year-old child were also invited to participate in the study with their children. Information on the study and an informed consent form for participation in the two-year study was enclosed with the invitation for the well-child visit. Parents were requested to complete the informed consent form and hand it in the at the start of the well-child visit; parents provided written informed consent on behalf of themselves and their child for participation in the two-year study. Parents and children participated for two subsequent years, from the well-child visit onwards; two-year follow-up assessments were performed between September 2009 and October 2010.
The Medical Ethics Committee of the Erasmus University Medical Center Rotterdam approved the study protocol (reference number MEC-2007-163). Parents were not aware of the research condition they were allocated to.

Intervention

When parent and child attended the well-child visit at a YHC team allocated to the intervention condition, and the child was classified as being overweight (not obese), the parents were offered the prevention protocol [17-18]. The prevention protocol offered parents information regarding overweight prevention and healthy lifestyle choices by using a motivational interviewing approach, if needed, to motivate the parents to change behavior [20]. The prevention protocol was initiated during the well-child visit and in addition up to three structured healthy lifestyle counseling sessions to promote overweight-prevention behaviors could be offered, approximately 3, 6 and 12 months after the well-child visit.
The content of an additional counseling session depended on the stage of behavioral change of the parents [19, 21-22]. The YHC professionals assessed the level of motivation of the parent during the well-child visit. The YHC professionals needed to create awareness of the overweight of the child among the parents. Information about overweight and associated consequences could be given to parents. Moreover, motivational interviewing techniques could be used to further motivate parents to change health behavior. The four lifestyle-related behaviors that are described in the protocol and could be promoted were playing outdoors, eating breakfast, reducing sweet drinks and sedentary behavior (watching television, computer gaming). Parents together with the YHC professional choose one or two behaviors to target during the

sessions. Advice to parents was given according to international guidelines (play outside at least one hour a day, have breakfast daily, drink no more than 2 glasses of sweet beverages and limit television viewing to maximum of 2 hours a day) [18, 22]. Information materials were provided to parents during the session, diet and activity diaries were discussed and family-oriented action plans to change health-related behavior were documented.

When a child who was overweight (not obese) was detected when visiting a YHC team allocated to the control condition, parents were also informed about the overweight of their child but usual care was given. Usual care consisted of general information about a healthy lifestyle during the well-child visit.

In accordance with the protocol, all YHC professionals, regardless of their team allocation, had to refer obese children to the general practitioner for further diagnosis and management. In the overweight prevention protocol, no additional care is prescribed for normal-weight and underweight children.

Outcome measurements

Data collection was scheduled at enrollment, baseline (the well-child visit), and two years post-baseline (follow-up). Parents received a questionnaire enclosed with the invitation for the well-child visit. The parents could return the questionnaire during the well-child visit when their child was five years old. Two years after the well-child visit, parents received an invitation for a second measurement of their child's height, weight and waist circumference and a questionnaire, which could be completed on paper or via the Internet.

At baseline, YHC professionals at the YHC center measured the height, weight and waist circumference of all children. At age 7 years, follow-up, there was no regular visit planned with the YHC professionals. At two centers, the YHC professionals were able to perform the measures, but in all other regions research assistants performed the measures visiting the children's primary schools. Both YHC professionals and research assistants used the same standardized methods and equipment as described in a protocol [16]. Research assistants were blinded to the research condition at the time of follow-up evaluation.

Primary outcomes

The BMI and waist circumference at follow-up were the primary outcome measurements, both were measured according to national protocols. Body weight was measured to the nearest 0.1 kilogram and height to the nearest 0.1 centimeter. Waist circumference was measured over the naked skin at the level midway between the lower rib margin and the iliac crest at the end of gentle expiration, while the children were in standing position [16]. The data collectors were trained to measure waist circumference using a measuring tape (SECA 200). BMI was calculated by dividing weight in kilogram by height per meter squared. Children were classified into having normal-weight, overweight (not obesity) or obesity according to the international age and gender specific cut-off points for BMI [23].

Other measures

Information on the child's age (in months) was obtained from the well-child visit registration. Information on the child's gender (male, female) and ethnic background (Dutch, non-Dutch) was obtained at enrollment via the parent report. Child ethnic background was categorized according to the parents' country of birth: if both parents were born in the Netherlands the child was classified 'Dutch' otherwise the child was classified 'non-Dutch' [24].

Mothers completed the majority of the questionnaires (88.1%). Information on maternal age (years), height (meters), weight (kilograms), country of birth (the Netherlands, other countries) and educational level (low/ mid-low, mid-high/ high) was self-reported in the baseline questionnaire. Maternal BMI was calculated and dichotomized into normal-weight (BMI < 25 kg/m^2) or overweight (BMI ≥ 25 kg/m^2) [25]. Maternal education level was dichotomized: low/ mid-low (no education, primary school, or ≤ 3 years of general secondary school, > 3 years of general secondary school) or mid-high/high (higher vocational training, undergraduate programs, Bachelor's degree, higher academic education) [26].

The YHC professionals in both intervention and control condition were to return a registration form after the well-child visit. The YHC professionals in the intervention condition also returned a registration form after each additional session. The forms addressed session duration, topics discussed, whether action plans for change or workbook-exercises were discussed, and whether a new session was planned. If there was no follow-up session planned, the reasons therefore were recorded. Questionnaires assessing the acceptability and feasibility of the prevention protocol were sent to the parents and YHC professionals after the first or second additional session. The YHC professionals could indicate challenges of the prevention protocol and give an overall grade. Parents were asked to indicate whether the information provided during the sessions was appreciated.

Sample size considerations

The calculation for the sample size in this study is described elsewhere [19]. The sample size calculations were based on an expected intra-cluster correlation coefficient (ICC) of 0.1, n= 44 clusters, an expected prevalence of overweight of 9%, while the power of the study was set to 80%. Based on these assumptions, a difference of 0.35 kg/m^2, assuming a standard deviation of 1.0 kg/m^2, could be detected, if the final sample of overweight children consisted of n= 356 subjects (n= 178 in each research condition).

The actual ICC's for follow-up BMI and waist circumference were calculated. A regression model with only a fixed intercept and a random intercept for YHC team was fitted; no other variables were included. Covariance parameters were used to calculate the ICC as cluster variance/ total variance. The observed ICC for BMI and waist circumference were rho= 0.06 and rho= 0.11 respectively. In the regression models predicting follow-up BMI and waist circumference, a random intercept for YHC team was included to correct for clustering.

Statistical analysis

Baseline data for the intervention and control condition clusters are described using descriptive statistics.

To predict follow-up BMI and waist circumference, regression models were applied. All participants were analyzed according to the 'intention-to-treat' principle. At follow-up, the population for BMI analysis was n= 505 and for waist circumference n= 482.

BMI and waist circumference at follow-up were predicted with a model using two predictors: research condition (intervention or control) and baseline value of the outcome variable[27-28]. Time between baseline and follow-up measurement was added to the model (mean 26.0 (SD 4.42) months, range 14 to 35 months, mean intervention condition 26.08 (SD 4.48), mean control condition 25.91 (SD 4.36)). A sensitivity analysis was conducted to compare the final model with and without inclusion of time between measurements; results were similar. Age at the baseline measurement was added to the model (mean 69.6 (SD 5.18) months, range 56.4 to 91.2). Gender and ethnic background of the child, and education level and BMI of the mother were evaluated as potential confounding variables. All models are presented with and without correction for clustering at YHC team-level (n= 44) [29]. The effect of the intervention was evaluated at $p< 0.05$ level in all analyses.

Interaction effects between the outcome variable and socio-demographic characteristics (gender and ethnic background of the child, education level of the mother) were examined [19, 30-31]. Additionally, a post-hoc analysis was performed and an interaction term between research condition and baseline value of the outcome was evaluated. A main effect for the interaction variable and an interaction term –research condition times interaction variable – were added to the regression model. The interaction terms were evaluated at $p< 0.10$ level [32]. In addition, the regression analyses were performed using age- and gender adjusted BMI-SDS scores based on the reference values of the in 1997 performed Dutch nation-wide growth study [33]. A per protocol analysis was performed comparing overweight children of parents that attended at least one additional session with overweight children in the control condition. Process measures with regard to use and appreciation of the intervention are described using descriptive statistics. Non-response to the intervention was evaluated by comparing mothers of children who attended at least one additional session with mothers that did not attend any additional session on demographical characteristics: age, country of birth, maternal education level and BMI.

Analyses were performed in SPSS (International Business Machines (IBM) Corp., SPSS statistics, version 20.0, Armonk, New York, USA). Cluster adjusted regression models were fitted using SAS software; proc mixed for continues outcomes with a random intercept for YHC team (SAS version 9.2; SAS Institute Inc., Cary, North Carolina, USA).

RESULTS

Figure 1 presents the flow of clusters and participants through the study. In order to detect children who are overweight a total of n= 13,638 parents and children was invited to participate in the study; n= 8,784 parents agreed to participate and provided written informed

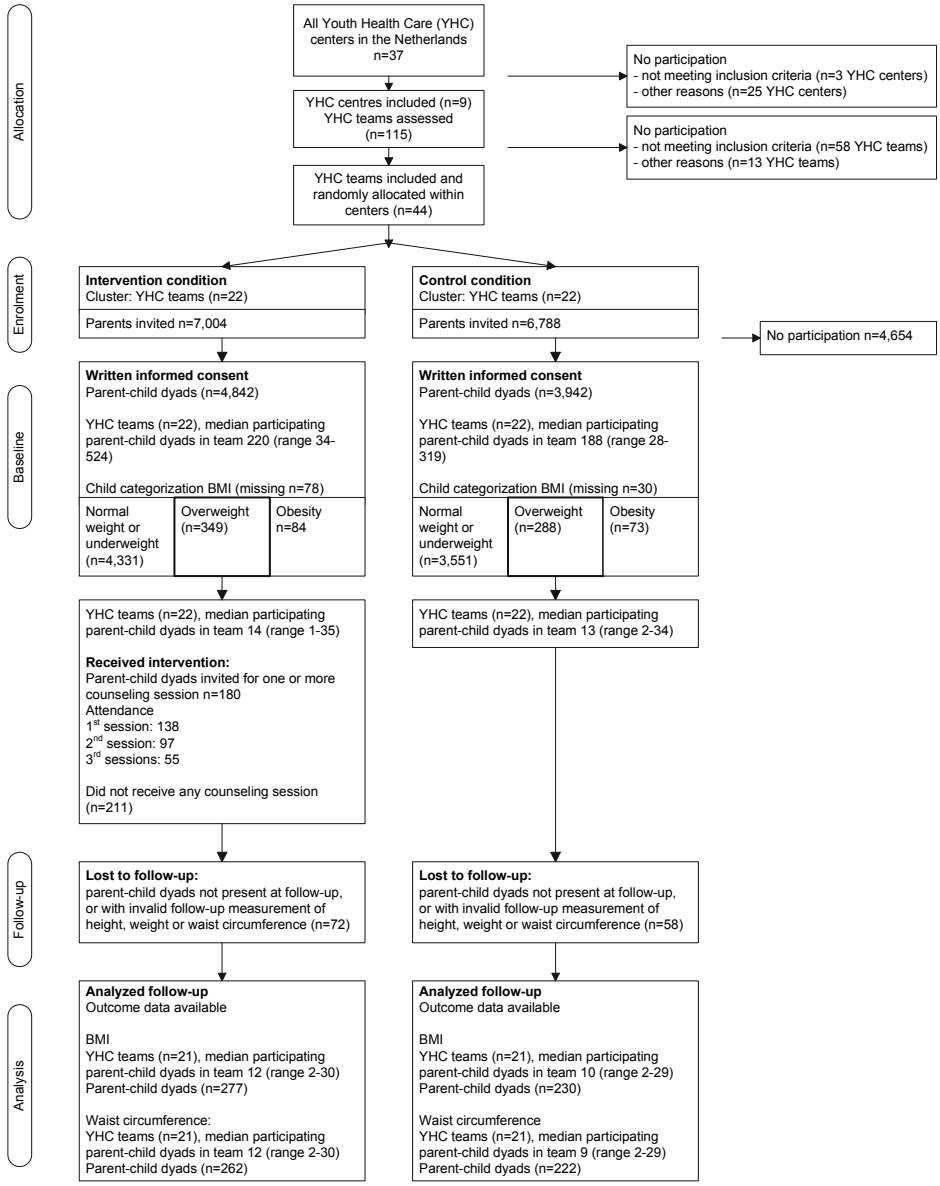

Figure 1 Flow diagram of the selection and follow-up of study participants

Table 1 Descriptive characteristics of the study sample, overweight not obese children (n=637)

	Overall (n=637)	Intervention condition (n=349)	Control condition (n=288)	p-value*
Child characteristics				
Age, mean (SD), months (missing n=0)	69.09 (5.18)	68.65 (4.98)	69.64 (5.37)	**0.016**
Gender (% boys) (missing n=0)	38.1	38.7	37.5	0.412
Ethnic background (% Dutch) (missing n=11)	78.0	75.8	80.6	0.091
BMI, mean (SD), kg/m^2 (missing n=0)	18.13 (0.62)	18.16 (0.63)	18.10 (0.61)	0.238
Characteristics of the mother				
Age, mean (SD), years (missing n=81)	35.85 (4.29)	35.80 (4.23)	35.92 (4.37)	0.741
Country of birth (% the Netherlands) (missing n=4)	83.1	82.4	84.0	0.335
Education level (missing n=6)				0.214
Low / Mid-low	33.3	34.8	31.5	
Mid-high/ High	66.7	65.2	68.5	
BMI categories (missing n=51)				0.422
Normal weight	56.0	55.5	56.6	
Overweight/ obesity	44.0	44.5	43.4	

* P-value derived from independent samples t-test (continuous variables) and Chi-square test (categorical variables).
Note: **bold** printed numbers indicate a statistically significant p-value.

consent (64.4%) (for descriptive characteristics of all study participants with informed consent please see the supplemental material Table S1). Of these parents n= 637 had a child that was overweight, not obese (7.3%).

In Table 1 characteristics of the children having overweight (not obesity) at baseline are presented; 38.1% were boys, the mean age at baseline was 69.09 (SD 5.18) months. Baseline BMI ranged from 17.5 (age 63.0 months) to 19.8 (age 78.0 months) in boys and from 17.2 (age 61.0 months) to 19.9 (age 77.0 months) in girls.

Primary outcomes

At baseline child overweight prevalence was 7.3% in the intervention condition and 7.4% in the control condition (missing n= 108, Figure 1). At follow-up the prevalence of normal-weight, overweight and obesity was 87.2%, 10.8% and 2.1% in the intervention condition and 86.4%, 11.4% and 2.2% in the control condition respectively (missing n= 1,693).

Of the children in the intervention condition that were overweight at baseline, at follow-up 61.0% remained overweight, 14.4% were categorized as obese and 24.5% were normal-weight. In the control condition among the children that were overweight at baseline, the prevalence of overweight, obesity and normal-weight was 62.7%, 11.0% and 26.3% respectively at follow-up (missing n= 60).

The mean change in BMI from baseline to follow-up was 1.37 (SD 1.53) in the intervention condition versus 1.44 (SD 1.71) in the control condition. The regression model showed that, at follow-up, there was no significant difference in BMI between children in the intervention

Table 2 Outcomes of linear regression models predicting BMI (kg/m^2) and waist circumference (cm) at follow-up

	BMI (n=505)		Waist circumference (n=482)	
	Beta coefficient (95% CI)	**p-value**	**Beta coefficient (95% CI)**	**p-value**
Model 1[1]	-0.06 (-0.34; 0.23)	0.687	-0.16 (-1.10; 0.78)	0.741
Model 2[2]	-10.25 (-18.57; -1.93)	**0.016**	10.04 (-4.94; 25.01)	0.188
Interaction term	0.56 (0.10; 1.02)	**0.016**	-0.17 (-0.43; 0.08)	0.181
Model 3[3]	-0.16 (-0.60; 0.27)	0.463	-0.46 (-1.82; 0.90)	0.506
Model 4[4]	-10.67 (-18.80; -2.54)	**0.010**	7.98 (-7.39; 23.34)	0.308
Interaction term	0.58 (0.13; 1.03)	**0.011**	-0.14 (-0.40; 0.12)	0.280

[1] Model with research condition (intervention versus control condition), baseline value of the outcome variable, time between measurements and age of the child at baseline measurement. [2] Model 1 including an interaction term between baseline BMI (continuous) and research condition (intervention condition compared to control condition – reference). [3] Model 1 corrected for cluster. [4] Model 3 including an interaction term between baseline BMI (continuous) and research condition (intervention condition compared to control condition – reference).
Note: **bold** printed numbers indicate a statistically significant p-value.

condition compared to the control condition (19.53 (SD 1.72) versus 19.55 (SD 1.74), beta intervention condition -0.16, 95% CI -0.60 to 0.27, p= 0.46) (Table 2). In the model predicting BMI, there was a statistically significant interaction between research condition and baseline BMI (p= 0.01) (Table 2). This indicated that the overall slopes of the regression lines for intervention condition and control condition were not equal. To gain more insight in the observed interaction we additionally evaluated for which exact value of the baseline BMI the difference between the intervention and control condition follow-up BMI was statistically significant. To explore this, marginal mean differences were estimated for baseline BMI values (17.25 to 19.25 with intervals of 0.25 kg/m^2) (Table 3). The results indicate that at baseline BMI values of 17.25 and 17.50 the intervention and control condition had a significant difference in mean follow-up BMI (adjusted estimated mean difference -0.67 (se: 0.30), p= 0.02 and -0.52 (se: 0.36), p= 0.05) (Table 3).

The mean change in waist circumference from baseline to follow-up was 7.20 (SD 5.49) centimeter in the intervention condition and 7.33 (SD 5.30) centimeter in the control condition. At follow-up children in the intervention condition had a waist circumference of 65.60 (SD 6.07) centimeter versus 66.21 (SD 6.03) centimeter in the control condition (beta intervention condition -0.46 centimeter, 95% CI -1.82 to 0.90, p= 0.51). There were no statistically significant interaction terms (Table 2).

The regression analyses performed with BMI-SDS scores (data not shown) also showed a significant interaction term for intervention condition times baseline BMI-SDS score (p= 0.07); indicating similar results as the analyses with the BMI scores. The per protocol analysis (data not shown), comparing children from parents attending at least one additional session (n= 138) with parents in the control condition (n= 288), showed similar results as the intention to treat analysis.

Table 3 Estimated least square marginal mean difference between intervention and control condition for given baseline BMI values

Baseline BMI (kg/m^2)	Intervention versus control condition estimated adjusted difference (se)[1]*	p-value
17.25	**-0.67 (0.30)**	**0.024**
17.50	**-0.52 (0.26)**	**0.045**
17.75	-0.38 (0.23)	0.106
18.00	-0.24 (0.22)	0.286
18.25	-0.09 (0.22)	0.382
18.50	0.05 (0.23)	0.815
18.75	0.20 (0.26)	0.443
19.00	0.34 (0.29)	0.243
19.25	0.49 (0.34)	0.146
19.50	0.63 (0.38)	0.096

[1] Model is corrected for cluster with research condition (intervention versus control condition), baseline value of the outcome variable, time between measurements and age of the child at baseline as independent predictors; model includes an interaction between baseline BMI and research condition.

* Covariate 'time between measurements' was evaluated in the model at the mean of 26.0 months and age at baseline was evaluated at the mean of 69.0 months.

Note: **bold** printed numbers indicate a statistically significant estimated adjusted difference between intervention and control condition.

Evaluation of the intervention

The YHC professionals performing the well-child visit were mainly health care physicians (72.0%). The YHC professionals did not invite all overweight children and parents for an additional session (51.6%, 180/ 349). The main reason for not inviting parents for an initial session was that based on the YHC professional judgment, the child was not overweight (n= 73) because of differences in posture, ethnic background or body composition. Other reasons were that the YHC professional was not able to motivate the parents or the parents refused additional counseling (n= 35) or the child had other problems that had priority, such as behavioral problems (n= 15).

Additional sessions were mainly performed by youth health care physicians (65.8%). Attendance at the first session was 76.7% (138/ 180), the second session 53.9% (97/ 180), and all three sessions 30.6% (55/ 180) (Figure 1). Average duration of first additional session was 24.76 minutes (SD 10.51, range 0-60 minutes). The baseline BMI of children whose parents attended at least one additional session was higher compared to the BMI of children whose parents did not attend any additional session (mean BMI 18.30 (SD 0.59) versus 18.07 (SD 0.64), p= 0.001). Mothers that attended at least one session (n= 138) were not statistically different with regard to age, country of birth, education level or BMI from mothers that did not attend any additional session.

The YHC professionals in the intervention condition filled in evaluation forms on the use of the prevention protocol (n= 54). In the intervention teams, 65% (15/ 23, n= 31 missing) of the YHC professionals evaluated the prevention protocol with a grade of 7 or higher (scale

range 1 to 10). Difficulties the YHC professionals most often experienced while using the prevention protocol were motivating parents to attend additional sessions and changing the family health-related lifestyle.
The additional sessions were assessed with a grade of 7 or higher by 90% (81/ 90) of the parents that filled in an evaluation form; 87% (78/ 90) reported receiving overall useful information, and 79% (71/ 90) reported receiving advice that suited them.

DISCUSSION

In this study, the overweight prevention protocol for parents of five-year-old overweight (not obese) children was evaluated. Results showed no overall difference between children in the intervention and control condition with regard to BMI and waist circumference at two-year follow-up. However, a significant interaction effect was found when predicting follow-up BMI, indicating that children with a relatively low overweight BMI (17.25 and 17.50) at the start of the intervention had a significantly smaller increase in BMI at follow-up when they had been allocated to the intervention condition relative to the control condition. This interaction was also observed when performing analysis based on BMI-SDS scores and with a per protocol analysis comparing overweight children of parents that attended at least one additional session to overweight children in the control condition.
The intervention showed a small effect among the mildly overweight children, but not for the more overweight children. Specifically, for parents of mildly overweight children, the YHC professional may be the first to point out that the child is overweight [34]. Parents often misperceive the child's weight status or are unaware of the consequences of excess weight for their child [34-37]. During the visit the YHC professional may therefore motivate parents to change behavior, or at least create awareness.
There are some factors in the intervention implementation and study that may have limited the detection of potential intervention effects. Results showed a lack of attendance to the additional counseling sessions, in line with other studies implementing this type of additional health visits [38-40]. There appeared to be two issues influencing the lack of attendance. Firstly, our registration showed that YHC professionals were not able to invite all parents to an additional session, partly due to the unwillingness of parents to attend these sessions. Although previous research has shown the positive effects of a motivational interviewing approach [39, 41] even when working with parents of obese children [38], the YHC professionals reported difficulties in motivating parents to attend additional counseling sessions or changing health-related behavior. In this study, the YHC professionals were provided with a one-day workshop on motivational interviewing. This level of instruction may not be optimal because research has suggested the beneficial effects of refreshment sessions and feedback on performance [38, 42-43]. Instruments are currently being developed for evaluating motiva-

tional interviewing performance [44]. However, the integration of this study in current practice, together with time and budget restraints, made monitoring the YHC professionals' skills and performance with regard to using the prevention protocol unfeasible but an important issue for future implementation of the protocol.

Secondly, the data showed that the YHC professionals often failed to start with the intervention because they considered the child not overweight, even though according to the international cut-off values the child was overweight; this is described in the prevention protocol as the 'clinical judgment' [17-18]. The clinical judgment can change the decision with regard to a child's weight status based on factors potentially influencing the weight status of the child: posture, body composition, ethnic background and other factors [18]. Nevertheless, the researchers instructed and emphasized that the YHC professionals should offer the prevention protocol to all children diagnosed having overweight according to the international cut-off values. Implementation of the intervention may have been less uniform due to the use of the clinical judgment by some YHC professionals. In addition to the clinical judgment or the cut-off values, the lifestyle of parent and child may be the foremost starting point for the decision on whether or not to offer the prevention protocol.

The parents that did attend an additional session had children with higher BMI's. This may have influenced the intervention effect observed as well, as the intervention was designed for overweight prevention, including children that only just meet the criteria for overweight, for which it also appeared to be effective. For obese children, more intensive, multidisciplinary interventions seem to be more effective in changing health behaviors [5, 45-46]. Mechanisms contributing to behavior change, for example self-efficacy and habit strength, [47-48] [49] may be different between overweight and obese children. In addition, as suggested by Wake and colleagues [50], the effect of the intervention may depend on the willingness of the parents to change, which may be greater among parents of obese children or parents who self-initiate participation in interventions.

In line with studies performed in the primary care setting minor effects were observed from providing an intervention [6, 38, 40, 51]. But, youth health care with high attendance rates of parents and children at regular appointments throughout the infant, child and adolescent period, during which height and weight measurements are taken, offers a setting for tailored prevention [11-13]. As part of a community approach to overweight prevention, the opportunity to intervene in youth health care may not be passed [50]. So, despite the fact that we could not demonstrate a convincing statistically significant effect between the intervention and control condition with regard to BMI or waist circumference, we believe that youth health care can contribute to overweight prevention and efforts are needed to optimize the protocols that can be implemented in this setting.

Hypothetically, to enhance effects the prevention protocol may best be implemented during the well-child visit; which is attended by most parents. Therefore, we recommend integrating elements of the prevention protocol in the well-child visit. But, not all elements can be inte-

grated and to prevent parents from dropping out before beginning the additional sessions, the first additional session should be planned shortly after the well-child visit [38]. Also, alternatives to face-to-face sessions could be telephone sessions or Internet-tailored advice. More personal contact with parents (e.g., text messages or e-mail) may increase participation and/or support sustained behavioral changes. However, even with optimal implementation of the intervention, an approach in which all health care organizations and both public and private institutions work together to create an overall healthier environment may be essential to effectively address childhood overweight on a societal level [52].

Methodological considerations

The strengths of this study include the broad acceptance and use of the prevention protocol in the YHC setting across the Netherlands, the large number of parents participating in the study which enabled the detection of overweight children, and the two-year follow-up. By using standardized protocols for the measurement of height, weight and waist circumference, measurement errors in this respect were kept limited.

Limitations include falling attendance of parents to the additional sessions and possible contamination in the control condition. In the control condition, additional sessions were planned sporadically (data not shown) and a lot of media attention was given to the protocol. Although not according to the prevention protocol, YHC professionals in the control condition provided, usual, tailored care with regard to overweight prevention and this may have decreased the potential to detect an effect of the intervention comparing both conditions.

Conclusion

With the prevention protocol, parents of overweight (not obese) children are offered a low-intensive intervention to change health-related behaviors associated with overweight and obesity. The intervention proved to be effective only among mildly overweight children.

We recommend repeating this study in different settings to confirm the observed results. Further research will need to evaluate adjustments and improvements of the prevention protocol, such as integrating elements in the regular well-child visit, higher parent participation in the additional sessions, and implementation improvement (i.e. training and feedback to the intervention practitioners) on health outcomes. More specifically, child health-related behaviors (playing outside, watching television, having breakfast and drinking sweetened beverages), psychosocial outcomes (psychological well-being, quality of life) and parent health-related behaviors should be evaluated complementarily to the weight-related outcomes.

In conclusion, the prevention protocol is designed to be implemented in practice and is rated positively by practitioners and parents. Overall, in line with McCallum et al [40], we emphasize the importance of determining whether and how in this case the setting of (school-based) preventive youth health care can contribute to overweight prevention among children.

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SUPPLEMENTAL MATERIAL

Table S1 Descriptive characteristics for the study population of the 'Be active, eat right' study (n=8,784)

	Overall (n=8,784)	Intervention condition (n=4,842)	Control condition (n=3,942)	p-value*	p-value**
Child characteristics					
Age, mean (SD), months (missing n=38)	68.93 (5.07)	68.86 (5.09)	69.03 (5.06)	0.121	0.776
Gender (% boys) (missing n=76)	50.9	51.7	50.0	0.055	0.106
Ethnic background (% Dutch) (missing n=176)	84.9	83.9	86.2	**0.002**	0.627
BMI, mean (SD), kg/m^2 (missing n=34)	15.49 (1.52)	15.53 (1.49)	15.43 (1.54)	**0.002**	0.158
Characteristics of the mother					
Age, mean (SD), years (missing n=1,116)	36.30 (4.46)	36.31 (4.50)	36.28 (4.41)	0.786	0.939
Country of birth (% the Netherlands) (missing n=108)	89.4	88.8	90.1	**0.023**	0.588
Education level (missing n=167)				**0.046**	0.508
Low / Mid-low	23.6	24.3	22.8		
Mid-high/ High	76.4	75.7	77.2		
BMI categories (missing n=921)				**0.018**	0.264
Normal weight	70.1	69.1	71.3		
Overweight/ obesity	29.9	30.9	28.7		

* P-value derived from Chi-square tests comparing intervention and control condition on categorical and binomial outcomes, p-value derived from independent samples t-test comparing intervention and control condition on continuous outcomes.

** P-value derived from multilevel regression model, demographic characteristic predicted by research condition (reference control condition). For example, there is no difference in age (p=0.776) between the children in the intervention clusters and control clusters.

Note: **bold** printed numbers indicate a statistically significant p-value.

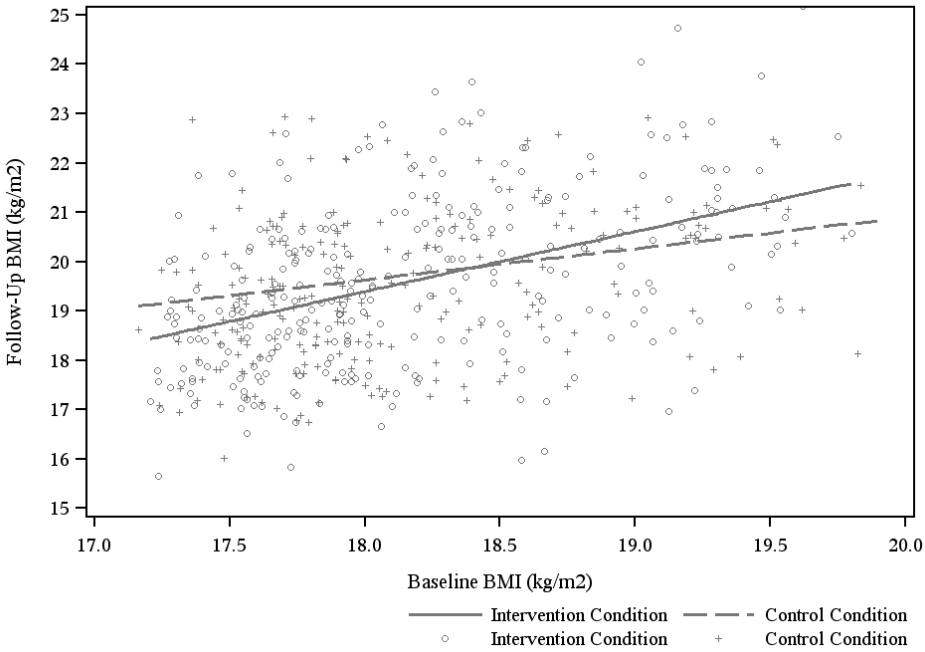

Figure S1 Graphical representation of the cluster corrected regression model

3

Promotion of a healthy lifestyle among 5-year-old overweight children: health behavior outcomes of the 'Be active, eat right' study

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Submitted

ABSTRACT

Purpose

This study evaluates the effects of an intervention performed by youth health care professionals on child health behaviors. The intervention consisted of offering healthy lifestyle counseling to parents of overweight (not obese) 5-year-old children. Effects of the intervention on the child having breakfast, drinking sweet beverages, watching television and playing outside were evaluated.

Methods

Data were collected with the 'Be active, eat right' study, a cluster randomized controlled trial among nine Municipal Health Services in the Netherlands. Parents of overweight children received lifestyle counseling according to the overweight prevention protocol in the the intervention condition (n= 349) and usual care in the control condition (n= 288). Parents completed questionnaires regarding demographic characteristics, health behaviors and the home environment at baseline and at 2-year follow-up. Cluster adjusted regression models were applied; interaction terms were explored.

Results

The population for analysis consisted of 38.1% boys; mean age 5.8 (SD 0.4) years; mean BMI SDS 1.9 (SD 0.4). There were no significant differences in the number of minutes of outside play or television viewing a day between children in the intervention and the control condition. Also, the odds ratio for having breakfast daily or drinking two or less glasses of sweet beverages a day showed no significant differences between the two conditions. Additional analyses showed that the odds ratio for drinking less than two glasses of sweet beverages at follow-up compared with baseline was significantly higher for children in both the intervention ($p< 0.001$) and the control condition ($p= 0.029$).

Conclusion

Comparison of the children in the two conditions reveals that the intervention does not contribute to a change in health behaviors. Further studies are needed to investigate opportunities to adjust the prevention protocol, such as integration of protocol elements in the regular well-child visit. The prevention protocol in youth health care may become part of a broader approach to tackle childhood overweight and obesity.

INTRODUCTION

The prevalence of childhood overweight and obesity has been increasing over recent years [1]. The prevalence of overweight among children in the Netherlands has been estimated at 13-15% and the prevalence of obesity was estimated at 2% (age 2-21 years) [2]. The consequences associated with overweight and especially obesity in childhood (e.g. type 2 diabetes, cardiovascular disease) represent a public health issue [3,4]. Worldwide, interventions aiming to prevent overweight and obesity among children have been developed and evaluated [5].

In the Netherlands, growth, development and health of all children (0-19 years) is monitored in a nationwide program with regular well-child visits at set ages by providers of preventive youth health care. In each Dutch region youth health care providers (mainly youth health care physicians and school nurses) work in teams at youth health care centers and schools to conduct this nationwide program [6,7]. The program is offered free of charge by the government and participation is voluntary (attendance rate 90-100%) [8]. Several successful preventive measures have been implemented through the youth health care, for example, the national immunization program and the prevention of Sudden Infant Death Syndrome (SIDS) [9-11].

In 2004, a practiced-based protocol was developed to help detect overweight and obesity among children attending a well-child visit [12,13]. By means of this protocol children were classified into weight categories using the international age-and-gender body mass index (BMI) cut-off values [14]. In 2005, a transitional plan, i.e. the prevention protocol, was developed to be used in daily practice to prevent overweight children from developing obesity [15]. This intervention offers additional healthy lifestyle counseling to parents of overweight, not obese, children [15]. Parents are supported in becoming aware of the overweight of their child, and motivated and assisted in making behavioral change. Parents play an important role in the child's health behavior by performing certain parenting practices (e.g. rules with regard to eating snacks) and influencing the home environment (e.g. availability of (un)healthy products) [16,17]. During the healthy lifestyle counseling, advice is given about behaviors relevant to the prevention of overweight, e.g. having breakfast, drinking less sweet beverages, playing outside, and watching less television [15]. The detection and prevention protocol has the potential to reach a considerable number of parents and children and to be structurally implemented in the youth health care setting. Consequently, even if individual changes are small, greater effects on the population level might be achieved.

We earlier reported that no effects of the prevention protocol were found on BMI and waist circumference of children in the total study population [18]. Therefore, this study evaluates changes in health behaviors targeted with the prevention protocol [19]. We hypothesized that children with overweight (not obesity) whose parents received advice according to the prevention protocol would, at follow-up, have breakfast more often, drink less sweet beverages per day, play outside more often, and watch less television per day compared to overweight children whose parents received usual care during the regular well-child visit. In addition,

we evaluated the effects of the intervention on related health behaviors (e.g. snacking, fruit consumption), parenting practices and home environment characteristics. Finally, implementation of the intervention (e.g. health behaviors discussed) was also evaluated.

METHODS

The 'Be active, eat right' study (trial registration Current Controlled Trials ISRCTN04965410) is a cluster randomized controlled trial (RCT) described in detail elsewhere [19]. The Medical Ethics Committee of the Erasmus University Medical Center Rotterdam approved the study protocol (reference number MEC-2007-163).

In 2007 all youth health care centers in the Netherlands (n= 37) were invited to participate in the study. Of these, nine services were eligible (i.e. a control condition could be created) and agreed to participate, with a total of 44 youth health care teams [19]. Within each youth health care center, youth health care teams (with youth health care physician, school nurse and assistant) were randomized for allocation to either the intervention or control condition. All parents invited to attend the well-child visit of their 5-year-old child between September 2007 and October 2008 were also invited to participate in the study with their child. Information on the study and an informed consent form for participation in the two-year study was enclosed with the invitation for the well-child visit. The parents could return the written informed consent form during the well-child visit when their child was 5 years old. Parents were not aware of the research condition to which they were allocated.

Intervention

The prevention protocol is based on theories and models of behavioral change, i.e. the ASE model, a theoretical model of exercise habit formation, the Precaution Adoption Process Model, the Elaboration Likelihood Model, the stages of change model, and motivational interviewing techniques [20-26]. During the well-child visit and in up to three additional visits, parents of overweight children were offered tailored information regarding overweight prevention and a healthy lifestyle [14,15]. An assessment form was available for youth health care professionals to assess child health behavior, parental awareness of the child's overweight, associated consequences and related health behaviors, and motivation to change health behavior. The content of the well-child visit and each additional session was adapted to the outcome of the assessment and dependent on the parents' stage of change. Youth health care professionals could make use of motivational interviewing techniques to create awareness, motivate parents to change behavior and/or support behavioral change [15,21,26].

Based on the international literature and expert meetings, four lifestyle-related behaviors were chosen to be promoted using the prevention protocol: i) playing outside for at least 1 h a day, ii) having breakfast daily, iii) drinking no more than 2 glasses of sweet beverages, and

iv) limiting television time to a maximum of 2 h a day [15,27-31]. Together with the parents, youth health care professionals chose one or two behaviors to target during the sessions. Parents drew up a family-oriented action plan and could complete diaries to gain insight into family health behavior.

When a child with overweight (not obesity) visited a youth health care team allocated to the control condition, usual care was given: i.e. the well-child visit, during which parents were offered general information about healthy nutrition and physical activity.

According to the protocol, all youth health care professionals, regardless of their team allocation, had to refer obese children to the general practitioner for further diagnosis and management. In the overweight prevention protocol no additional care or education is described for normal-weight and underweight children.

Data collection

Data collection was scheduled at enrolment, baseline (the well-child visit), and at 2 years post-baseline (follow-up). A baseline questionnaire was enclosed with the regular invitation for the well-child visit. Parents could return the baseline questionnaire during the well-child visit when their child was 5 years old. Two years after the well-child visit, parents received an invitation to fill in a questionnaire, which could be completed by paper or via the Internet.

Outcomes

The primary outcomes of the study, as described by Veldhuis et al. [19], were BMI and waist circumference, as reported elsewhere [18]. Here we report on the secondary outcome measures: child health behaviors. Questionnaires used in related research were used to assess outcomes [32-35]. Power calculations used to calculate the power to detect a difference between both conditions are reported by Veldhuis et al. [19]. Details on the variables and their psychometric properties are available in the supplemental material Table S1.

Child health behavior (breakfast, sweet beverages, playing outside and TV viewing) was assessed by parent report by means of questionnaires; parents had to keep in mind an average week when reporting on the health behaviors of their child.

Parents reported the number of days the child had breakfast (never to 7 days a week). Parents reported the average number of glasses of sweet beverages per day; examples of sweet beverages were given (e.g. soda, lemonade, fruit juice). Due to the categorical response scales and the distribution of data, these variables were dichotomized: drinking >2 glasses of sweet beverages a day vs. drinking ≤2 glasses a day, and having breakfast daily vs. not having breakfast daily.

The average number of days of screen time of the child during the week and the weekend was reported by parents; they also estimated the time spent in front of the screen (including DVD viewing) in hours and minutes on both a weekday and weekend day. An estimated screen

time in minutes per day was calculated. Time playing outside was assessed in a similar manner. Outside play and TV viewing were also dichotomized: playing outside <1 h a day vs. playing outside ≥1 h per day, and watching television >2 h a day vs. watching television ≤2 h a day.

Outcomes measured at follow-up

Related child health behaviors. How many days the child walked and bicycled to school was reported by parents and dichotomized into 'never' vs. 'once or more a week'. The time the child spent exercising at sports clubs and the time spent behind the computer or game console was reported; minutes of sports per week and minutes of computer time per day were calculated. Parents estimated daily child consumption of snacks, in between meals, (1 serve=1 piece), fruit (1 serve=one medium apple, banana or pear) and vegetables (1 serve=1 serving spoon). Also, the child's consumption of water or tea without sugar was estimated by parents and thereafter dichotomized into < 2 glasses a day vs. ≥ 2 glasses a day.

Parenting practices. Parents indicated whether they had rules for the child (yes vs. no) for 12 health behaviors: 8 behaviors were classified as healthy behaviors and 4 as unhealthy behaviors. A typical question is "Do you have rules at home about what your child can eat for breakfast?". Two indexes for rules were created, one for healthy and one for unhealthy behavior, by adding the number of times a parent answered 'yes'.

Whether the parent monitored child behavior was assessed with 10 items: 6 on healthy and 4 on unhealthy behaviors. A typical question was "How often do you monitor how much vegetables your child eats?". Questions were accompanied by a 5-point response scale ranging from 'never' to 'always'. The items were combined by adding up scores and calculating the average score, this was done for healthy (Cronbach's α 0.71) and unhealthy behaviors (Cronbach's α 0.77) separately (scale range 1-5).

Similarly, also assessed was whether the parent actively encouraged healthy behavior (6 items), or discouraged unhealthy behavior (4 items), by saying this to the child (e.g. go play outside, or do not drink sweet beverages). An encouraging (Cronbach's α 0.90) and discouraging (Cronbach's α 0.79) scale score was calculated (scale range 1-5).

The number of days the parent had breakfast together with the child (1-7 days), how often parents collected food from a fast-food restaurant (ranging from 'never' to 'every day' on a scale from 0-7) and parental television time (minutes per day) was reported.

Home environment characteristics. Home environment included the availability of healthy and unhealthy products, reported by parents on a scale from 1-5, with a higher score indicating more healthy (Cronbach's α 0.78) or more unhealthy (Cronbach's α 0.67) products available.

Intervention implementation evaluation

The youth health care professionals from the intervention and control condition teams were to return a registration form after the well-child visit. The youth health care professionals in the intervention condition also returned a registration form after each additional session.

These forms addressed the duration of each session, the topics discussed during the session (e.g. overweight in general, playing outside, having breakfast, sweet beverages, watching television), whether action plans for change or workbook exercises regarding health behaviors were discussed, and whether an additional session was planned.

Other measures

Child measures

Body weight, height and waist circumference were measured by the healthcare professionals during well-child visits using standardized methods as described in a protocol [12]. BMI was calculated by dividing weight in kilograms by squared height in meters. Child BMI Standard Deviation Scores (SDS) were calculated using the reference population of children from the 2009 Dutch National Growth study [2]. Children were classified as having normal-weight, overweight (not obesity) or obesity according to the international age- and gender specific cut-off points for BMI [36].

Information on the child's age (months) was obtained from the well-child visit registration. Information on child's gender (male, female) and ethnic background (Dutch, non-Dutch) was obtained at enrollment by parent report. The child's ethnic background was categorized according to the parents' country of birth: if both parents were born in the Netherlands the child was classified as 'Dutch' otherwise the child was classified as 'non-Dutch'[37].

Maternal measures

The majority of the questionnaires was completed by mothers (88.1%). Information on maternal age (years), height (meters), weight (kilograms), country of birth (the Netherlands, other countries) and educational level (low, mid-low, mid-high, high) was self-reported in the baseline questionnaire. Maternal BMI was calculated and dichotomized into normal-weight (BMI <25 kg/m^2) or overweight (BMI ≥25 kg/m^2) [38]. Maternal education level consisted of four categories: low (no education, primary school, or ≤3 years of general secondary school) mid-low (>3 years of general secondary school), mid-high (higher vocational training, undergraduate programs, Bachelor's degree) or high (higher academic education) [39].

Statistical analysis

Baseline socio-demographic characteristics of the intervention and control condition clusters are described using descriptive statistics.

For each research condition, we evaluated whether health behavior made a significant change between baseline and follow-up. A cluster-corrected, intercept only, linear regression model was fitted for television viewing and outside play (minutes per day). For having breakfast daily and drinking ≤ 2 glasses of sweet beverages a day, cluster-corrected McNemar tests were performed (R software, R 2.7.1, Development Core Team, Vienna, Austria [40]).

To predict follow-up health behavior and compare research conditions, regression models were fitted. All participants were analyzed according to the intention-to-treat principle. All models are presented with and without correction for clustering at youth health care team level (n= 44) [41]. A two-predictor model was fitted: research condition (intervention or control) and baseline value of the outcome variable [42]. Time between baseline and follow-up measurement was added to the model (mean 26.0 (SD 4.42) months, range 14-35 months) and age at baseline measurement was added to the model (mean 69.6 (SD 5.18) months, range 56.4-91.2). Chi-square tests showed that the distribution of the months in which the questionnaires at baseline and follow-up were completed was comparable between both research conditions. Analyses corrected for season were performed (data not shown) and results were comparable to the analyses without correction. In all analyses, the effect of the intervention was evaluated at the $p< 0.05$ level. Interaction effects between research condition and socio-demographic characteristics (gender and ethnic background of the child, education level of the mother) were explored [19]. The interaction terms were considered statistically significant at $p< 0.10$ [43].

Additional analyses included an evaluation of related health behaviors, parenting practices and the home environment characteristics measured at follow-up, by means of cluster-corrected regression analysis. The analyses were similar to the main health behavior outcomes, except that there was no correction for the baseline value of the outcome. A cluster-corrected per protocol analysis was performed predicting health behaviors at follow-up with regression analysis comparing overweight children of parents that attended one or more additional sessions (n= 138), two or more additional sessions (n= 97) and three additional sessions (n= 55) with overweight children in the control condition (n= 288) (supplemental material Table S3). Also, we performed explorative analyses to evaluate the effects of the intervention based on the behavior that was discussed during the well-child visit. For example, the effects on breakfast for the subgroup of children in the intervention condition in which the parents discussed breakfast; these children were compared with children in the control condition. Analyses were corrected for cluster (supplemental material Table S4).

Demographic characteristics (age, country of birth, education level, overweight) of mothers attending at least one session were compared with characteristics of mothers receiving no session by means of descriptive statistics. Also, descriptive statistics were used to describe implementation of the prevention protocol from the registration data of the youth health care professionals.

Analyses without cluster correction were performed in SPSS (International Business Machines (IBM) Corp., SPSS statistics, version 20.0, Armonk, NY, USA). Linear and logistic regression analyses, taking into account the clustered design of the study, were performed using SAS software (SAS version 9.2; SAS Institute Inc, Cary, NC, USA).

RESULTS

Figure 1 presents the flow of clusters and participants through the study. Supplemental material Table S2 presents the baseline characteristics of all participants (n= 8,784). The intervention was to be offered to parents with children with overweight, not obesity, at baseline

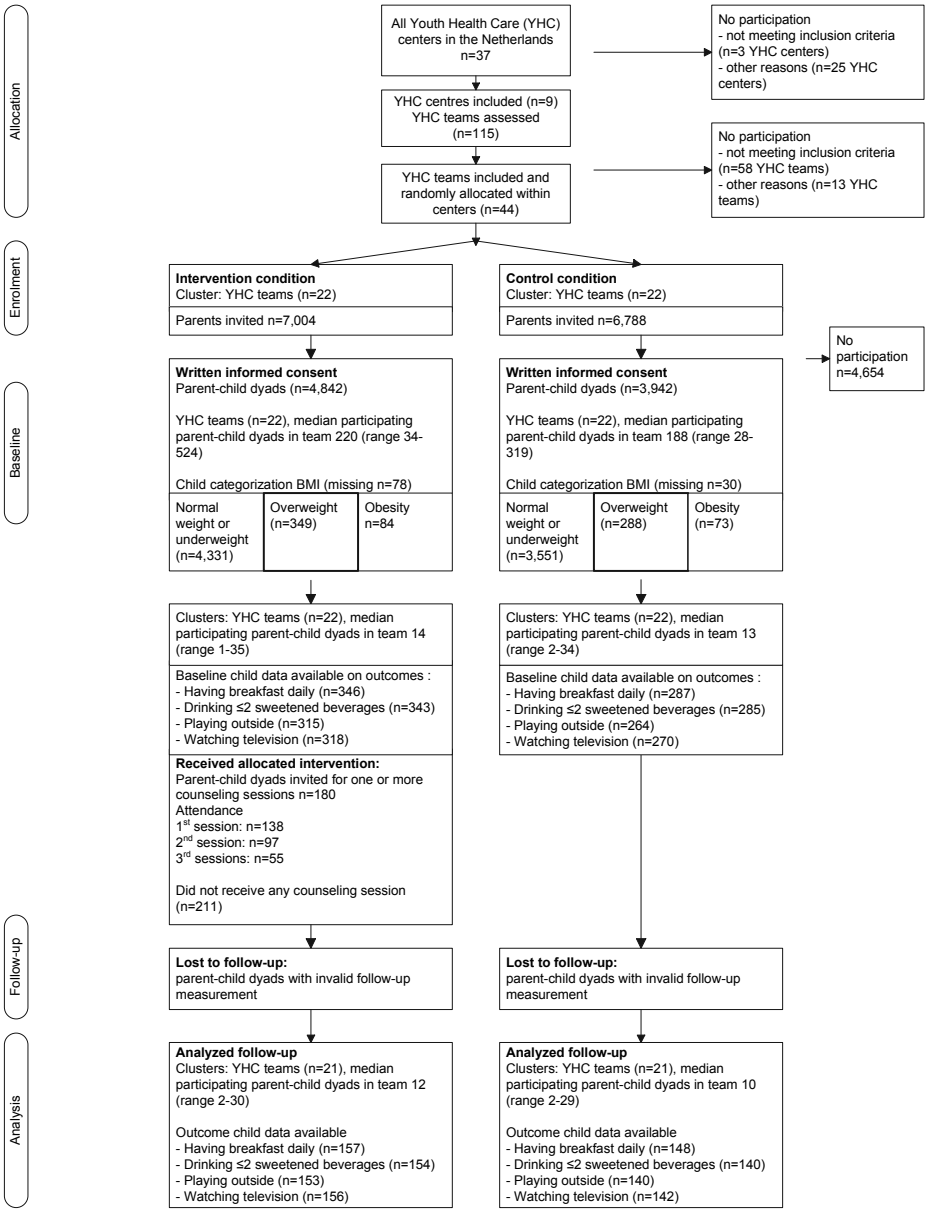

Figure 1 Flow diagram of the selection and follow-up of study participants

(n= 637). Due to missing data at follow-up (i.e. no return of the questionnaire), the population for analysis for having breakfast was n= 305, for sweet beverages n= 294, for television viewing n= 298 and for playing outside n= 293 (Figure 1).

Characteristics of children with overweight, not obesity (n=637) at baseline

At baseline, 38.1% of the children was male and the mean age was 69.09 (SD 5.18) months (Table 1). Mothers had an average age of 35.9 (SD 4.3) years and 16.9% was born outside the Netherlands.

Table 1 Descriptive socio-demographic characteristics of the study sample at baseline (n=637)

	Total sample (n=637)	Intervention condition (n=349)	Control condition (n=288)	p-value*
Child characteristics				
Age, months (SD) [n=0 missing]	69.09 (5.18)	68.65 (4.98)	69.64 (5.37)	**0.016**
Gender, % boys [n=0 missing]	38.1	38.7	37.5	0.412
Ethnic background, % Dutch [n=11 missing]	78.0	75.8	80.6	0.091
BMI SDS (SD)§ [n=0 missing]	1.90 (0.37)	1.93 (0.38)	1.88 (0.35)	0.087
Parental characteristics				
Mothers				
Age, years (SD) [n=81 missing]	35.85 (4.29)	35.80 (4.23)	35.92 (4.37)	0.741
Country of birth, % the Netherlands [n=4 missing]	83.1	82.4	84.0	0.335
Education level, % [n=6 missing]				
Low	7.3	7.8	6.6	0.238
Low to mid-low	26.0	27.0	24.8	0.086
Mid-high to high	44.7	40.0	50.3	0.721
High	22.0	25.2	18.2	**0.003**
BMI, % overweight [n=51 missing]	44.0	44.5	43.4	0.422
Fathers				
Age, years (SD) [n=562 missing]	40.19 (7.35)	40.60 (7.87)	39.71 (6.78)	0.606
Country of birth, % the Netherlands [n=9 missing]	83.6	80.8	87.0	**0.022**
Education level, % [n=18 missing]				
Low	5.3	4.5	6.4	0.602
Low to mid-low	26.0	25.3	26.9	0.478
Mid-high to high	42.5	42.6	42.4	0.156
High	26.2	27.7	24.4	0.059
BMI, % overweight [n=252 missing]	66.5	66.3	66.7	0.514

* P-value from t-test for continuous variables evaluating the difference between intervention and control condition. P-value from Chi-square test for categorical variables, evaluating the differences between frequencies between intervention and control condition.

§ BMI SDS: reference data from the 2009 Dutch National Growth Study.

Note: **bold** printed p-values indicate statistically significant difference between intervention and control condition.

Health behavior outcomes

Table 2 presents descriptive statistics of the health behaviors and results of the logistic regression analyses. At follow-up, in both conditions a significantly higher percentage was found for playing outside for < 1 h and watching > 2 h of TV compared with baseline. At follow-up, in the control condition the percentage of children eating breakfast daily was higher than at baseline (p= 0.027). In both conditions, at follow-up a higher percentage of children was drinking ≤ 2 sweet beverages a day compared with baseline (Table 2).

At follow-up there were no significant differences between the two conditions with regard to having breakfast, drinking sweet beverages, playing outside or viewing television. Also, there was no significant difference at follow-up between the two conditions when comparing outside play and television viewing using linear regression analysis (change in minutes per day) (Table 3).

The per protocol analyses, comparing children of parents that received at least one, two or three additional sessions with the control condition, showed that only for children of parents receiving 3 or more additional sessions was there a significantly higher OR for drinking ≤ 2

Table 2 Baseline and follow-up percentages of health behaviors and regression coefficients of the intervention condition compared with the control condition

	n	Intervention condition	n	Control condition	Odds Ratio (95%CI)[1]	Odds Ratio (95%CI)[2]
Having daily breakfast						
Baseline	346	89.9%	287	**88.2**%*		
Follow-up	157	95.5%	148	**94.6**%*	1.04 (0.29; 3.75)	1.04 (0.28; 3.78)
Drinking ≤ 2 sweet beverages a day						
Baseline	343	**32.1**%***	285	**33.3**%*		
Follow-up	154	**55.2**%***	140	**47.9**%*	1.38 (0.84; 2.26)	1.38 (0.84; 2.27)
Outside play ≥ 1 hour a day						
Baseline	315	**93.3%***	264	**94.3%****		
Follow-up	153	**77.1%***	140	**77.1%****	1.11 (0.60; 2.06)	1.09 (0.53; 2.26)
Watching television ≤ 2 hours a day						
Baseline	318	**74.8%***	270	**75.2%***		
Follow-up	156	**66.0%***	142	**69.0%***	0.93 (0.54; 1.61)	0.93 (0.53; 1.61)

º Within condition change of behavior from baseline to follow-up was evaluated using cluster-adjusted McNemar analysis.

[1] Odds ratio (OR) and 95% confidence interval (CI) from regression model evaluating the difference between intervention and control condition on the outcome at follow-up, corrected for baseline distribution of the outcome, time between measurements and age of the child at baseline.

[2] Odds ratio (OR) and 95% confidence interval (CI) from multilevel regression model evaluating the difference between intervention and control condition on the outcome at follow-up, corrected for baseline distribution of the outcome, time between measurements and age of the child at baseline.

Note: **bold** printed numbers indicate statistically significant within-group change or between-groups change of behavior; asterisks indicate significance level: * p<0.05, ** p<0.01, *** p<0.001.

Table 3 Baseline and follow-up means of playing outside and watching television per day, and regression coefficients of the intervention condition compared with the control condition

	n	Intervention condition º	n	Control condition º	Beta coefficient (95%CI)[1]	Beta coefficient (95%CI)[2]
Outside play, mean (SD)						
Baseline	315	**161.84 (106.66)***	264	160.50 (100.91)		
Follow-up	153	**135.93 (91.32)***	140	123.82 (76.34)	15.00 (-4.14; 34.15)	8.22 (-15.77; 32.22)
Watching television, mean (SD)						
Baseline	318	103.93 (74.05)	270	105.94 (66.57)		
Follow-up	156	102.64 (61.67)	142	104.34 (54.81)	-1.56 (-14.56; 11.44)	-1.56 (-14.57; 11.45)

º Within-group change of behavior from baseline to follow-up was evaluated using cluster-adjusted intercept only regression analysis.

[1] Beta coefficient and 95% confidence interval (95% CI) from regression model evaluating the difference between intervention and control condition on the outcome at follow-up, corrected for baseline value of the outcome, time between measurements and age of the child at baseline.

[2] Beta coefficient and 95% confidence interval (95% CI) from multilevel regression model evaluating the difference between intervention and control condition on the outcome at follow-up, corrected for baseline value of the outcome, time between measurements and age of the child at baseline.

Note: **bold** printed numbers indicate statistically significant within-group change or between-groups change of behavior; asterisks indicate significance level: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

sweet beverages a day compared with children in the control condition ($p< 0.05$) (see supplemental material Table S3).

The explorative analyses indicated that children of parents discussing sweet beverages during the well-child visit had a higher OR for drinking ≤ 2 sweet beverages at follow-up compared with children in the control condition, almost reaching significance ($p< 0.10$) (supplemental material Table S4). With regard to the other health behaviors, parents in the intervention condition had a significantly lower OR of having children watching ≤ 2 hours of television ($p< 0.05$) when this behavior was discussed.

Evaluation of potential interaction

Three significant interactions were observed: gender and intervention condition when predicting outside play in minutes per day ($p= 0.019$) and sweet beverage consumption ($p= 0.038$), and education level and intervention condition in the model predicting minutes of television viewing a day ($p= 0.011$). Stratified analyses were performed. Boys in the intervention condition had an OR of 2.74 (95% CI 1.19 to 6.35) and girls had an OR of 0.93 (95% CI 0.40 to 1.77) to drink ≤ 2 sweet beverages a day. Boys in the intervention condition had a change in outside play of -13.99 min/day (95% CI -46.11 to 18.13) while girls in the intervention condition had a change in outside play of 31.65 min/day (95% CI 4.32 to 58.98). Education level was merged into two categories (low/mid-low and mid-high/high) to perform stratified analyses. No significant results were observed when evaluating the effects on TV viewing for children of mothers with low/mid-low or mid-high/high education level.

Evaluation of related health behaviors, parenting practices and home environment characteristics

Table 4 presents descriptive characteristics and results of the regression analyses for the related health behaviors, parenting practices and home environment characteristics. There were no significant differences between children in the two conditions with regard to re-

Table 4 Descriptive statistics and regression analyses predicting secondary health behavior outcomes of the child, parenting practices and home environment characteristics at follow-up

	n	Intervention condition	n	Control condition	Beta coefficient/ Odds Ratio (95%CI)[1]	Beta coefficient/ Odds Ratio (95%CI)[2]
Health behaviors						
Walk to school (once or more a week)	159	52.8%	145	49.7%	1.15 (0.71; 1.87)	1.12 (0.63; 1.98)
Bicycle to school (once or more a week)	158	65.8%	148	64.2%	1.16 (0.71; 1.92)	1.15 (0.60; 2.21)
Average time spent performing sports (min/week, mean [sd])	128	113.83 [60.67]	115	115.43 [64.21]	1.68 (-14.33; 17.68)	1.68 (-14.34; 17.69)
Computer games (min/day, mean [sd])	144	29.61 [28.22]	144	30.62 (36.76)	-2.56 (-10.38; 5.27)	-2.98 (-11.99; 6.03)
Candy and snacks (pieces/day, mean [sd])	151	1.06 [0.45]	140	1.09 [0.65]	-0.03 (-0.16; 0.11)	-0.03 (-0.16; 0.11)
Vegetables (spoons/day, mean [sd])	157	1.61 [0.87]	144	1.72 [0.99]	-0.13 (-0.36; 0.10)	-0.13 (-0.36; 0.10)
Fruit (pieces/day, mean [sd])	154	1.39 [0.88]	138	1.41 [0.91]	-0.02 (-0.25; 0.20)	-0.01 (-0.29; 0.27)
Water or tea without sugar (≥2 per day)	144	25.7%	127	22.0%	1.27 (0.70; 2.29)	1.24 (0.63; 2.43)
Parenting practices						
Family breakfast (days/week, mean [sd])	158	5.46 [2.03]	145	5.25 [2.11]	0.32 (-0.18; 0.82)	0.52 (-0.15; 1.20)
Eating outside the home (days/week, mean [sd])	156	0.26 [0.18]	142	0.29 [0.24]	-0.04 (-0.09; 0.01)	-0.04 (-0.09; 0.01)
Rules (number of rules, mean[sd])						
Healthy behavior (range 0-8)	159	6.24 [1.84]	147	5.83 [1.89]	**0.60 (0.17; 1.05)****	**0.52 (0.05; 0.99)***
Unhealthy behavior (range 0-4)	158	3.35 [0.99]	143	2.96 [1.19]	**0.53 (0.27; 0.79)*****	**0.43 (0.11; 0.75)****
Monitoring (range 1-5, mean [sd])						
Healthy behavior	157	4.56 [0.41]	142	4.53 [0.43]	0.04 (-0.06; 0.14)	0.04 (-0.07; 0.14)
Unhealthy behavior	156	4.23 [0.63]	145	4.19 [0.63]	0.05 (-0.10; 0.20)	0.06 (-0.11; 0.24)
Reinforcing/ discouraging (range 1-5, mean [sd])						
Healthy behavior	153	2.89 [1.22]	135	2.89 [1.17]	-0.04 (-0.33; 0.26)	-0.07 (-0.42; 0.28)
Unhealthy behavior	151	3.15 [0.87]	140	2.98 [0.79]	0.15 (-0.05; 0.35)	0.12 (-0.13; 0.37)
Parental TV viewing (min/day, mean [sd])	155	133.75 [87.27]	146	125.53 [76.50]	14.45 (-4.90; 33.79)	11.93 (-9.30; 33.17)
Home environment						
Healthy products available (range 1-5, mean [sd])	159	4.79 [0.35]	145	4.82 [0.33]	-0.02 (-0.11; 0.06)	-0.02 (-0.11; 0.06)
Unhealthy products available (range 1-5, mean [sd])	159	4.05 [0.80]	148	4.17 [0.81]	-0.09 (-0.28; 0.11)	-0.09 (-0.34; 0.16)

[1] Beta coefficient or odds ratio (95% confidence interval) for the intervention condition versus control condition (reference) at follow-up from regression model unadjusted for cluster, corrected for time between measurements and age at baseline.

[2] Beta coefficient or odds ratio (95% confidence interval) for the intervention condition versus control condition (reference) at follow-up from regression model adjusted for cluster, corrected for time between measurements and age at baseline.

Note: **bold** printed numbers indicate a statistically significant difference between groups; asterisks indicate significance level: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

lated health behaviors (Table 4). With regard to parenting practices, parents of children in the intervention condition appeared to have more rules with regard to lifestyle behaviors compared with the control condition (rules on healthy behaviors mean 6.1 (SD 2.0) vs. 5.8 (SD 1.9) (p= 0.030), and rules on unhealthy behaviors mean 3.2 (SD 1.2) vs. 2.3 (SD 1.3) (p= 0.009) (Table 4). There were no significant differences between the two conditions for the remaining parenting practices or home environment characteristics (Table 4).

Evaluation of the intervention

The youth health care professionals performing the well-child visit and the additional sessions in the intervention condition were mainly youth health care physicians (72.0% and 65.8%). Attendance at the first session was 76.7% (138/180), the second session 53.9% (97/180) and at all three sessions 30.6% (55/180) (Figure 1). Average duration of the first additional session was 24.8 [SD 10.5] minutes. The baseline BMI SDS of children whose parents attended at least one additional session was higher than that of children whose parents did not attend any additional session (mean BMI SDS 1.99 [SD 0.35] vs. 1.89 [SD 0.0.394], p= 0.011). Mothers that attended at least one session (n= 138) showed no significant difference with regard to age, country of birth, education level or BMI compared with mothers that did not attend any additional session.

During the well-child visit youth health care professionals most often advised parents with regard to drinking less sweet beverages (134/349, 38.4%) and playing outside more often (104/349, 29.8%). During the first counseling session, most attention was given by the youth health care professionals to creating awareness and knowledge with regard to overweight (86/138, 62.3%) and the four health behaviors targeted in the intervention (78/138, 56.5%). Physicians also reported that they motivated parents to change health behaviors during the session (73/138, 52.9%). During the first counseling session youth health care professionals most often made an appointment with the parents about changing the amount and type of sweet beverages consumed by the child (78/138, 56.5%). In 41.3% (57/138) of the sessions diaries or workbook exercises were provided to the parents to be completed at home.

DISCUSSION

The aim of the overweight prevention protocol was to change health behaviors related to overweight in 5-year-old children by providing their parents with low-intensive lifestyle counseling sessions. The results show no overall difference between children aged 5-7 years in the intervention and control condition with regard to changes in having breakfast, drinking sweet beverages, TV viewing and playing outside. This is in line with the lack of effects of the prevention protocol observed on measures of body composition: BMI and waist circumference, in the total study population [18].

Results indicate that in both conditions the behavior changed in a similar direction from baseline to follow-up. Youth health care professionals were enthusiastic about the prevention protocol and were motivated to contribute to overweight prevention among children. Therefore, although the control condition teams were instructed to offer usual care, professionals allocated to the control condition may have provided improved usual care to the parents, consequently stimulating health behavior change. Also, the low attendance of parents to the optional additional sessions may have diminished the contrast between both conditions. However, in both conditions, a significant healthful change in sweet beverage consumption was observed between baseline and follow-up. Together with the youth health care professional, parents chose the health behavior they thought most feasible to change and, therefore, only one or two behaviors were discussed during the sessions [15]. In line with this, most often sweet beverage consumption was discussed within the prevention protocol. Sweet beverage consumption is associated with overweight; interventions may effectively decrease sweet beverage consumption and thus body weight of children [44,45]. The prevention protocol may have increased awareness among parents about the amount of sugar in sweet beverages, or alternative non-sweet beverages to offer the child.

Evaluation of the prevention protocol was performed in youth health care and the current results may reflect the use of the prevention protocol in its current design [15]. It may be worthwhile to investigate improvements of elements of the protocol to enhance implementation and use, because of the reach of youth health care among parents and children [46,47]. According to the youth health care professionals that provided the intervention, it is difficult to motivate parents to change health behavior and attend an additional session [18]. The involvement of parents is essential for successful overweight prevention, and especially valuable in interventions targeting young children [48]. Lack of attendance is often observed in interventions performed in a primary care setting [49,50]. Motivational interviewing is reported to be effective in increasing motivation and participation of parents [51-54]. The youth health care professionals' training applied in this study provided elements of motivational interviewing skills; we recommend to assess whether more training of professionals is needed to further improve these skills and apply them more effectively in daily practice [51,55]. Qualitative research with parents is recommended to assess what motivates parents to change their child's health behavior.

Another opportunity to improve the prevention protocol may be elaboration of its implementation during the well-child visit; this visit was well attended by parents. Social media (such as e-mail or messages by telephone) may be used to improve adherence to additional sessions [56]. In addition, potentially, internet-based tailored intervention elements may be used to improve adherence or to complement the information provided during the well-child visit or the additional sessions [57]. Research is needed to evaluate whether these types of improvements to the prevention protocol have a positive impact on effects on health behaviors.

The present results are in contrast to the successful realization of an earlier immunization program and the large contribution to the prevention of SIDS by youth health care in the Netherlands [9-11]. However, overweight is a complex problem [58] and, until now, few interventions performed in settings comparable to youth health care have been found effective [50,59-61]. In the Netherlands, youth health care performs regular height and weight checks and has the opportunity to offer parents and children individual, tailored advice and acts on the local level, which enables referral to local programs and care providers [7,8]. We recommend collaboration between youth health care and local intervention programs. This may provide opportunities to enhance effects and provide more children and parents with suitable intervention programs that help them to change health behavior [62]. Overall, tackling overweight as a public health problem should include more than this low-level prevention protocol but, youth health care may contribute to the broader approach [13].

Methodological considerations

Strengths of this study include the large number of youth health care centers willing to participate and apply the prevention protocol in daily practice. Moreover, we were able to evaluate the prevention protocol in the youth health care setting throughout the Netherlands, including a large number of parents and children. Consequently, we were able to detect the smaller number of overweight children and follow them for a period of two years.

Considerations with regard to implementation of the prevention protocol have been discussed elsewhere [18]. Other limitations include the missing data at follow-up; therefore, the present findings need to be interpreted with caution because a selective group of parents participated in the follow-up measurement. Because parents reported on health behaviors of their child, we recommend complementing parent-report measures with objective and observational research to assess validation of parent report of child health behavior. Especially for physical activity behaviors, additional measures (e.g. accelerometers in combination with GPS tracking) are recommended to distinguish between different types of physical activity behaviors.

Repeating the study and including more children with overweight is recommended to evaluate the effect of the intervention in specific subgroups. Further evaluation of the prevention protocol needs to include examination of potential side-effects on, e.g., health-related quality of life of the children.

Conclusion

By means of this prevention protocol, parents of overweight (not obese) children are offered a low-intensive intervention to change health behaviors associated with overweight and obesity. Comparison of the intervention and control conditions revealed that the prevention protocol did not contribute to a change in health behaviors. However, a significant improvement (i.e. reduction) in sweet beverage consumption was observed in both conditions.

We recommend further research to evaluate the effect of adjustments and improvements of the prevention protocol (e.g. integrating elements in the regular well-child visit or higher parent participation in the additional sessions) on health outcomes. Qualitative research may be performed to gain insight into how to motivate parents to change health behavior. Collaboration between youth health care and intervention initiatives at local level is recommended to enhance effects and create a broad approach for the prevention and treatment of overweight and obesity.

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SUPPLEMENTAL MATERIAL

Table S1. Background information and psychometric properties of the variables

Variable item(s)	Response scale (assigned value)	Outcome in analyses	Label
Child health behaviors			
How many days in the week does your child have breakfast?	1(1), 2(2), 3(3), 4(4), 5(5), 6(6), 7(7)	<7 days a week vs. ≥7 days a week	Having daily breakfast
How many glasses of sweet beverages does your child consume on an average day?	Less than 1 (0.5), 1 to 2(1.5), 3 to 4(3.5), 5 to 6 (5.5), 7 to 8 (7.5), 9 or more (9.5)	≤2 glasses vs. > 2 glasses	Drinking sweet beverages
On an average day how much time does your child play outside?	Open ended(hours/min)	Min/day and <1 hour a day vs. ≥1 hour a day	Outside play
On an average day how much time does your child watch TV?	Open ended(hours/min)	Min/day and ≤2 hours a day vs. > 2 hours a day	TV viewing
Related child health behaviors			
How many days in the week does your child walk to school?	Never (0), 1 day(1), 2 days(2), 3 days(3), 4 days(4), 5 days(5)	Never vs. once or more a week	Waking to school
How many days in the week does your child bicycle to school?	Never(0), 1 day(1), 2 days(2), 3 days(3), 4 days(4), 5 days(5)	Never vs. once or more a week	Bicycle to school
How many hours a week does your child spent in organized sports activities?	Open ended(hours/min)	Min/week	Average time spent performing sports
How many days a week/ weekend does your child spent on the computer or game console? How much time does your child spent on the computer or game console on an average week/weekend day?	Never(0), 1 day(1), 2 days(2) Never (0), 1 day(1), 2 days(2), 3 days(3), 4 days(4), 5 days(5) Open ended(hours/min) Open ended(hours/min)	Min/week	Computer games
How many snacks / candies does your child eat on an average day?	None or less than 1(0.5), 1(1), 2(2), 3(3), 4(4), 5(5), 6(6), 7(7), 8(8), 9 or more(9.5)	Snacks and candy/day	Candy and snacks
How many serving spoons of vegetables does your child eat on an average day?	None (0), less than ½ a spoon (0.25), ½ a spoon(0.5), 1 spoon(1), 2 spoons(2), 3 spoons(3), 4 spoons(4), 5 spoons or more (5.5)	Spoons/day	Vegetables
How many pieces of fruit does your child eat on an average day?	None(0), less than ½ a piece(0.25), ½ an piece(0.5), 1 piece(1), 2 pieces(2), 3 pieces(3), 4 pieces(4), 5 pieces or more(5)	Pieces/day	Fruit
How many glasses of water or tea without sugar does your child consume on an average day?	None or less than 1(0.5), 1(1), 2(2), 3(3), 4(4), 5(5), 6(6), 7(7), 8(8), 9 or more(9.5)	≤2 glasses vs. > 2 glasses	Water or tea without sugar
Parenting practices			
Do you have rules in your home about: - Whether your child has to play outside - Whether your child has to take part in physical activity - Whether your child should eat breakfast - What your child can and can't eat with his/her breakfast - Having breakfast as a family at the table - How much and what kind of dinner your child can have - How often and how many snacks and candy your child can eat - How often and how many vegetables your child should eat - How often and many fruit your child should eat - How often and how many sweet beverages your child can drink	Yes (1), no(0)	Total rules healthy behaviors (n=8 items, score range 0-8) Total rules unhealthy behaviors (n=4 items, score range 0-4)	Rules healthy behavior Rules unhealthy behavior

Table S1 *(continued)*

Variable item(s)	Response scale (assigned value)	Outcome in analyses	Label
- How often and how long your child can watch TV - How often and how long your child can sit behind the computer of game console			
Do you monitor whether your child: - plays outside - is physically active - has breakfast daily - has dinner daily - eats snacks and candy - eats vegetables - eats fruit - drinks sweet beverages - watches TV - sits behind the computer/ game console	Never(1), rarely(2), sometimes(3), often(4), always(5)	Monitoring healthy behavior (n=6 behaviors, Cronbach's α 0.71) Monitoring unhealthy behavior (n=4 items, Cronbach's α 0.77)	Monitoring healthy behavior Monitoring unhealthy behavior
How often do you actively reinforce your child to: - go play outside - go be physically active - have breakfast daily - have dinner daily - not eat snacks and candy - eat vegetables - eat fruit - not drinks sweet beverages - turn of the TV - turn of the computer/ game console	Never(1), rarely(2), sometimes(3), often(4), always(5)	Encouraging healthy behavior (n=6 items, Cronbach's α 0.90) Discouraging unhealthy behavior (n=4 items, Cronbach's α 0.79)	Reinforcing healthy behavior Discouraging unhealthy behavior
How many days a week do you have breakfast with your child at the table?	1(1), 2(2), 3(3), 4(4), 5(5), 6(6), 7(7)	Days/ week	Family breakfast
How many days a week does your family eat a mail from a fast food restaurant? How many days a week does your family eat meals from McDonalds, KFC, Burgerking e.o? How many days a week does your family eat pre-prepared meals (for example Chinese food or pizza delivery)?	Never(0), 1-3 times a months(0.5), 1 day a week(1), 2 days a week(2), 3 days a week(3), 4 days a week(4), 5 days a week(5), 6 days a week(6), every day(7).	Days/ week	Eating outside the home
How many days a week/ weekend do you watch television?	Never(0), 1 day(1), 2 days(2) Never (0), 1 day(1), 2 days(2), 3 days(3), 4 days(4), 5 days(5)	Min/day	Parental TV viewing
How much time do you watch television an average week/ weekend day?	Open ended (hours/min) Open ended (hours/min)		
Home environment			
There are usually enough breakfast products available in our home to have breakfast There are usually enough products in home to have dinner There are usually snacks and candy products available in our home There are usually vegetables available in our home There is usually fruit available in our home There are usually sweet beverages available in our home	Totally disagree(1), disagree(2), slightly agree/ slightly disagree(3), agree(4), totally agree (5)	Healthy products available (n=6 items, Cronbach's α 0.78) Unhealthy products available (n=4 items, Cronbach's α 0.67) Sum/ number of items	Healthy products available Unhealthy products available

Table S2 Descriptive characteristics of the children participating in the 'Be active, eat right' study (n=8,784)

	Overall (n=8,784)	Intervention condition (n=4,842)	Control condition (n=3,942)	p-value*
Child characteristics				
Mean age (sd), months (missing n=38)	68.93 (5.07)	68.86 (5.09)	69.03 (5.06)	0.121
Gender (% boys) (missing n=76)	50.9	51.7	50.0	0.055
Ethnical background (% Dutch) (missing n=176)	84.9	83.9	86.2	**0.002**
Mean BMI (sd), kg/m^2 (missing n=34)	15.49 (1.52)	15.53 (1.49)	15.43 (1.54)	**0.002**
Mean BMI SDS (sd)§ (missing n=72)	0.10 (1.11)	0.14 (0.02)	0.05 (1.14)	**<0.001**
Mothers' characteristics				
Mean age (sd), years (missing n=1,116)	36.30 (4.46)	36.31 (4.50)	36.28 (4.41)	0.786
Country of birth (% the Netherlands) (missing n=108)	89.4	88.8	90.1	**0.023**
Education level (missing n=167)				**0.046**
Low / Mid-low	23.6	24.3	22.8	
Mid-high/ High	76.4	75.7	77.2	
BMI categories (missing n=921)				**0.018**
Normal weight	70.1	69.1	71.3	
Overweight/ obesity	29.9	30.9	28.7	

* p-value derived from Chi-square tests comparing intervention and control condition on categorical and binomial outcomes, p-value derived from independent samples t-test comparing intervention and control condition on continuous outcomes.

§ BMI SDS: reference data from the 2009 Dutch National Growth Study.

Note: **bold** printed numbers indicate a statistically significant p-value.

Table S3 Evaluation of intervention effects based on 'dose'

	Number of additional sessions		
	1 or more (n=138)	**2 or more (n=97)**	**3 or more (n=55)**
Continues	*Beta (95%CI)*	*Beta (95%CI)*	*Beta (95%CI)*
Playing outside (min/day)	17.53 (-8.76; 43.83)	21.75 (-6.22; 49.72)	32.90 (-0.33; 66.14)
TV viewing (min/day)	5.88 (-11.41; 23.18)	6.81 (-12.06; 25.68)	2.25 (-21.33; 25.82)
Dichotomized	*OR (95%CI)*	*OR (95%CI)*	*OR (95%CI)*
Daily breakfast	1.18 (0.22; 6.23)	1.75 (0.25; 12.37)	3.49 (0.26; 47.09)
≤ 2 sweet beverages a day	1.63 (0.87; 3.06)	1.68 (0.84; 3.35)	**2.43 (1.04; 5.67)***
Outside play ≥ 1 hour a day	1.63 (0.70; 3.79)	2.78 (0.96; 8.00)	2.03 (0.61; 6.80)
TV viewing ≤ 2 hour a day	0.63 (0.32; 1.25)	0.50 (0.08; 0.44)	0.62 (0.25; 1.51)

Note: beta and OR with 95% Confidence Interval (CI) for children in intervention condition, selection based on number of additional sessions, compared to the children in the control condition (n=288). **Bold** printed numbers indicate a statistically significant beta or OR, asterisk indicates significance level: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Table S4 Evaluation of intervention effects based on the behavior discussed during the well-child visit

	Intervention condition (n)	**Control condition (n)**		
	Discussed/ available for analysis	**Total/ available for analysis**	**Odds Ratio (95%CI)[1]**	**Odds Ratio (95%CI)[2]**
Having breakfast (daily)	60/ 19	288/ 133	0.59 (0.09;4.06)	0.59 (0.09; 4.13)
Drinking sweet beverages (≤ 2 glasses a day)	134/ 46	288/ 125	1.79 (0.89; 3.61)	1.79 (0.88; 3.63)
Playing outside (≥ 1 hour a day)	104/ 37	288/ 121	1.18 (0.46; 2.73)	1.10 (0.44; 2.82)
Watching television (≤ 2 hours a day)	65/ 22	288/ 122	**0.34 (0.13; 0.92)***	**0.34 (0.13; 0.93)***

[1] Odds Ratio (95% Confidence Interval) for the intervention condition vs. control condition (reference) at follow-up from regression model unadjusted for cluster, corrected for time between measurements and age at baseline.

[2] Odds Ratio (95% Confidence Interval) for the intervention condition vs. control condition (reference) at follow-up from regression model adjusted for cluster, corrected for time between measurements and age at baseline.

Note: **bold** printed numbers indicate statistically significant behavior change between intervention and control condition, asterisk indicates significance level: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

4

Primary prevention of overweight in children and adolescents: a meta-analysis of the effectiveness of interventions aiming to decrease sedentary behavior

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ABSTRACT

Purpose

The objectives of this meta-analysis were to provide an overview of the evidence regarding the effects of interventions, implemented in the school- and general population setting, aiming to prevent excessive sedentary behavior in children and adolescents on (1) the amount of sedentary behavior and (2) BMI. Differences in effects on sedentary behavior and BMI between single health behavior interventions (sedentary behavior only) and multiple health behavior interventions were explored.

Methods

A literature search was conducted in PubMed, EMBASE, Web of Science, PsycINFO and Cochrane Database of Systematic Reviews. Thirty-four (R)CT studies evaluating 33 general population interventions, published between 1990 and April 2011, aiming to decrease sedentary behavior in normal-weight children or adolescents (0-18 years) were included. Intervention duration ranged from 7 days to 4 years. Mean change in sedentary behavior and BMI from baseline to post-intervention was calculated using a random effects model.

Results

Results showed significant decreases for the amount of sedentary behavior and BMI. For sedentary behavior the post-intervention mean difference was -17.95 min/day (95% CI -26.61 to -9.28); the change-from-baseline mean difference was -20.44 min/day (95% CI -30.69 to -10.20). For BMI the post-intervention mean difference was -0.25 kg/m^2 (95% CI -0.40 to -0.09); the change-from-baseline mean difference was -0.14 kg/m^2 (95% CI -0.23 to -0.05). No differences were found between single and multiple health behavior interventions.

Conclusion

Interventions in the school- and general population setting aiming to reduce only sedentary behavior and interventions targeting multiple health behaviors can result in significant decreases in sedentary behavior. Studies need to increase follow-up time to estimate the sustainability of the intervention effects found.

INTRODUCTION

The high prevalence of overweight and obesity among children and adolescents is of worldwide concern [1]. Obese children are more likely than normal-weight children to maintain a high body weight throughout their life making them more vulnerable to health problems in adulthood [2-3].

Studies have demonstrated the relationship between an increase in television viewing or screen time and weight gain [4-5]. Recently, Tremblay et al (2011) suggested that TV viewing of more than 2 hours a day is associated with reduced physical and psychosocial health [6]. Sedentary behavior may be associated with energy intake, for example through increased snacking during television viewing [4-5]. Also, sedentary behavior may be associated with energy expenditure by replacing more active pursuits such as playing outside [5, 7]. These associations provide rationale for the development of interventions to decrease sedentary behavior. Interventions performed in a general setting, for example the school setting, allow for a broad population to be reached, and may contribute to the prevention of overweight and obesity [5,8]. Previous reviews and meta-analyses did not distinguish between interventions that were developed to prevent excessive sedentary behavior in the general population setting, and interventions that were developed to decrease high levels of sedentary behavior as part of a treatment for overweight and obese children [6, 9-17]. It is important to evaluate interventions specific for the general population setting, to map the preventive effect these interventions may have on sedentary behavior and overweight prevention. This meta-analysis is the first to provide an overview of the evidence regarding the effects of interventions, implemented in the general population setting, aiming to prevent excessive sedentary behavior among children and adolescents (0-18 years).

The main study question was: can interventions aiming to prevent high levels of time spent in sedentary behaviors (e.g. television viewing, watching video/DVD), implemented in school- and general population settings, targeting children and adolescents, successfully reduce (1) the amount of sedentary behavior and (2) Body Mass Index (BMI). Additionally, we explored whether the effects on sedentary behavior and BMI of single health behavior interventions (sedentary behavior only) are similar to the effects of multiple health behavior interventions (e.g. interventions focusing on sedentary behavior, dietary intake and physical activity).

METHODS

Literature search

A literature search was conducted in PubMed, EMBASE, Web of Science, PsycINFO and Cochrane Database of Systematic Reviews in July 2010 using the following key terms: overweight, obesity, intervention, sedentary, television, video, games and children. The complete

PubMed search strategy can be found in the supplemental material (Table S1). The search strategy was adapted for each of the other databases. A search update was performed in March 2011. Included articles and relevant reviews were hand searched for additional eligible studies.

Inclusion criteria

In order to be included, the study had to be published in a peer-reviewed journal after 31 December 1989. Controlled trials with at least one intervention and one control or non-intervention group were included. The study had to detail an intervention, of any duration, that aimed to reduce the level of sedentary behavior in children or adolescents (age range 0-18 years). Studies were allowed to also target other behaviors, such as physical activity or dietary behaviors; these studies are referred to as multiple health behavior studies. These studies needed to explicitly state the intervention elements aimed at sedentary behavior. Finally, studies had to include a sedentary behavior outcome (TV viewing snacks during TV viewing) and/or a weight related outcome (e.g. BMI, BMI-z, percentage overweight children). Sedentary behavior included screen time activities and behaviors such as listening to music, reading, 'sitting around doing nothing' or talking on the phone. Screen time activities included watching television, DVD/ video/ HDD viewing, electronic gaming (e.g. game console), computer activities (e.g. internet, gaming) and small screen activities (e.g. PDA, Smartphone).

Exclusion criteria

Studies performed in laboratory settings, studies with a pre-post test design, studies without a control group, and cohort studies were excluded. We excluded studies aiming at high-risk populations, defined as children or adolescents being overweight or obese. Studies comparing normal-weight children and overweight or obese children were included when the results for the normal-weight group were described separately.

All studies without sedentary behavior elements in their intervention (e.g. information regarding the influence of advertising or replacement activities for TV-viewing) were excluded. In accordance, studies were excluded when they only targeted physical activity and sedentary behavior was solely included as an additional outcome.

Selection process

Titles and abstracts were reviewed independently by two authors (AG and NE) to identify relevant intervention studies. Relevant review articles were identified and reference lists (bibliographies) were screened for additional intervention studies by one author (AG) [18-22]. Authors of relevant design papers were contacted with a request to provide effect papers where available (AG). All studies identified based on the title and abstract were reviewed by both authors (AG and NE) for inclusion and disagreements were discussed with a third party (HR) until consensus was achieved.

Quality assessment

The Cochrane Collaboration tool for Assessing Risk of Bias was used to assess the quality of the selected studies [23]. For each study seven domains were scored with high, low or unclear risk for bias: sequence generation, allocation concealment, blinding of participants and personnel, blinding of outcome assessment, incomplete outcome data, selective outcome reporting and 'other' issues (similarity in baseline characteristics and timing of outcome assessment). These seven domains assess the level of risk regarding selection bias, allocation bias, performance bias, detection bias, attrition bias, reporting bias and other bias. The quality assessment was performed independently by two authors (AG and NE) and the findings were compared and discussed until consensus was achieved.

Statistical analysis

Study outcomes were quantitatively compared using Review Manager software [24]. Overall mean differences were estimated for the effects of all included interventions. To graph these effect sizes, forest plots were created for study outcomes on (1) sedentary behavior (minutes per day) and (2) BMI (kg/m^2). Separate forest plots were created for (1) post-intervention results of intervention and control group (mean, SD) and (2) post-intervention change-from-baseline difference between intervention and control group (mean, SD). The post-intervention results were used, instead of latest follow-up measurement, for the mean difference estimates to achieve comparable results. Forest plots display the mean and the variance around the mean for each study, and provide a combined estimate with variance of the overall intervention effect.

With regard to sedentary behavior, 22 studies were included in the post-intervention mean difference estimate and 18 studies were included in the post-intervention change-from-baseline mean difference estimate. For BMI scores, 14 studies were included for the post-intervention mean difference estimate and 14 studies were included for the post-intervention change-from-baseline mean difference estimate. The number of studies included in the above mentioned estimates differed due to study data availability. For example, post-intervention results of a study were given for BMI-z scores only; this study could not be included in the analysis to calculate the overall BMI estimate. Also, a study reporting, for example, post-intervention results only, could not be included in the change-from-baseline analysis.

In addition to the overall mean difference estimate, mean difference estimates for single health behavior interventions (sedentary behavior) and multiple health behavior interventions can be found in each forest plot. These analyses were performed to investigate whether there is a stronger effect of interventions solely focusing on decreasing sedentary behavior versus interventions combining different health behaviors; previous research has suggested no difference in the effectiveness [25]. Age group (<12 years, 12-18 years) and intervention setting (school setting, home/family setting or combination of settings) were evaluated as potential moderators of the overall intervention effect estimates with post-hoc analyses.

The Cochrane Handbook (version 5.0) was used for guidance regarding missing data and combining data [26]. Available t and p values were used to recalculate missing standard errors. When change-from-baseline data was reported, post-intervention estimates could be calculated. The standard deviation of the baseline estimate was adopted for the follow-up estimate.

Studies with multiple intervention arms were included. The outcomes in each intervention arm were summed and averaged according to the number of participants in each arm. Following guidelines, separately reported results for boys and girls were combined. Child self-report on sedentary behavior was used whenever both the parent report and child self-report were available. This was done because the majority of the studies used child self-reports.

For sedentary behavior, some additional calculations were performed. Most studies reported an overall measure for sedentary behavior. For the few studies that reported on distinct sedentary behaviors, the total post-intervention effects were calculated by summing all distinct estimates. In a similar manner the change-from-baseline result was achieved. To estimate the overall sedentary behavior change-from-baseline standard error, the coefficient of variation (standard error of the mean divided by the mean) was calculated for every distinct sedentary behavior change-from-baseline result. When the coefficients of variation of the distinct sedentary behavior measures differed by less than 0.5, the mean coefficient of variation was estimated and used to calculate the standard error for the overall sedentary behavior change-from-baseline result. Television viewing was chosen to represent sedentary behavior when the difference between the coefficients of variation of the distinct sedentary behaviors was larger than 0.5.

If studies only reported one sedentary behavior (for example TV viewing), this was taken as the sedentary behavior outcome in the analysis (details on the reported outcomes can be found in supplemental material Table S2).

Heterogeneity

Random effects were estimated, assuming additional variance beyond the set of studies. Estimation of random effects allows for the results to be generalized. The fixed-effect forest plots are available as supplemental material (Supplemental material Figure 1, 2, 3 and 4). Heterogeneity statistics are provided in the forest plots (I^2) and can be interpreted as low (25%), moderate (50%) and high (75%) variance between studies [27].

RESULTS

Search results

Figure 1 presents the literature search flowchart using the Preferred Reporting Items for Systematic reviews and Meta-Analyses format [28]. The search revealed 3069 articles. Thirty-

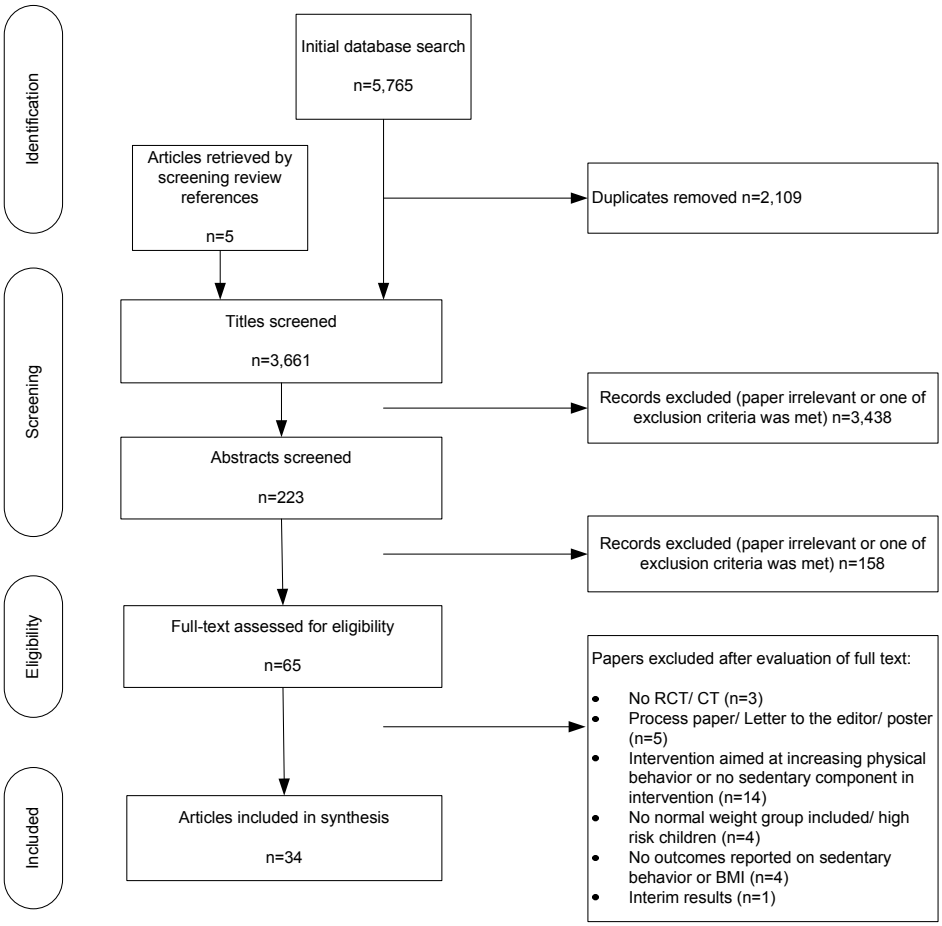

Figure 1 Study selection process

four studies reporting 33 different interventions met the inclusion criteria. Four controlled trials [29-32] and 30 randomized controlled trials [33-62] were included. Supplemental material Table S2 provides a summary of the general characteristics of each study included.

Quality assessment

Figure 2 shows the results of the quality assessment. Sequence generation of the randomization procedure was adequately reported in 13 studies. Nine studies reported adequate allocation in concealment. However, given the nature of the studies, not reporting allocation concealment does not necessarily mean a study bias. Eight studies reported blinding of the outcome assessor. Dropout rates were reported and rated acceptable in 29 studies. Thirteen studies reported on possible baseline differences between intervention and control groups.

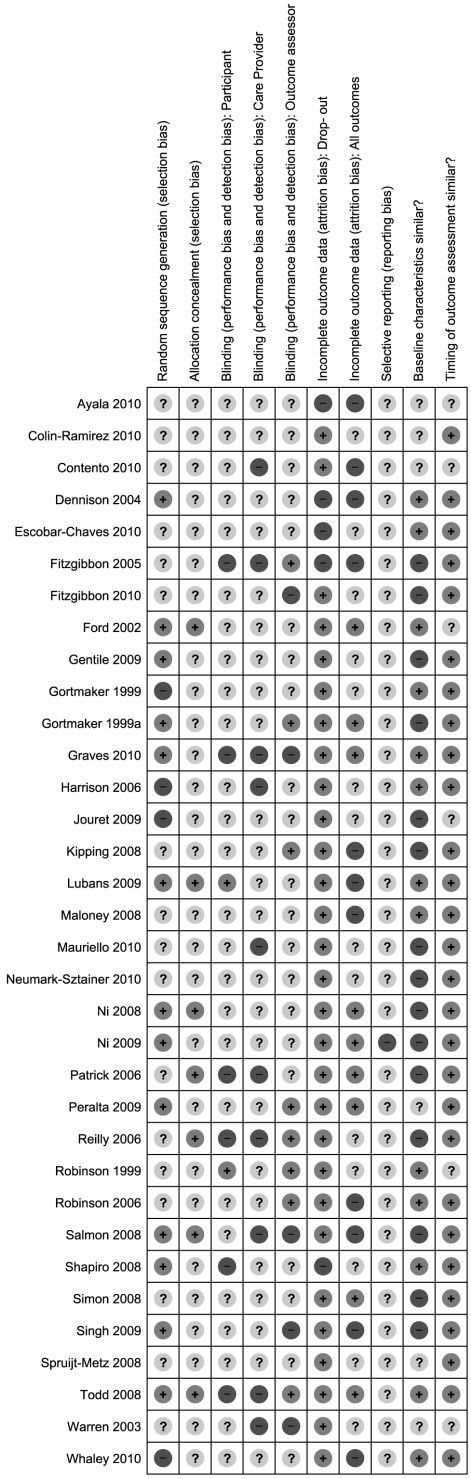

Figure 2 Risk of bias summary

Sedentary behavior outcomes

Of the 34 included studies, 13 reported a statistically significant effect of the intervention on sedentary behavior [34, 37-38, 41-42, 48-49, 51, 53-55, 57-58].

The random effects model showed a post-intervention mean difference of -17.95 minutes of sedentary behavior per day in favor of the intervention group (95% Confidence Interval (CI) -26.61 to -9.28, Figure 3) (standardized mean difference -0.14, 95% CI -0.21 to -0.08). Post-intervention change-from-baseline mean difference was -20.44 minutes of sedentary behavior per day (95% CI -30.69 to -10.20) for the intervention group compared with the control group (Figure 4). There were no significant differences in effects on sedentary behavior between single and multiple health behavior interventions. No moderating effects of age or intervention setting were observed for sedentary behavior (p> 0.10).

BMI outcomes

Overall, 6 of the 34 included studies reported a significant effect of the intervention on BMI (kg/m^2) or BMI-z score [40, 44, 53, 55, 57-58].

The random effects model showed a post-intervention BMI mean difference of -0.25 kg/m^2 (95% CI -0.40 to -0.09) in favor of the intervention group (Figure 5) (standardized mean

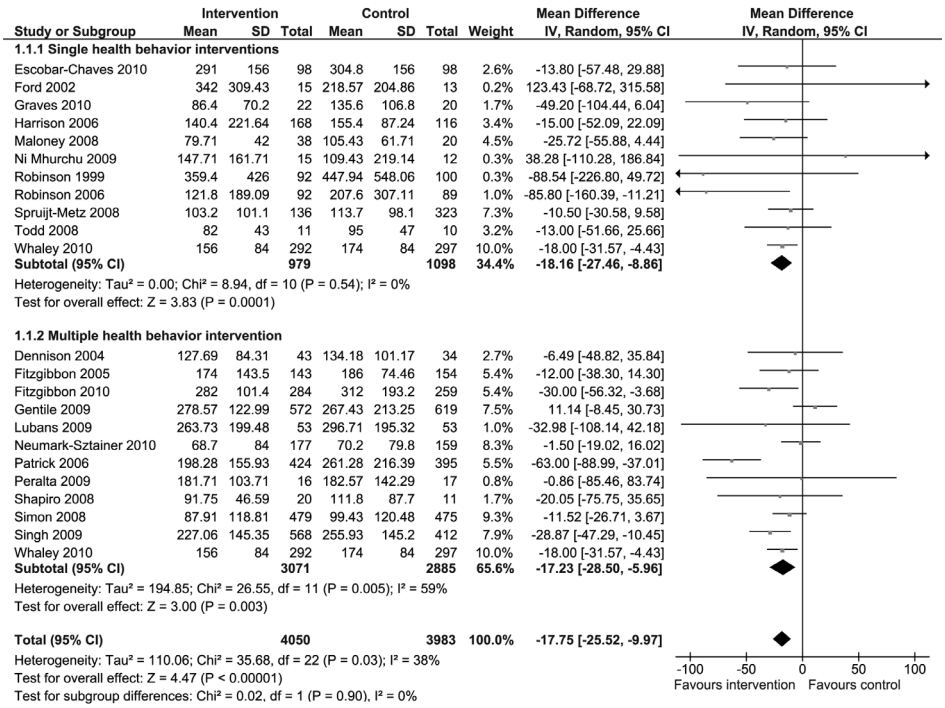

Figure 3 Forest plot, random effects model, comparing intervention and control group on post-intervention sedentary behavior (minutes per day)

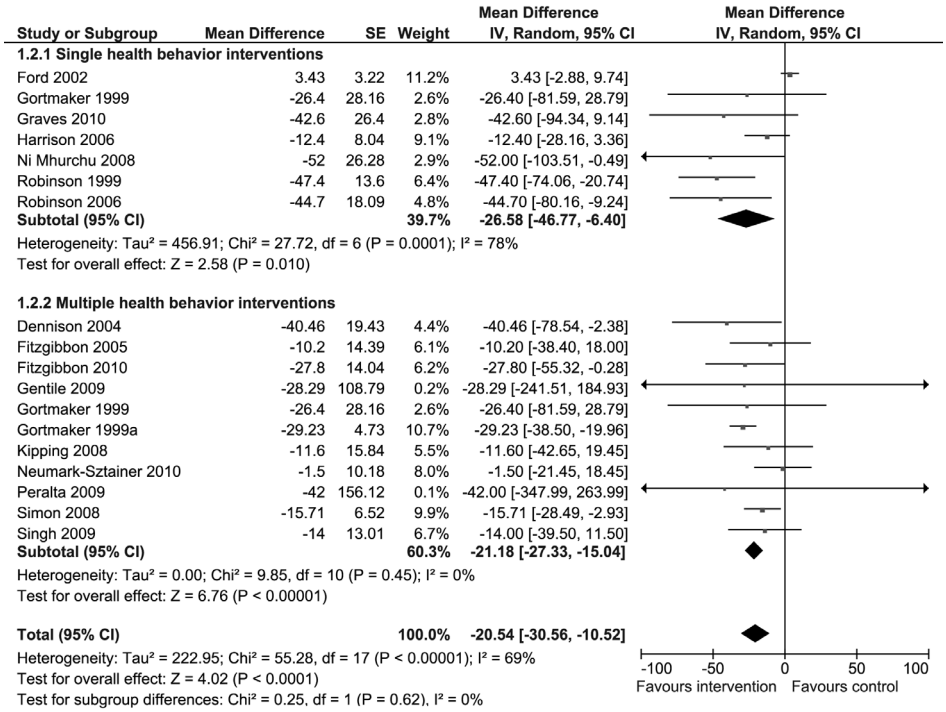

Figure 4 Forest plot, random effects model, comparing intervention and control group on post-intervention change-from-baseline sedentary behavior (minutes per day)

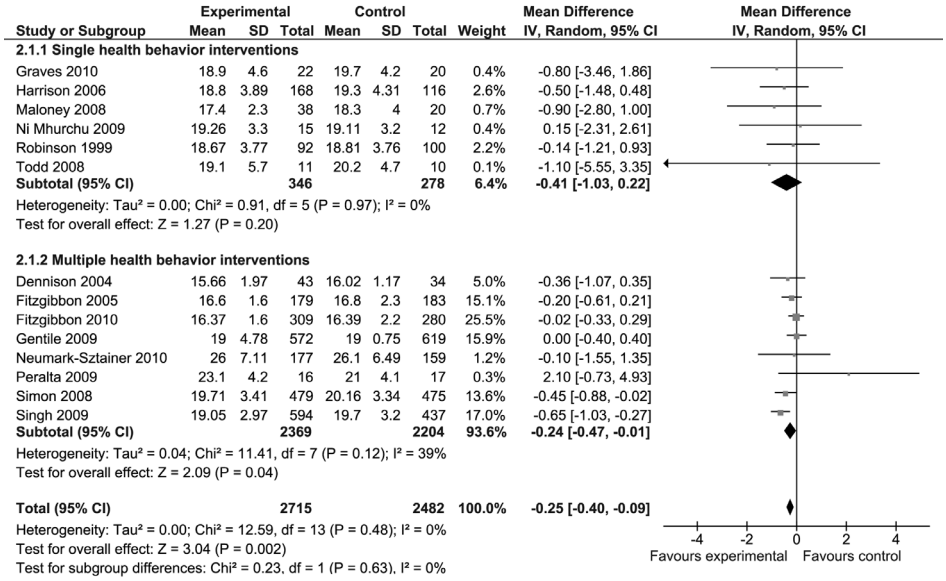

Figure 5 Forest plot, random effects model, comparing intervention group and controlgroup on post-intervention BMI (kg/m^2)

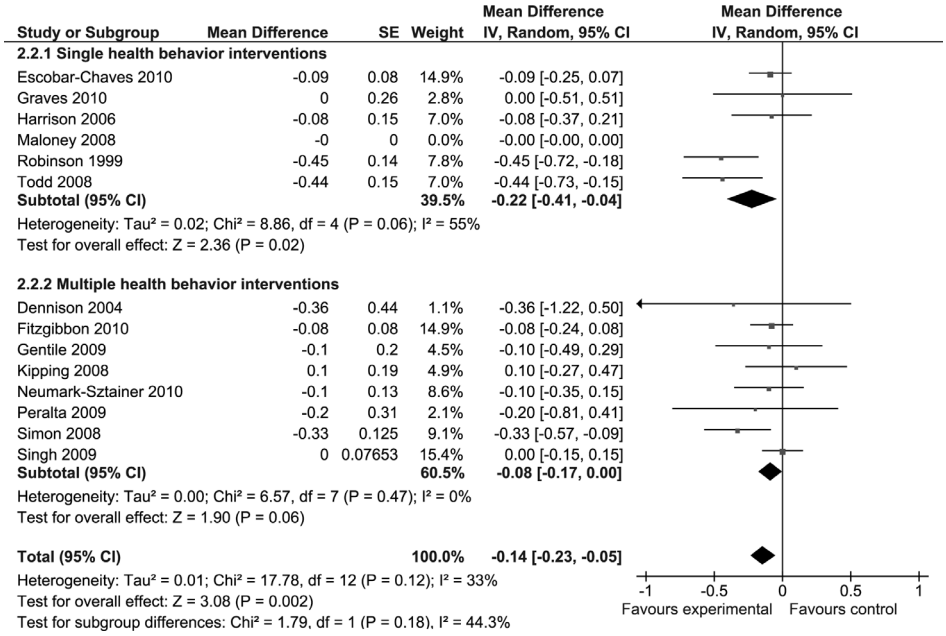

Figure 6 Forest plot, random effects model, comparing intervention and control group on post-intervention change-from-baseline BMI (kg/m^2)

difference -0.09, 95% CI -0.14 to -0.03). The post-intervention change-from-baseline mean difference was -0.14 kg/m^2 (95% CI -0.23 to -0.05) in favor of the intervention group (Figure 6). There were no significant differences in effects on BMI between single and multiple health behavior interventions. No moderating effects of age or intervention setting were observed for BMI (p> 0.10).

DISCUSSION

This meta-analysis is the first to quantitatively compare 34 studies evaluating interventions that were developed to prevent excessive sedentary behavior (e.g. television viewing, video/DVD viewing) in general population settings among children and adolescents. The results of this meta-analysis show that the interventions aiming to prevent excessive sedentary behavior may contribute to the prevention of overweight; a significant overall decrease in sedentary behavior as well as a significant decrease in BMI was found.

Previous reviews and meta-analyses have been published on this topic [6, 9-17]. The current meta-analysis is the first to examine the effects of intervention aiming to prevent excessive sedentary behavior in the general population setting. Sedentary behavior is increasing across the entire population and prevention of excessive sedentary behavior is warranted [63-64]. The

association between sedentary behavior and overweight [6] supports the relevance of targeting children and adolescents independent of their current weight status or current amount of TV viewing. Our results showed that efforts, to target the broad child- and adolescent population in decreasing their sedentary behavior, are successful. The results suggest that in order to improve a healthy weight among children and adolescents, aiming to prevent excessive sedentary behavior in the general population, e.g. school settings, may be part of an effective approach.

Our study did not show significant differences in the effects on sedentary behavior or BMI between single health behavior interventions and multiple health behavior interventions. This finding is in line with previous research by Krebs et al [25]. But, studies evaluating an intervention specifically designed to prevent high levels of sedentary behavior could achieve changes in other health behaviors. Effects on other health behaviors were not measured in most studies.

The overall effect estimates of both sedentary behavior and BMI were not moderated by setting of the intervention and the age of the children targeted with the intervention were not significant moderators of the overall effect estimates we found of both sedentary behavior and BMI. The majority of the interventions was aimed at children below 12 years of age and was performed in the school setting. In the school setting, sedentary behavior was generally targeted with individual level interventions such as counseling or tailored feedback. Parents were often involved by means of a newsletter or sometimes by means of more intensive workshops or information meetings. Another approach, although used less frequently, was the home-based intervention. Todd et al [30] found significant results for an intervention targeting both the child's and the family's level of sedentary behavior. These results imply that family members might also benefit from the intervention. Elements from interventions implemented at home included television manager devices. This intervention element can be relatively easily implemented and offered to the parents, and help limit opportunities to be sedentary.

The quality of the studies reporting the interventions varied. The information needed to evaluate risk of bias, was missing in many studies. In almost all studies random allocation of participants was reported, however, the procedures used were not always clearly described. Regarding the blinding of participants, providers and outcome assessors, it should be recognized that the type of research performed within the included studies does not always allow for blinding. Dropout rates were mostly acceptable and well described. Some studies reported being pilot studies and, therefore, reported results on very small samples. This might have added to the differences between groups on baseline characteristics that were reported in some of the studies. For this reason, reporting both unadjusted and adjusted results adds to the quality of the studies.

Suggestions for future research

Some suggestions for future research should be made. To explore effective intervention elements for the reduction of sedentary behavior or BMI, studies need to provide details on the intervention and the types of outcome measures taken. A clear description of the intervention should include the health behaviors targeted and the alternatives provided for sedentary behavior. Owen et al [65] has shown that an effect on health outcomes might already be achieved through replacing sedentary activity with light physical activity. Healy et al [66] found positive effects on health outcomes by increasing the number of breaks during sedentary behavior. When studies include outcomes measures, such as physical activity levels and dietary intake in addition to sedentary behavior or BMI, relevant changes in physical activity and other health-related behaviors can be studied in relation to sedentary behavior.

To improve the understanding of the relationship between sedentary behaviors and weight-related outcomes, mediation analyses of interventions studies can be used. In these analyses the indirect role of sedentary behavior in the direct relationship between the effect of the intervention and the weight-related outcome is studied.

A drawback of the studies included in this meta-analysis was the short follow-up time in some studies. In our meta-analysis, comparisons were made based on post-intervention results: these post-intervention results were based on measurements taken directly after the intervention or, in some cases, three months after the intervention. The effects found on sedentary behavior and BMI may alter when longer follow-up results are available for comparison. Based on the studies included in this meta-analysis, providing an estimation of the sustainability of the effects found is therefore difficult.

Our search strategy included terms representing different types of sedentary behavior, in the included studies the most often targeted behavior was either TV viewing or screen time (DVD/ video viewing and TV viewing). Recently, Salmon et al [14] reported that based on objective measures of activity, only one third of the total sedentary time consists of TV viewing [14]. However, intervention elements to decrease specifically TV viewing may result in more positive effects on health outcomes: increases in TV-time have been significantly associated with several negative health outcomes [5-6].

Considering the weight-related outcome, our study compared outcomes on BMI: BMI-z scores could have provided a more standardized estimate; however, few studies report these scores.

Methodological considerations

A major strength of this paper is that we could include many studies and were able to estimate an effect based on all interventions combined. Moreover, we reported both adjusted mean differences, taking into account baseline differences, and unadjusted mean differences. In addition, we selected studies performed in school- and general population samples to be able to estimate the effect of interventions aiming to decrease sedentary behavior for the primary prevention of overweight.

As this meta-analysis is based on published literature, there is a possibility that there is an overrepresentation of effective studies. We did not try to identify unpublished studies. Moreover, the studies included in this meta-analysis reported several distinct types of sedentary behavior (e.g. computer, television, video). In order to make comparisons, various types of sedentary behavior were taken together making the effects on unique sedentary behaviors indistinguishable. Therefore, no indication on whether interventions, for example, aiming to reduce computer time are more effective compared to interventions aiming to reduce television-time.

Conclusion

To summarize, the results of this meta-analysis show that both interventions aiming to prevent excessive sedentary behavior only and interventions targeting multiple health behaviors in the general population setting, can result in significant decreases in sedentary behavior and BMI in children and adolescents.

The results indicate that interventions performed in school- and general population settings can help prevent excessive sedentary behavior and therefore unfavorable health outcomes, among children and adolescents. The intervention can focus on more than one health behavior and can have a positive effect on sedentary behavior. Alternatively, interventions can target sedentary behavior and have relatively small, but positive effects on BMI. Future research should focus on discovering which of the intervention elements, or which combination of elements, is most effective in preventing increases in sedentary behavior and BMI. Well-designed intervention studies providing details on targeted behaviors and including relevant health-behavior outcomes with long follow-up are necessary.

This meta-analysis highlights that there are many interventions available to help prevent excessive sedentary behavior among children and adolescents in a general population setting.

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SUPPLEMENTAL MATERIAL

Table S1 Search strategy PubMed

Database	Search strategy
Pubmed	(overweight(mesh) OR overweigh*(tw) OR adipos*(tw) OR obes*(tw) OR weight gain*(tw) OR weight chang*(tw) OR weight excess*(tw) OR ((body weight*(tw) OR body mass*(tw) OR bmi(tw)) AND (toddler*(tw) OR child*(tw) OR infan*(tw) OR pediatr*(tw) OR paediatr*(tw) OR adolesc*(tw)) AND (prevent*(tw) OR intervent*(tw)) AND (play and playthings(mesh) OR screen (tw) OR computer*(tw) OR game(tw) OR games(tw) OR gaming*(tw) OR TV(tw) OR television*(tw) OR sedent*(tw) OR sitting(tw) OR reading(tw) OR lazy(tw) OR laying(tw))

Table S2 General characteristics of included studies

Study	Methods	Participants	Intervention	Duration intervention/ follow-up	Outcome measures of interest	
					Sedentary behavior[1]	Anthropometric
Ayala et al (2010)	RCT Country: USA	N (control)=227 N (intervention)= IG1 n=200 IG2 n=165 IG3 n=214 Mean age (years): NR (Median 6) Sex: 51% male Race: 71% Latino Lost to follow-up: 48%	Multi-behavior study/intervention Intervention group: home-based, family-based & school-based intervention. IG1 MICRO: Each participating family was assigned a *promotera* who visited the home over a 7-month period. A newsletter was reviewed each visit and other material was provided. The parent was guided in setting goals for the next month to improve family lifestyle. The newsletters covered themes such as access and availability to healthy options, increasing FV intake, decreasing TV viewing & increasing active play. Environmental changes included physical changes such as moving a TV out of a child's bedroom and setting rules and boundaries. After the home visit period, four booster sessions were delivered. Booster calls were made three times. IG2: MACRO; school and community physical environment changes (e.g. child menus in local restaurants). IG3: MICRO + MACRO. Control group: no intervention.	Duration: 7 months Follow-up: >12 months post-intervention	TV during dinner[1]	NR
Colín-Ramírez (2010)	RCT Country: Mexico	N (control)=253 N (intervention)=245 Mean age (years): 9.4 Sex: 51.1% male Race: NR Lost to follow-up: study based on complete follow-up measurements (n=121 lost to follow-up)	Multi-behavior study/intervention Intervention group: school-based & family-based intervention. Individual level: classroom lessons and exercise breaks. Weekly 30-min lessons for 20 weeks. Exercise breaks were 2-10 min. School level: physical education class; regular exercise for 30 min twice a week (moderate to vigorous energy output). Family level: family members to support and reinforce; book with physical exercises to take home. Parents received recommendations for a more active lifestyle, including reducing SB. Control group: normal curriculum, no intervention.	Duration: 12 months Follow-up: post-intervention	SST (TV; video; computer)[2]	NR
Contento et al (2010)	RCT Country: USA	N (control)=574 N (intervention)=562 Mean age (years): 12 Sex: 51% male Race: 70% Latino Lost to follow-up: 22.8%	Multi-behavior study/intervention Intervention group: school-based intervention. Twenty-four 45-min lessons during 8-10 weeks, some lessons spanned multiple days resulting in about 33 sessions per class. Curriculum addressed selected national science standards in different topics. Activities were performed aimed at taking action. Teachers received a 3-hour pre-intervention session and one session in the middle of the intervention. Teachers were supported by research staff members and received curriculum materials. Control group: normal curriculum.	Duration: 8-10 weeks Follow-up: post-intervention	SST (leisure screen time) [2]	NR
Dennison et al (2004)	RCT Country: USA	N (control)=34 N (intervention)= 43 Mean age (years): 3.9 Sex: 19% male Race: NR Lost to follow-up: 7.4%	Multi-behavior study/ intervention Intervention group: parent-based & school-based intervention. 1-hour session each week, 39 weeks with the parents. Half of the session was musical, 10 min. was spent eating a snack and 20 min. was spent participating in an interactive educational session. Seven sessions were on reducing TV viewing.	Duration: 7/ 39 weeks Follow-up: post-intervention	TV[1]/ Video Gaming[1]/ Other[1]	BMI[5]/ BMI-z[b]/ Body Fat[7]

Table S2 (*continued*)

Study	Methods	Participants	Intervention	Duration intervention/ follow-up	Outcome measures of interest	
					Sedentary behavior[1]	Anthropometric
			The seven lessons aimed at: turn off of the TV, more family mealtime, identifying alternative activities and having discussions. Control group: safety and injury prevention intervention.			
Escobar-Chaves et al (2010)	RCT Country: USA	N (control)=101 N (intervention)=101 Mean age (years): 18.2 Sex: 51.5% male Race: 43.6% White Lost to follow-up: 3%	Single-behavior study/intervention Intervention group: school-based & family-based intervention. Aims: reduce TV watching, turn of TV when nobody is watching, no TV during meals, no TV in child's bedroom and to engage in fun non-media related activities. Workshops with e.g.: puppet show, interactive discussion, sharing experiences about family routines, communication skills & alternative activities. At the end (of what?) a fun family plan was made where they (who?) negotiated on child activities and family activities to do as alternative. Newsletters (6 bimonthly). Control group: no intervention.	Duration: one workshop and 6 bimonthly newsletters Follow-up: approx. 3 months post-intervention	SST[1]/ TV[1]/ Video[1]/ Video Games[1]/ Computer[1]/ Handheld[1]/ Other[1]	NR
Fitzgibbon et al (2005)	RCT Country: USA	N (control)=212 N (intervention)=197 Mean age (years): 4.2 Sex: 50% male Race: 89.9% African American Lost to follow-up: 26.7%	Multi-behavior study/intervention Intervention group: school-based & parent-based intervention. 40-min lesson three times a week. Each week covered a particular topic and included two major components: (1) 20 min. introducing a healthy eating or exercise concept with an activity. In week 10 the topic 'instead of TV. . .' was discussed. Puppets were used to represent food groups and educate children. (2) 20 min. of ongoing PA. PA included games, e.g. an aerobic trip to the zoo. Parents received weekly newsletters with a homework assignment. Parents received a $5 grocery store coupon for each completed homework assignment. Homework/newsletters mirrored children's program. Control group: Weekly curriculum about different health topics for 14 weeks. Topics included seatbelt use and dental care. Parents received a newsletter but did not have to return homework assignments.	Duration: 14 weeks Follow-up: 12 months, 24 months post-intervention,	TV[1]	BMI[5]/ BMI-z[b]
Fltzgibbon et al (2010)	RCT Country: USA	N (control)=323 N (intervention)=346 Mean age (years): 4.3 Sex: 48% male Race: 94% African American Lost to follow-up: 7.6%	Multi-behavior study/intervention Similar to Fitzgibbon et al (2005); school-based & parent-based intervention. Intervention group: Lessons 2-3 times a week for 14 weeks, curriculum. Control group: Weekly curriculum about different health topics for 14 weeks. Topics included seatbelt use and dental care. Parents received a newsletter but did not have to return homework assignments.	Duration: 14 weeks Follow-up: post-intervention	SST[1]/ TV[1]	BMI[5]/ BMI-z[b]
Ford et al (2002)	RCT Country: USA	N (control)=13 N (intervention)=15 Mean age (years): 9.5 Sex: 47% male Race: African American Lost to follow-up: 10.7%	Single-behavior study/intervention Intervention group: primary care & parent-based intervention. A brief 5-10 min. counseling intervention based on discussion of potential problems associated with excessive media use and three brochures were given. 15-20 min. discussion about setting television viewing budgets. And parents received a brochure with steps to reduce child's TV- watching with a budget.	Duration: 5-10 minutes basic counseling +15-20 minutes extra discussion Follow-up: 4 weeks post-intervention	SST (TV; video; video games)/ other[1,2]	NR

Table S2 (*continued*)

Study	Methods	Participants	Intervention	Duration intervention/ follow-up	Outcome measures of interest	
					Sedentary behavior[1]	Anthropometric
			Parents also received an electronic TV time manager to monitor and budget TV time. Control group: brief 5-10 minutes counseling intervention similar to intervention group.			
Gentile et al (2009)	RCT Country: USA	N (control)=653 N (intervention)=670 Mean age (years): 9.6 Sex: 47% male Race: 90% White Lost to follow-up: 25.1%	Multi-behavior study/intervention Intervention group: community-based intervention. Several levels: (1) Increasing community awareness and knowledge on preventing childhood obesity. Components included launching project with an event, advertisement campaign, posters, printed materials & public education training/workshops for parents & teachers. (2) School. Teachers received materials and ideas on how to include the core concepts into existing curriculum-> switch was not school based; teachers had to decide themselves what to use. (3) Family. Self-identified goals were rewarded, activities included making a healthy fruit recipe & utilizing the screen time box to track time spent in front of screen (TV, video game, computer). Control group: normal situation.	Duration: 8 months Follow-up: 6 months post-intervention	SST (TV; video; computer games)[4]	BMI[5, c]
Gortmaker et al (1999a) (EWKM)	CT Country: USA	N (control)=289 N (intervention)=190 Mean age (years): 9.2 Sex: 44% male Race: 91% African American Lost to follow-up: 15%	Multi-behavior study/intervention Intervention group: school-based intervention. Materials were developed to fit in existing curricula. Four behavioral change goals: decreasing intake of foods high in fat, increasing FV intake, reducing TV to <2 hrs/day, increasing moderate and vigorous PA. Lessons on different health subjects. Cards introduced students to new foods and school lunches included these foods. Classroom campaigns were based on reducing TV time, promoting FV and increasing walking (including the family as well). Newspapers based on the lesson content were sent to parents. Control Group: no intervention, normal curriculum.	Duration: 2 years Follow-up: post-intervention	TV[2]	NR
Gortmaker et al (1999)	RCT Country: USA	N (control)=654 N (intervention)=641 Mean age (years): 11.7 Sex: 52% male Race: 69% White Lost to follow-up: 18.5%	Multi-behavior study/intervention Intervention group: school-based intervention. 16 lessons each year, each lesson had one major subject (specific content unclear in paper). Additionally one lesson was a 2-week 'reduce TV-watching' campaign. Classroom lessons were one or two 45-min. periods in duration. Physical Education lesson materials focused on activity and inactivity themes, student self assessment, goal setting and reducing or replacing inactivity. These lessons were thirty 5-min micro-units in duration. Fitness funds were monetary incentives of $400-$500 provided to IG schools in response to teacher submitted proposals. Control group: normal curriculum.	Duration: 2 years Follow-up: post-intervention	TV[2]	BMI[5]/Skinfolds[7]/ %Overweight [d]
Graves et al (2010)	RCT Country: UK	N (control)=29 N (intervention)=29	Single-behavior study/intervention Intervention group: home-based intervention. Families received a package with instructions to use active video game playing and to encouraging play in a step-powered manner. Control group: normal video game playing.	Duration: 12 weeks (use of device) Follow-up: post-intervention	SST (TV; computer; video; games; reading; doing homework)[2]	BMI[5]/ Body fat[7]

Table S2 (*continued*)

Study	Methods	Participants	Intervention	Duration intervention/ follow-up	Outcome measures of interest	
					Sedentary behavior[1]	Anthropometric
Harrison et al (2006)	CT Country: Ireland	N (control)=130 N (intervention)=182 Mean age (years): 10.2 Sex: 57% male Race: NR Lost to follow-up: 9%	Single-behavior study/intervention Intervention group: school-based intervention. Ten 30-min. lessons. Two messages: decrease time spent watching TV and playing computer games and increase PA. Topics: reflecting on spending leisure time and challenging the children to identify realistic alternatives to TV viewing and computer gaming. Self-monitoring, budgeting and goal setting were practiced. Children could receive points. Diaries were part of homework and parents had to sign diary entries. IG schools were visited every two weeks to offer the teachers support. Parents were encouraged in writing to support children. Control group: continued normal curriculum.	Duration: 16 weeks Follow-up: post-intervention	SST (TV; video; computer games)[2]	BMI[5, c]
Jouret et al (2009)	RCT Country: France	N (control)=410 N (intervention)= IG1 n=750 IG2 n=1030 Mean age (years): 3.8 Sex: 49% male Race: NR Lost to follow-up: 30%	Multi-behavior study/intervention Intervention group: primary care based intervention. Parents were requested to provide child's medical records and general practitioner's information. Children had a medical examination; BMI was determined, parents of at risk children (75-90th BMI percentile) or of overweight children (>90th BMI percentile) were sent a letter to go to the general practitioner (GP). GP provided follow-up care. GP received training in obesity prevention. Reinforcement strategy for parents: Education program, ten 20-min. sessions (5x per year) with learning activities and games about knowledge of food(groups) and health, breakfast, water, sugar, PA & reducing sedentary behavior. Audiocassette and books reinforced these messages at home. All parents received information on nutrition, PA & obesity in relation to health and well-being. Control group: no intervention.	Duration: 2 years Follow-up: post-intervention	NR	% Overweight[a]/ BMI[5]/BMI-z[a]
Kipping et al (2008)	RCT Country: UK	N (control)=348 N (intervention)=331 Mean age (years): 9.4 Sex: 47.9% male Race: NR Lost to follow-up: screen time 52.5%	Multi-behavior study/ intervention Intervention group: school-based intervention. Sixteen lessons on healthy eating, increasing PA and reducing TV viewing were taught over 5 months. There were nine lessons on PA, six lessons on nutrition and one lesson on screen viewing. In the PA lessons, children played food-group based games using photos of food. The games reinforced theory from nutrition lessons. The specific TV lesson was about analyzing leisure time to identify time spent watching TV and create a list of alternative activities. Teacher materials included lesson plans. Control group: normal curriculum.	Duration: 16 lessons over 16 weeks. Follow-up: post-intervention	SST (TV; video; computer games)[2]	BMI[5]/ % Overweight[a]
Lubans et al (2009)	RCT Country: Australia	N (control)=66 N (intervention)=58 Mean age (years): 14.1 Sex: 43% male Race: 94.4% born in Australia Lost to follow-up: 14.6%	Multi-behavior study/intervention Intervention group: school-based intervention with five major components: (1) enhanced school sports program focusing on lifetime physical activities (10 weekly activities e.g. aerobics), (2) information sessions and interactive lecture on PA and healthy diet (at start of each PA session, (3) pedometers,	Duration: 10 weeks Follow-up: 2 months post-intervention	TV[2] Electronic games[2]	NR

Table S2 (*continued*)

Study	Methods	Participants	Intervention	Duration intervention/ follow-up	Outcome measures of interest	
					Sedentary behavior[1]	Anthropometric
			(4) PA and nutrition handbook for participants signed by parents and monthly information for parents & 5) social support. A lecture summarizing the 10 messages was given at the end of the program. Control group: 10-week school sport program.			
Maloney et al (2008)	RCT Country: USA	N (control)=20 N (intervention)=40 Mean age (years): 7.5 Sex: 50% male Race: 75% White Lost to follow-up: 10%	Single-behavior study/intervention Intervention group: home-based intervention. Equipment for using the Dance Dance Revolution (DDR) was provided to all families and two mats were provided to encourage social and competitive play in the family home. Four sessions were recommended per week for a total of 120 min. per week. Half of the DDR group received five 30-min. one-on-one coaching sessions to see whether coaching encouraged more social and competitive play. Control group: did not play any DDR (received DDR after intervention).	Duration: 10 weeks Follow-up: 4.5 months post-intervention	SST (Various activities)[1,2]	BMI[5]/ BMI-z[9]
Mauriello et al (2010)	RCT Country: USA	N (control)=1128 N (intervention)=672 Mean age (years): 15.9 Sex: 49% male Lost to follow-up: 34.3%	Multi-behavior study/intervention Intervention group: individual-based intervention. Students answered questions via a 30-minute interactive media-program. Stage-matched tailored feedback was then given on physical activity, fruit & vegetable consumption and TV viewing. Multi media was used and included animations, audio and video. Control group: no intervention.	Duration: 2 months Follow-up: 6 months, 12 months post-intervention	TV[2]	Height[2]/ weight[2]/BMI[2]/ %Overweight[2,b]
Neumark-Sztainer et al (2010)	RCT Country: USA	N (control)=174 N (intervention)=182 Mean age (years): 15.8 Sex: 0% male Lost to follow-up: 6%	Multi-behavior study/intervention Intervention group: school-based intervention with eight behavioral objectives throughout the program; more PA; limit SB, increase FV; limit SSB; eat breakfast; decrease portion size and listen to body for signs of hunger; avoid unhealthy weight control behaviors & focus on positive traits. Program consisted of a (16 week) physical education class, individual counseling sessions with motivational interviewing; lunch get together; and minimal parent outreach activities. Control group: no intervention.	Duration: 9 months Follow-up: post-intervention	SST[2]/ TV[2]	BMI[5]/ %Overweight[5,b]/ Body fat[7]
Ni Mhurchu et al (2008)	RCT Country: New Zealand	N (control)=10 N (intervention)=10 Mean age (years): 12 Sex: 60% male Race: NR Lost to follow-up: 0%	Single-behavior study/intervention Intervention group: home-based intervention. Participants received a package consisting of the EyeToy camera, EyeToy active games and a dance mat. Instruction was to replace usual non-active gaming with active video games (as provided). Control group: normal situation, no equipment provided.	Duration: 12 weeks Follow-up: post-intervention	Video[3,1,2]/ video gaming[3, 1, 2]	% Overweight[5,c]/ BMI[5]/ Waist circumference[5]
Ni Mhurchu (2009)	RCT Country: New Zealand	N (control)=14 N (intervention)=15 Mean age (years): 10.4 Sex: 62% male Race: 65% European Lost to follow-up: 7%	Single-behavior study/intervention Intervention group: home-based intervention. Participants were provided with TV time monitors to reduce access to the TV. Tokens were inserted which activated the TV for 30 min. Parents could also block certain programs.	Duration: 1 group meeting & 6 weeks of TV device usage	SST (Various activities)[2]/ TV[2]	BMI[5]

Table S2 (*continued*)

Study	Methods	Participants	Intervention	Duration intervention/ follow-up	Outcome measures of interest	
					Sedentary behavior[1]	Anthropometric
			Discussion (one session when receiving the device) with parents and researchers on how to use the device, create rules, set TV-free days, record programs to skip adverts & move TV to less accessible location. Recommendation was to monitor TV for <1 hour a day. Control group: one single session with verbal advice on general strategies to decrease TV watching.	Follow-up: post intervention (6 weeks)		
Patrick et al (2006)	RCT Country: USA	N (control)=395 N (intervention)=424 Mean age (years): 12.7 Sex: 48% male Race: 42% other than white non-Hispanics Lost to follow-up: 7%	Multi-behavior study/intervention Intervention group: individual-based intervention with computer-generated tailored progress plans addressing PA and DI. Two PA, two nutrition and two SB targets were chosen by the computer to compare behavior to guidelines. According to TTM stage a plan was made, which was signed by the adolescent as a behavioral contract. The next component was delivered by a 16-section printed Teen Guide; mail and telephone using stage-based cognitive and behavioral strategies to support behavioral changes. Monthly reminder phone calls were scheduled during the 12 months: 6 calls were aimed at chosen targets, and remaining calls were on changing plans. Parents were to encourage behavior through praise, active support and positive role modeling. Adolescents received monetary incentives. Control group: SunSmart program to increase the use of sun protection.	Duration: 12 months Follow-up: post-intervention	SST (TV; video gaming; sitting talking on the phone; sitting listening to music)[2]	BMI[5]/ % overweight[b]
Peralta et al (2009)	RCT Country: Australia	N (control)=17 N (intervention)=16 Mean age (years): 12.5 Sex: 100% male Race: NR Lost to follow-up: 0.33%	Multi-behavior study/intervention Intervention group: school-based intervention, weekly 60-min. curriculum sessions over 16 weeks and two 20-min. lunchtime PA sessions. PA sessions were organized by 11th-grade students to encourage good role modeling. Lessons focused on promoting PA through increasing self esteem and self efficacy, reducing time spent in small screen recreation on weekends, decreasing sugar-sweetened beverage consumption & increasing fruit consumption. Acquisition of self-regulatory behaviors was used throughout the program. Parents received six newsletters with information on program content to motivate them to help their child. Control group: sixteen 60-min. curricular PA sessions.	Duration: 16 weeks Follow-up: post-intervention	SST (TV; video; video gaming; computer gaming; internet use; computer use for homework)[2]	BMI[5]/ Body fat[7]/ Waist Circumference[5]
Reilly et al (2006)	RCT Country: Scotland	N (control)=277 N (intervention)=268 Mean age (years): 4.2 Sex: 50% male Race: NR Lost to follow-up: BMI 8%	Multi-behavior study/intervention Intervention group: nursery-based & home-based intervention. Nursery component: enhanced PA program: three 30-min. sessions of PA per week over 24 weeks. Home element: family received a resource pack linking physical play at the nursery and at home. They also received two health education leaflets (one on evidence that PA is low and one on encouraging families to reduce the time spent watching television). Control group: usual curriculum, no intervention.	Duration: 24 weeks Follow-up: 6 months post-intervention (only BMI)	SST[3]	BMI[5]

Table S2 (*continued*)

Study	Methods	Participants	Intervention	Duration intervention/ follow-up	Outcome measures of interest	
					Sedentary behavior[1]	Anthropometric
Robinson et al (1999)	RCT Country: USA	N (control)=103 N (intervention)=95 Mean age (years): 8.9 Sex: 54.4% male Race: 70-80% white Lost to follow-up: 3%	Single-behavior study/intervention Intervention group: school-based intervention of eighteen 30-50 min. lessons. Lessons included self-monitoring and self-reporting to reduce time spent playing video games, watching television etc. Additional lessons focused on selective TV viewing. Final lessons were on reducing media use with children as advocates. Each household received an electronic television time manager. Control group: children received normal curriculum at school and no TV-time manager was provided.	Duration: 2 months Follow-up: post-intervention	SST[2]/ TV[2]/ Video[2]/ Video gaming[2]/ other[2]	BMI[5]/ Skinfolds[5]/ Waist circumference[5]
Robinson (2006)	RCT Country: USA	N (control)=102 N (intervention)=95 Mean age (years): 8.9 Sex: 54% male Race: 79% White Lost to follow-up: 2.5%	Single-behavior study/intervention Intervention group: school-based intervention of eighteen 30-50 min. lessons. Lessons were divided in four sections: TV awareness, TV turnoff, staying in control & helping others. A weekly 5-10 min. booster session was given in the last four months. Three primary approaches to …..: (1) Decreasing total television and other video time; (2) Selectively decreasing TV time by becoming more selective of context and content and (3) Replacing TV with other activities (no alternatives were given). Non-selective approaches: budgeting, limiting physical access. Selective approaches: certain days or times to watch, restricting to specific content, limiting to particular circumstances. Parents received a newsletter. Control group: normal curriculum.	Duration: 6 months Follow-up: post-intervention	TV[1,2]/ Video[1,2]/ Video gaming[1, 2]	NR
Salmon et al (2008)	RCT Country: Australia	N (control)=62 N (intervention)= IG1 n=66 IG2 n=74 IG3 n=93 Mean age (years): 10.1 Sex: 51% male Race: NR Lost to follow-up: BMI data 12%	Multi-behavior study/intervention Intervention group: school-based intervention with two intervention-types (both 19 lessons). (1) The BM condition: reduce TV time by 20% (from 2.5->2 hrs/day). Aim of lessons: increase children's awareness of time issues, learn to self-monitoring time spent in sedentary behavior and PA, increase awareness of home and community environments in relation to PA and sedentary behavior choices, improve decision making skills, identify alternatives to sedentary behavior, increase intelligent watching, identify advertisements on TV & increase advocacy skills. Elements used were: pedometer usage, activity games & poster presentations to younger children. (2) FMS condition: focused on six additional skills (three object control skills and three loco-motor skills). Skills were taught through fun games and maximum involvement for all kids. IG1: BM; IG2: FMS: IG3: BM+FMS. Control group: no intervention, normal curriculum.	Duration: 9 months Follow-up: 6 months, 12 months post-intervention	TV[2]/ Electronic games[2]/ Computer use[2]	BMI[5, a]/% overweight[5, c]
Shapiro et al (2009)	RCT Country: USA	N (control)=22 N (intervention)= IG1 n=18 IG2 n=18 Mean age (years): 8.7 Sex: 64% male Race: 32% White Lost to follow-up: 53%	Multi-behavior study/intervention Intervention group: family-based intervention. IG1: Families participated in three weekly educational group sessions (90 min. each). Session 1 introduced the three target behaviors: pedometer usage, estimating beverage sizes and estimating screen time (TV, video game and computer).	Duration: 8 weeks Follow-up: post-intervention	SST (Screen time)[1,2]	BMI(NR)[5,b]

Table S2 (*continued*)

Study	Methods	Participants	Intervention	Duration intervention/ follow-up	Outcome measures of interest	
					Sedentary behavior[1]	Anthropometric
			Session 2 focused on increasing PA and decreasing sedentary behavior (identifying alternatives, incorporate daily activities). Session 3 focused on the amount of sedentary behavior and consumption of sugar-sweetened beverages. Each family was given a phone for the study. Instructions were to send 1 SMS a day (with amount on pedometer, number of sedentary behaviors and screen time minutes); an immediate automated SMS feedback message was sent. IG2: same as IG1, but used self-monitoring forms instead of daily SMS and received weekly verbal feedback. Control group: participated in the 3 sessions but were not expected to self-monitor.			
Simon et al (2008)	RCT Country: France	N (control)=476 N (intervention)=632 Mean age (years): 11.6 Sex: 49% male Race: NR Lost to follow-up: 10%	Multi-behavior study/intervention Intervention group: school-based intervention with an educational component focusing on PA and sedentary behavior. At least two educational classes or debates were devoted to PA. New opportunities for PA during school hours and after school were offered, with a mean of 10 different activities on each site. Sporting events were organized. School transportation by bicycle or by foot was organized (no explicit sedentary behavior component mentioned). Control group: normal curriculum.	Duration: 4 years Follow-up: post-intervention	SST (TV; Video)[2]	% overweight[5,c]/ BMI[5]/BMI-median[a]/Body fat (FatMassIndex)[7]
Singh et al (2009)	RCT Country: The Netherlands	N (control)=395 N (intervention)=424 Mean age (years): 12.7 Sex: 50% male Race: Lost to follow-up: 19.3%	Multi-behavior study/intervention Intervention group: school-based intervention. Individual component: educational program covering 11 lessons on biology and physical education. The first 6 lessons were on increasing awareness and information processing regarding energy balance related behaviors. Students monitored their own behavior over three days and received feedback. The intervention program guided the students in their choice which of the four behaviors they were going to change and helped formulate implementation intentions. The remaining 5 lessons aimed at facilitating the choice to improve chosen behaviors. To guide the students a computer program was developed. The environmental component was to encourage schools in additional physical education lessons and create changes in and around school cafeterias. Posters suggesting alternative and healthier food choices were delivered to the canteen area and foods were given colored labels. Control group: normal curriculum.	Duration: 8 months Follow-up: 4 months, 12 months post-intervention	SST (TV/ Computer use)[2]	BMI[5]/ Skinfolds[5]/ Waist Circumference[5]
Spruijt-Metz et al (2008)	RCT Country: USA	N (control)=323 N (intervention)=136 Mean age (years): 12.5 Sex: 0% male Race: 72.8% Latino	Multi-behavior study/intervention Intervention group: a school-based and media-based PA intervention was delivered to students during five to seven in-class sessions over five to seven consecutive school days. Students received information about PA and sedentary behavior and	Duration: 5-7 consecutive days Follow-up: 3 months post-intervention	SST (TV; Video gaming; Internet)[2]	BMI-z[5,b]/ BMI Percentile[5]/ BMI(NR)[5]/ Body fat[7]

Table S2 (*continued*)

Study	Methods	Participants	Intervention	Duration intervention/ follow-up	Outcome measures of interest	
					Sedentary behavior[1]	Anthropometric
		Lost to follow-up: 7.4% (Whole sample including boys)	participated in learning activities that supported engagement in PA and reduction of time spent watching TV, sitting in front of computer or 'just sitting around'. Each classroom had to make Public Service Announcement aimed at increasing PA and decreasing physical inactivity in girls just like themselves. Each step in making the Public Service Announcement was aimed to increase both targets of increase in positive meaning in intrinsic motivation. Each lesson had teachable moments delivered in print or verbally (e.g. a fact sheet on health issues). Control group: normal curriculum.			
Simon et al (2008)	RCT Country: France	N (control)=476 N (intervention)=632 Mean age (years): 11.6 Sex: 49% male Race: NR Lost to follow-up: 10%	Multi-behavior study/intervention Intervention group: school-based intervention with an educational component focusing on PA and sedentary behavior. At least two educational classes or debates were devoted to PA. New opportunities for PA during school hours and after school were offered, with a mean of 10 different activities on each site. Sporting events were organized. School transportation by bicycle or by foot was organized (no explicit sedentary behavior component mentioned). Control group: normal curriculum.	Duration: 4 years Follow-up: post-intervention	SST (TV; Video)[2]	% overweight[5,c]/ BMI[5]/BMI-median[a]/Body fat (FatMassIndex)[7]
Singh et al (2009)	RCT Country: The Netherlands	N (control)=395 N (intervention)=424 Mean age (years): 12.7 Sex: 50% male Race: Lost to follow-up: 19.3%	Multi-behavior study/intervention Intervention group: school-based intervention. Individual component: educational program covering 11 lessons on biology and physical education. The first 6 lessons were on increasing awareness and information processing regarding energy balance related behaviors. Students monitored their own behavior over three days and received feedback. The intervention program guided the students in their choice which of the four behaviors they were going to change and helped formulate implementation intentions. The remaining 5 lessons aimed at facilitating the choice to improve chosen behaviors. To guide the students a computer program was developed. The environmental component was to encourage schools in additional physical education lessons and create changes in and around school cafeterias. Posters suggesting alternative and healthier food choices were delivered to the canteen area and foods were given colored labels. Control group: normal curriculum.	Duration: 8 months Follow-up: 4 months, 12 months post-intervention	SST (TV/ Computer use)[2]	BMI[5]/ Skinfolds[5]/ Waist Circumference[5]
Spruijt-Metz et al (2008)	RCT Country: USA	N (control)=323 N (intervention)=136 Mean age (years): 12.5 Sex: 0% male Race: 72.8% Latino Lost to follow-up: 7.4% (Whole sample including boys)	Multi-behavior study/intervention Intervention group: a school-based and media-based PA intervention was delivered to students during five to seven in-class sessions over five to seven consecutive school days. Students received information about PA and sedentary behavior and participated in learning activities that supported engagement in PA and reduction of time spent	Duration: 5-7 consecutive days Follow-up: 3 months post-intervention	SST (TV; Video gaming; Internet)[2]	BMI-z[5,b]/ BMI Percentile[5]/ BMI(NR)[5]/ Body fat[7]

Table S2 (*continued*)

Study	Methods	Participants	Intervention	Duration intervention/ follow-up	Outcome measures of interest	
					Sedentary behavior[1]	Anthropometric
			watching TV, sitting in front of computer or 'just sitting around'. Each classroom had to make Public Service Announcement aimed at increasing PA and decreasing physical inactivity in girls just like themselves. Each step in making the Public Service Announcement was aimed to increase both targets of increase in positive meaning in intrinsic motivation. Each lesson had teachable moments delivered in print or verbally (e.g. a fact sheet on health issues). Control group: normal curriculum.			
Todd et al (2008)	CT Country: USA	N (control)=11 N (intervention)=11 Mean age (years): 9.8 Sex: 100% male Race: NR Lost to follow-up: 4.5%	Single-behavior study/intervention Intervention group: primary care & home-based intervention. A total of five meetings were organized. Meeting one was to provide consent and receive pedometers. Meeting two was to return logbooks and collect BMI. After meeting two, participants were paired. Meeting three was a seminar designed to enhance awareness of electronic media use and to set goals to minimize television use. Awareness education included an interactive 90-min. family session based on TV turnoff network, three follow-up newsletters, ENUFF software (to limit computer and internet use), follow-up call after meeting three, recommendation for progressive reduction in media use to 90 min. per day or less after the first 10 weeks. Participants were contacted by phone each week to encourage and reinforce compliance with the intervention strategy. There was no guidance on PA or DI.Control group: meeting 1, 2 and meeting 4 (measurements), no other information or materials.	Duration: 20 weeks Follow-up: post-intervention	SST (Electronic media)[2,4]	BMI[5]/ Body fat[7]
Warren et al (2003)	RCT Country: UK	N (control)= 54 N (intervention)= IG1 n=56 IG2 n=54 IG3 n=54 Mean age (years): 6.1 Sex: 51% male Race: 89% Caucasian Lost to follow-up: 17%	Multi-behavior study/intervention Intervention group: 14-month school-based intervention with 25-min. lessons. IG1: The nutrition group: exploring concepts of health, providing a variety of foods, tasting lessons and games. After that a focus on breakfast and snacking and ending with tooth friendly food. IG2: The physical activity group: insects as theme promoting playground activity, reducing TV viewing, team games, fun PA and quizzes. IG3: Combined groups: both nutrition and physical activity. All intervention groups received a homework book accompanying the lessons. Parents received a newsletter with a resume/an overview of the lessons (each term one newsletter). Control group: educational program: food in a non-nutrition sense (food in different countries etc).	Duration: 14 months Follow-up: 1 month post-intervention	NR	% Overweight[5,9]/ BMI(NR)[5]/ Skinfolds(NR)[5]
Whaley et al (2010)	CT Country: USA	N (control)=409 N (intervention)=412 Mean age (years): 1.9 Sex: 50.5% male Race: 93% of mothers Latino Lost to follow-up: 28.3%	Multi-behavior study/intervention Intervention group: primary care intervention. One-on-one dialogue with WIC staff; six predetermined topics were available for discussion (yummy FV; healthy beverages; less TV; getting up and moving; small, healthy and fun snacks; blank option). At the end of the dialogue a goal and plan for change was	Duration: 12 months Follow-up: post-intervention	TV[2]	NR

Table S2 (*continued*)

Study	Methods	Participants	Intervention	Duration intervention/ follow-up	Outcome measures of interest	
					Sedentary behavior[1]	Anthropometric
			developed for the next 6 months. At each meeting a different or the same subject was discussed. Every 6 months the intervention was repeated. Control group: normal WIC meetings.			

Abbreviations: RCT, randomized controlled trial; CT, controlled trial; IG, intervention group; CG, control group; BMI, Body Mass Index; SB, sedentary behavior; SST, sedentary screen time; TV, television; FV, fruit and vegetables; DI, dietary intake; PA, physical activity; SSB, sugar sweetened beverages, NR, not reported.

¶ SST (TV, video, internet); one outcome was reported, in this example overall SST was reported, between brackets the authors definition of SST is given: TV, video and Internet. SST/ TV/ Video/ Gaming; all sedentary behaviors mentioned were reported as distinct outcomes.

[1] parent self-report.

[2] child self- report.

[3] accelerometers.

[4] pedometers.

[5] height/ weight/ waist circumference/ skin folds measured by (trained) research assistants.

[a] use of reference values of a national norm sample.

[b] use of reference values from the CDC charts.

[c] ITOF values (Cole et al, 2000).

[d] use of percentiles in study data.

[7] Body fat analyzer/ DEXA scans.

[9] Unclear.

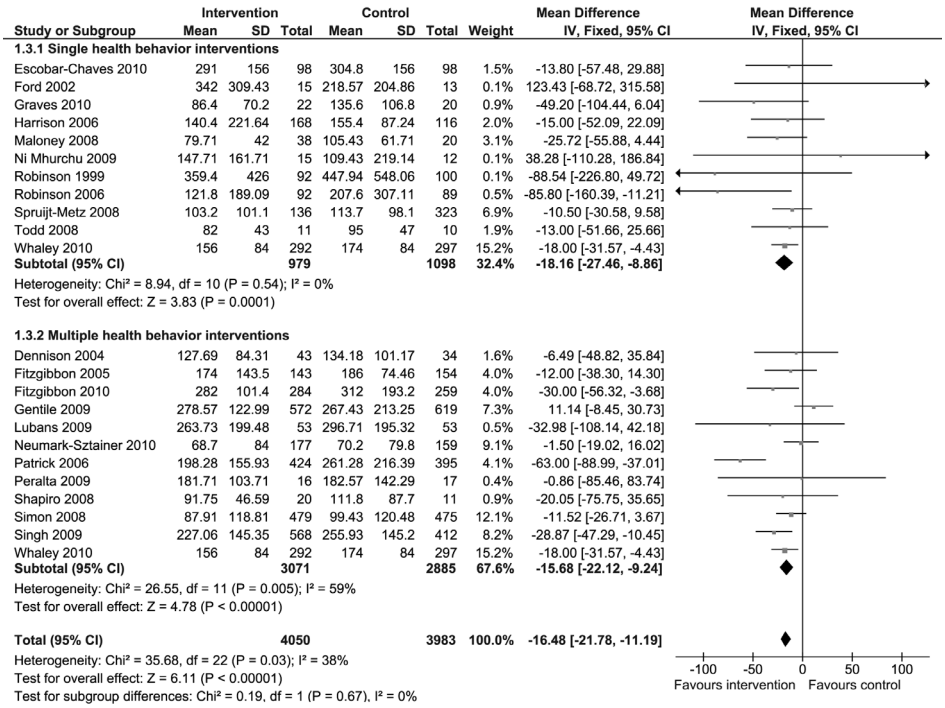

Figure S1 Forest plot, fixed effects model, comparing intervention and control group on post-intervention sedentary behavior (minutes per day)

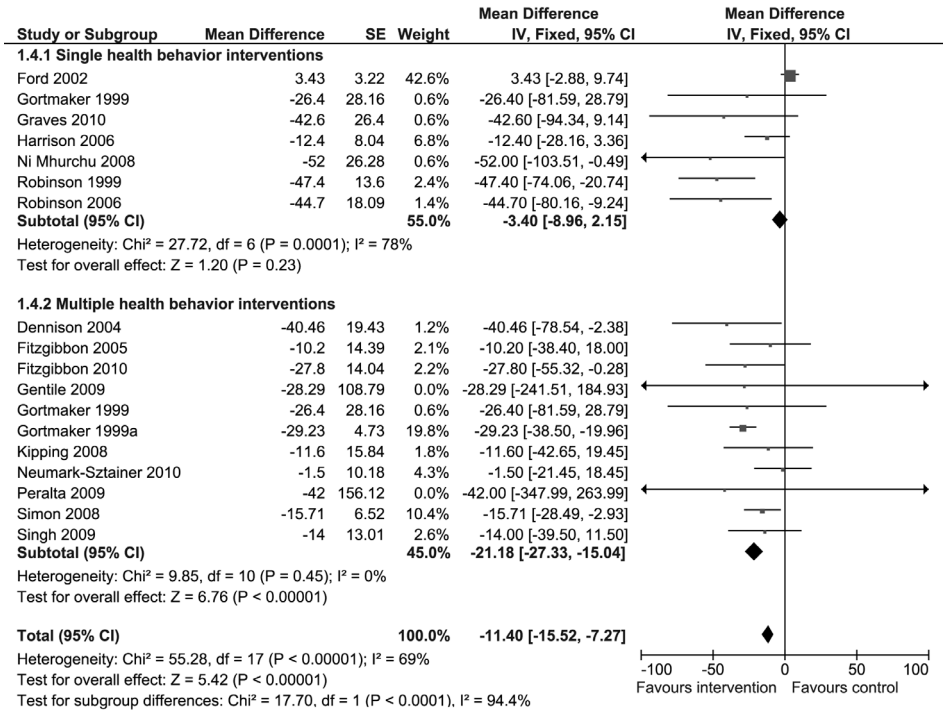

Figure S2 Forest plot, fixed effects model, comparing intervention and control group on post-intervention change-from-baseline sedentary behavior (minutes per day)

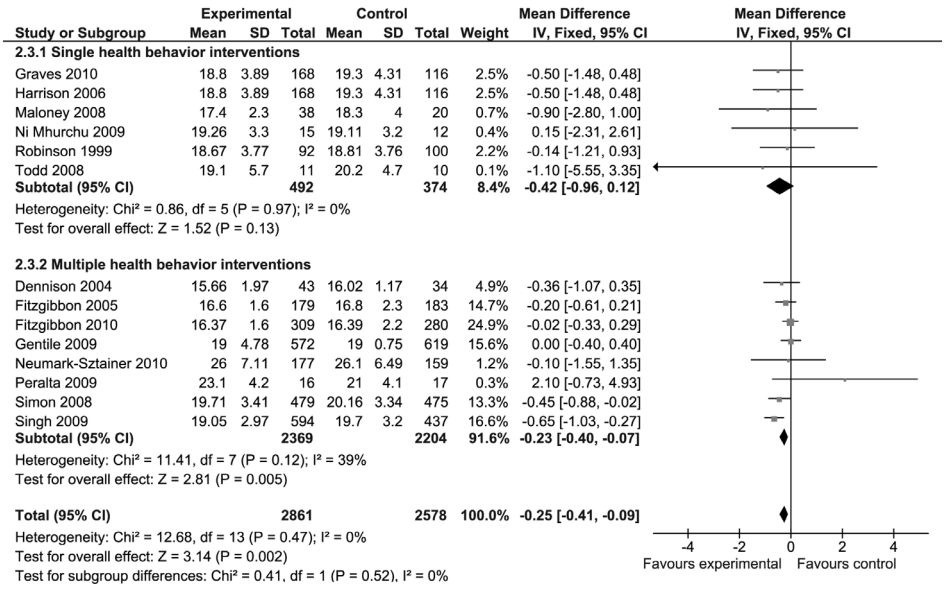

Figure S3 Forest plot, fixed effects model, comparing intervention group and control group on post-intervention BMI (kg/m^2)

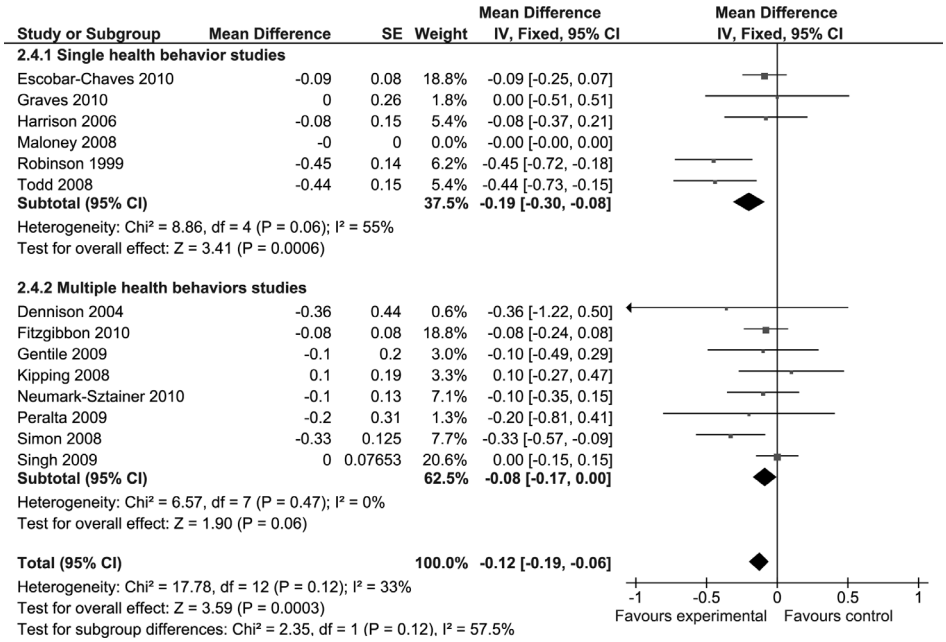

Figure S4 Forest plot, fixed effects model, comparing intervention and control group on post-intervention change-from-baseline BMI (kg/m^2)

Part II

Child weight status and indicators of health

5

Impaired parent-reported health-related quality of life of underweight and obese children at elementary school entry.

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Quality of life research, 2013; 22(4)

ABSTRACT

Purpose

Examine the health-related quality of life of 5-6-year-old underweight, overweight and obese children.

Methods

Our cross-sectional study included 3,227 parent-child dyads from the 'Be active, eat right' study. Parents completed questionnaires regarding child and parental characteristics. Health-related quality of life of the child was measured using the Child Health Questionnaire Parent Form 28. Children were classified normal-weight, overweight, obese, severely obese, and underweight according to the international age and gender BMI cutoff points. Bootstrap analyses were performed for general linear models corrected for potential confounding variables.

Results

Severely obese children (beta -2.60, 95% CI -4.80 to -0.57, $p< 0.01$) and underweight children (beta -1.11, 95% CI -1.85 to -0.39, $p< 0.01$) had lower parent-reported scores on the physical summary scale. On the physical functioning profile scale parents of overweight and severely obese children also reported statistically significant lower scores ($p< 0.05$ and $p< 0.01$, respectively).There were no significant differences regarding the psychosocial summary scale scores between the different weight categories.

Conclusion

Underweight and overweight children experience impaired health-related quality of life on the physical functioning domain. Physicians, teachers and parents should be aware of possible negative impact on health-related quality of life in underweight and overweight 5-6-year-old children.

INTRODUCTION

According to a recent study, the global prevalence of overweight (including obesity) among preschool children (0-5 years) has increased from 4.2% in 1990 to 6.7% in 2010; if this trend continues, a prevalence of 9.1% is projected in 2020 [1]. In the Netherlands, the prevalence of overweight and obesity among children and adolescents (age, 2-21 years) in 2009 was estimated at 12.8% for boys and 14.8% for girls [2].

Being overweight and/or clinically obese in childhood can have profound physical and psychosocial consequences (e.g., diabetes, hypertension and negative self-evaluation), which impact the everyday health-related quality of life for children and adolescents [3-4]. Overweight adults have reported more limitations on the physical dimension of health-related quality of life compared to normal-weight adults [5-6]. Also, among overweight and obese adolescents and older school-aged children (10-18 years), decrements have been reported for both the physical and psychosocial dimensions of health-related quality of life [7-19]. However, the few studies that have reported on the association between health-related quality of life and being overweight among children (4-7 years) [20-21] have reported contradicting results. Wake et al [20] reported that health outcomes were similar for normal-weight and obese children, whereas Skinner et al [21] reported that parents of very obese children reported decreases in general health and limitations in activity.

The prevalence of underweight in children (2-6 years) was estimated as 13% for boys and 12% for girls in the Netherlands in 1997 [22]. An impact on health-related quality of life has been reported among underweight adults [23]. However, studies that have examined the association between health-related quality of life and being underweight in children and adolescents reported more mixed results [11, 20, 24-27].

At the age of 5–6 years when children enter elementary school, any limitations with regard to physical and psychosocial well-being and therefore health-related quality of life could impede a child's start to his or her school career [28-30]. The aim of this study was to compare the health-related quality of life for 5-6-year-old children who are underweight, overweight, and obese relative to age-matched peers of normal weight by means of the Child Health Questionnaire Parent Form 28 (CHQ-PF28) [31-32]. Our hypothesis was that the health-related quality of life of underweight, overweight and obese children would be lower (i.e., worse) relative to age-matched children of normal weight.

METHODS

Study population

The present cross-sectional study used data obtained at enrollment in the 'Be active, eat right' study, a cluster randomized controlled trial that aims to assess the effects of an overweight

prevention protocol as described in detail elsewhere [33]. The Medical Ethics Committee of the Erasmus MC (University Medical Center Rotterdam) approved the study protocol (reference number MEC-2007-163). A total of 13,638 parents visiting one of the 44 participating Youth Health Care centers for their 5–year-old child's regular preventive health check between 2007 and 2008 were invited to participate in the study. The Youth Health Care centers sent parents the regular invitation to come to the center for the child's regular preventive health check; information on the study, an informed consent form and the first questionnaire on child and parental characteristics was included with the invitation. Of the parents who presented for their child's health check, 64.4% provided informed consent (n= 8,784) for participation in this study and 98.9% (n= 8,683) of the parents with consent returned the first questionnaire. A second questionnaire, including the CHQ-PF28, was provided to all study participants visiting 22 Youth Health Care centers (n= 3,942) (these families were not eligible to receive an intervention) and to study participants with overweight or obesity in the remainder 22 Youth Health Care centers (n= 439) (these families were eligible to receive an intervention). The Youth Health Care centers were randomly assigned to either provide an intervention or not, in the context of the 'Be active, eat right' study. Not all parents received the second questionnaire in order to minimize respondent burden. The response rate to the second questionnaire was 74.8% (Figure S1 in the supplementary material shows a flow chart of the data collection process).

A study population of 3,227 children remained after removing records with missing data on child's gender, weight, height or all CHQ-PF28 items (n= 51).

Weight status of the child

Each child's weight and height was measured by trained Youth Health Care professionals using standardized methods during the regular preventive health check [34]. Body mass index (BMI) was calculated by the researchers as weight in kilograms divided by height in meters squared. Children were categorized into one out of five weight categories according to their BMI as follows: underweight, normal-weight, overweight (not (severe) obesity), obesity (not severe obesity) or severe obesity. The international age-specific and gender-specific BMI cutoff points were applied to categorize children into underweight, normal-weight, overweight and obesity [35-36]. Obese children were categorized into obese (not severely obese) and severely obese. There are currently no international BMI cut-off points for severe obesity for children, but based on recent literature [37] and sample size considerations, we used the following cut-off points to categorize severe obesity: for boys, BMI ≥ 20.00; for girls, BMI ≥ 21.00.

Health-related quality of life

Health-related quality of life was assessed by means of the CHQ-PF28. There are 28 items on the CHQ-PF28 with four, five or six response options across eight multi-item scales and five single-item concepts. For the interpretation of the CHQ-PF28 scale scores and the psycho-

metric properties of the CHQ-PF28 scales in the present study please see table 1. As per the standardized developer instructions, the items from each of the scales were summed (some recoded/recalibrated) and transformed into 0 (worst possible score) to 100 (best possible score) scale [38]. From these 'profiles' it is also possible to compute a two-dimensional summary known as the physical and psychosocial summary scales [32]. Both summary scales were considered the main outcomes; the profile scales were analyzed in an exploratory way [39].

Table 1 CHQ-PF28 scales, number of items per scale, score interpretation* and psychometric properties in the present study (n=3,227).

CHQ-PF28 scales				Overall (n=3,227)						
	Number of items	Description low score	Description high score	Missing	Mean (SD)	Median (IQR)	Score range	% min[2]	% max[2]	Cronbach's α[3]
Physical summary [1]		Lower summary score represents lower physical health[1]	Higher summary score represents higher physical health[1]	101	56.8(6.5)	58.4(4.9)	-8.6 - 67.2	na	na	0.71¶
Psychosocial summary [1]		Lower summary score represents lower psychosocial health [1]	Higher summary score represents higher psychosocial health[1]	101	53.0(6.6)	53.8(8.1)	12.2 - 66.2	na	na	0.83¶
Physical functioning	3	Child is limited a lot in performing all physical activities, including self care, because of health	Child performs all types of physical activities, including the most vigorous, without limitations attributable to health	28	97.2(11.0)	100.0(0.0)	0-100	0.2	90.6	0.86
Role funct.-physical	1	Child is limited a lot in school work or activities with friends as a result of physical health	Child has no limitations in schoolwork or activities with friends as a result of physical health	27	97.0(11.9)	100.0(0.0)	0-100	0.2	93.1	na
Bodily pain	1	Child has extremely severe, frequent, and limiting bodily pain	Child has no pain or limitations because of pain	28	85.7(16.1)	80.0(20.0)	0-100	0.6	44.7	na
General behavior	4	Child very often exhibits aggressive, immature, delinquent behavior	Child never exhibits aggressive, immature, delinquent behavior	17	71.8(14.3)	71.3(18.75)	0-100	0.0	2.6	0.69
Self-esteem	3	Child is very dissatisfied with abilities, looks, family/peer relationships, and life overall	Child is very satisfied with abilities, looks, family/peer relationships' and life overall	22	82.1(13.1)	75.0(16.7)	0-100	0.1	24.3	0.82
Gen health perc.	4	Parent believes child's health is poor and likely to get worse	Parent believes child's health is excellent and will continue to be so	17	85.1(15.7)	90.0(18.8)	7.5-100	0.0	21.7	0.49
Parental-emotional	2	Parent experiences a great deal of emotional worry/concern as a result of child's physical and/or psychosocial health	Parent doesn't experience feelings of emotional worry/concern as a result of child's physical and/or psychosocial health	20	89.2(14.5)	100.0(12.5)	0-100	0.1	51.3	0.38

Table 1 (*continued*)

CHQ-PF28 scales				Overall (n=3,227)						
	Number of items	Description low score	Description high score	Missing	Mean (SD)	Median (IQR)	Score range	% min[2]	% max[2]	Cronbach's α[3]
Parental-time	2	Parent experiences a lot of limitations in time available for personal needs because of child's physical and/or psychosocial health	Parent doesn't experience limitations in time available for personal needs because of child's physical and/or psychosocial health	27	95.2(12.8)	100.0(0.0)	0-100	0.2	82.7	0.56
Family activities	2	The child's health very often limits and interrupts family activities or is a source of family tension	The child's health never limits or interrupts family activities or is a source of family tension	24	89.2(16.3)	100.0(25.0)	0-100	0.2	59.6	0.70
Family cohesion	1	Family's ability to get along is rated "poor"	Family's ability to get along is rated "excellent"	63	73.6(17.8)	85.0(25.0)	0-100	0.1	14.8	na
Change in health	1	Child's health is much worse now than one year ago	Child's health is much better now than one year ago	34	56.2(15.4)	50.0(0.0)	0-100	0.2	7.9	na

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[1] Physical and Psychosocial CHQ summary scores based on a factor-analytical model on U.S. population samples. A score of 50 represents the mean in the general U.S. population; scores above/below 50 are above/below the average in the general U.S. population [38]. Summary scales do not include the family activities, family cohesion and change in health scales.

[2] % of respondent with the highest, respectively lowest possible CHQ-PF28 scale score (ceiling/floor).

[3] average Cronbach's α of the eight multi-item scales 0.77.

¶ Cronbach's α of the summary scales might be higher because the single item scales (role func-emo/behav, role func-physical and bodily pain) could not be included.

Na: not applicable.

Child and maternal characteristics

Information on child gender (male and female), age (years), ethnic background (Dutch, non-Dutch) and chronic health conditions was obtained at enrollment (Table 2). Child ethnic background (Dutch, non-Dutch) was determined based on the parents' country of birth: if both parents were born in the Netherlands, the child was classified 'Dutch', and otherwise, the child was classified 'non-Dutch' [40]. The prevalence of common chronic conditions was assessed and included asthma, hearing difficulties, seeing difficulties, abdominal pain, headaches or migraine, allergies, and eczema.

The majority of the questionnaires were completed by mothers (89.3%). Information on maternal age (years), height (meters), weight (kilograms), country of birth (Dutch, non-Dutch), educational level (low, mid-low, mid-high, and high) and marital status (married/ cohabiting or single) was obtained at enrollment. Maternal BMI was calculated as weight in kilograms divided by height in meters squared. Weight status of the mother was categorized into one of the two categories based on BMI: no overweight (BMI < 25) or overweight (BMI ≥ 25) [41]. Maternal level of education was categorized into one of the four levels: low (no education, primary school, or ≤ 3 years of general secondary school), mid-low (>3 years of general sec-

ondary school), mid-high (higher vocational training, undergraduate programs, or bachelor's degree), and high (higher academic education) [42].

Statistical analysis

Normal-weight, overweight, obese, severely obese and underweight children were compared by means of one-way analysis of variance on mean age, average number of chronic health conditions and maternal age. Chi-square tests were performed to compare child (gender, ethnic background, number of chronic health conditions) and maternal characteristics (country of birth, educational level, marital status, weight status) among the weight categories.

Taking into account the non-normal distribution of some of the CHQ-PF28 scale residuals, nonparametric tests were performed to compare scale outcomes across weight categories. The normal-weight children were considered the reference group in all analyses. Kruskal–Wallis tests were used to compare the CHQ-PF28 scale scores across weight categories; a significant test ($p< 0.05$) provides statistical support for performing pairwise comparisons [39]. Mann–Whitney U-tests were used to compare the CHQ-PF28 scale scores pairwise; each subgroup was compared with the reference group of normal-weight children.

General linear models were fitted to study the association between child weight status and health-related quality of life as measured by the CHQ-PF28 scales. The CHQ-PF28 scales were studied as dependent variables, and the weight categories were studied as determinants, with the normal-weight children as reference group. Adjusted general linear models were fitted to correct for potentially confounding variables; both child (age, gender, ethnic background, and number of chronic health conditions) and maternal variables (age, BMI, country of birth, education and marital status) were included.

Following the suggestions made by Griffiths et al [18], an interaction term was introduced to the model to examine whether there were differences in the association between weight status and health-related quality of life for boys and girls and Dutch and non-Dutch children. Associations and interaction terms were evaluated at $p< 0.05$ level. Significant interactions were found for both gender and ethnic background. Statistical analyses were performed with SPSS 18.0 (SPSS Inc., Chicago, IL).

Due to the non-normal distribution of some of the CHQ-PF28 scale residuals, the bootstrap procedure was applied to estimate the regression coefficients of the general linear models [43-44]. Both the unadjusted (uncorrected for potentially confounding variables) and the adjusted (corrected for potentially confounding variables) bootstrap sampling results are reported with 95% confidence intervals (95% CI) and coefficient p-values. The bootstrap procedure was conducted in R version 2.7.1 (R Development Core Team 2008).

Table 2 General characteristics of the study population, stratified by children's weight status (n=3,227)

	Total (n=3,227)	Under-weight† (n=449)	Normal weight† (n=2,278)	Overweight† (n=405)	Obesity† (n=50)	Severe obesity† (n=45)
Child characteristics						
Age in years, mean (SD)	5.7 (0.4)	5.8 (0.4)	5.7 (0.4)	5.8 (0.4)	5.8 (0.4)	5.9 (0.4)
Gender**, % boys	49.3	50.8	51.4	37.0	26.0	66.7
Ethnic background, % Dutch (n=34 missing)	98.3	97.3	98.4	99.0	95.9	97.7
BMI**, mean (SD)	15.7 (1.7)	13.4 (0.5)	15.45 (0.9)	18.2 (0.6)	20.2 (0.4)	21.7 (1.1)
Number of chronic conditions, mean (SD)	0.6 (0.9)	0.6 (0.8)	0.5 (0.9)	0.6 (0.9)	0.7 (1.2)	0.6 (0.8)
Number of chronic conditions, % no chronic condition	62.4	60.9	62.9	61.5	68.0	57.8
Characteristics of the mother						
Age in years, mean (SD) (n=38 missing)	36.5 (4.3)	36.7 (4.0)	36.5 (4.3)	35.3 (3.9)	36.0 (5.2)	36.1 (6.0)
Gender, % mother is respondent (n=32 missing)	89.3	88.5	89.5	89.3	83.7	93.2
Born in the Netherlands***, % yes (n=32 missing)	90.9	91.0	92.0	87.4	79.6	77.3
Educational level*** (n=49 missing)						
% low	3.1	2.3	2.6	4.8	8.2	14.3
% mid- low	17.7	14.9	16.8	23.1	26.5	35.7
% mid- high	46.1	46.8	46.1	47.0	44.9	31.0
% high	33.1	36.0	34.4	25.1	20.4	19.0
Marital status***, % married or living together (n=46 missing)	93.5	92.7	94.5	92.1	85.3	80.5
Weight status±***, % normal weight (n=93 missing)	70.4	81.5	72.5	52.7	47.5	41.0

† Categories based on international age and gender specific BMI cut-off values, for severe obesity cut-off values of BMI: 20.00 in boys and BMI: 21.00 in girls were used.

± According to the World Health Organization definition, BMI< 25: normal weight, BMI 25-30: overweight, BMI >30: obesity[41].

Note: * $p< 0.05$; ** $p< 0.01$; *** $p< 0.001$: p-value from Chi-square tests for categorical variables and ANOVA for continues variables comparing general characteristics across weight categories.

RESULTS

The mean age of the children in the sample was 5.7 (SD 0.4) years. Within the sample, 49.3% were boys. Of all children in the sample, 37.6% had one or more chronic health conditions. There were significantly more Dutch children in the underweight and normal-weight categories compared to the percentage Dutch children in the overweight, obese and severely obese categories (p< 0.001). The overall mean BMI of the children in the study sample was 15.7 (SD 1.7), and the mean BMI of the children with normal-weight was 15.5 (SD 0.9). There were more boys than girls within the subgroups of severe obesity (66.7%), and less boys than girls in the overweight and obese subgroups (37.0% and 26%, respectively). The mean age of the mother was 36.5 years (SD 4.3), 89.3% of mothers were born in the Netherlands, and 93.5% were married or in a de facto relationship (Table 2).

Table 3 CHQ-PF28 scale scores stratified by children's weight status (n=3,227)

	Normal weight†[1] (n=2,278)		Overweight† (n=405)		Obesity† (n=50)		Severe obesity† (n=45)		Underweight† (n=449)		
	mean (SD)	median (IQR)	mean (SD)	median (IQR)	mean (SD)	median (IQR)	mean (SD)	median (IQR)	mean (SD)	median (IQR)	Kruskal Wallis p-value[2]
Physical summary	57.1 (6.1)	58.6 (4.6)	56.3 (7.2)	58.1 (5.5)	56.0 (8.7)	58.1 (6.5)	54.4 (7.3)	56.2 (7.7)**	55.9 (7.3)	58.0 (5.2)***	0.000
Psychosocial summary	53.0 (6.6)	53.8 (8.2)	52.9 (7.3)	54.1 (8.0)	51.4 (7.1)	52.3 (7.3)	52.5 (6.1)	52.9 (6.5)	53.2 (6.3)	53.7 (7.7)	0.552
Physical functioning	97.7 (9.8)	100.0 (0.0)	96.1 (13.6)	100.0 (0.0)*	93.9 (17.0)	100.0 (0.0)***	91.1 (15.8)	100.0 (11.1)***	96.6 (12.2)	100.0 (0.0)	0.000
Role funct.-emo/ behav.	97.5 (10.8)	100.0 (0.0)	97.5 (11.5)	100.0 (0.0)	96.0 (14.5)	100.0 (0.0)	96.2 (12.9)	100.0 (0.0)	98.1 (10.0)	100.0 (0.0)	0.432
Role funct.-physical	97.3 (11.1)	100.0 (0.0)	96.6 (13.6)	100.0 (0.0)	95.3 (16.5)	100.0 (0.0)	96.2 (12.9)	100.0 (0.0)	96.1 (13.7)	100.0 (0.0)	0.483
Bodily pain	85.9 (15.7)	80.0 (20.0)	86.7 (15.9)	80.0 (20.0)	82.8 (23.2)	80.0 (20.0)	90.2 (13.4)	100.0 (20.0)	84.1 (17.2)	80.0 (20.0)	0.036
General behavior	71.8 (14.2)	71.3 (18.8)	71.2 (14.9)	71.3 (16.3)	68.3 (13.9)	65.0 (18.8)	72.4 (15.0)	75.0 (18.8)	72.3 (14.1)	71.3 (18.8)	0.287
Mental health	81.8 (14.1)	83.3 (16.7)	81.6 (14.8)	83.3 (16.7)	77.6 (17.3)	83.3 (19.2)	83.7 (13.1)	83.3 (16.7)	81.4 (13.5)	83.3 (16.7)	0.390
Self-esteem	82.1 (13.1)	75.0 (16.7)	82.4 (13.4)	75.0 (25.0)	78.2 (11.9)	75.0 (8.3)*	79.8 (12.4)	75.0 (12.5)	82.4 (13.1)	75.0 (25.0)	0.128
Gen. health perc.	86.1 (14.9)	90.0 (18.8)	83.4 (16.9)	90.0 (22.2)**	78.9 (19.4)	87.5 (25.0)**	78.6 (18.1)	83.8 (31.3)**	83.4 (17.0)	90.0 (25.0)***	0.000
Parental-emotional	89.4 (14.1)	100.0 12.5)	89.7 (15.2)	100.0 (12.5)	84.7 (17.7)	87.5 (25.0)	82.2 (20.4)	87.5 (25.0)**	88.8 (14.5)	87.5 (12.5)	0.010
Parental-time	95.6 (11.9)	100.0 (0.0)	94.0 (16.1)	100.0 (0.0)	94.6 (12.5)	100.0 (0.0)	90.5 (17.8)	100.0 (16.7)*	94.6 (13.4)	100.0 (0.0)	0.070
Family activities	89.3 (16.4)	100.0 (25.0)	89.1 (16.5)	100.0 (25.0)	90.1 (15.9)	100.0 (25.0)	88.9 (15.6)	100.0 (25.0)	88.7 (16.2)	100.0 (25.0)	0.892
Family cohesion	73.5 (17.9)	85.0 (25.0)	73.0 (18.1)	85.0 (25.0)	70.0 (16.9)	60.0 (25.0)	71.1 (17.2)	60.0 (25.0)	74.9 (17.3)	85.0 (25.0)	0.166
Change in health	56.0 (14.9)	50.0 (0.0)	57.1 (17.1)	50.0 (0.0)	57.1 (17.7)	50.0 (0.0)	60.0 (20.2)	50.0 (25.0)	56.3 (15.2)	50.0 (0.00)	0.605

† Subgroups of weight categories based on international age and gender specific BMI cut-off values, for severe obesity cut-off values of BMI: 20.00 in boys and BMI: 21.00 in girls were used.

[1] Reference group.

[2] Kruskal-Wallis tests to compare the CHQ-PF28 scale scores across all subgroups; a significant p-value ($p < 0.05$) provides statistical support for performing pair wise comparisons.

* Represents p-value from Mann-Whitney U test: CHQ-PF28 scale score of each subgroup compared to the scale score of the reference group of normal weight children, * $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$.

In Table 3, the mean and median scores on the CHQ-PF28 scales are presented. Table 4 presents the bootstrap sampling results of the general linear models.

CHQ-PF28 summary scales

A significant lower parent-reported score on the physical summary scale for underweight children compared to normal-weight children (p< 0.01) was found with the general linear model (adjusted model beta, -1.11, 95% CI -1.85 to -0.39, p< 0.01). Additionally, severely obese children (adjusted model beta -2.60, 95% CI -4.80 to -0.57, p< 0.01) showed lower parent-reported scores on the physical summary scale (Table 3). The general linear model showed no association with lower parent-reported scores on the physical summary scale for overweight and obese children compared to normal-weight children (p> 0.05). There were no significant differences on the psychosocial summary scale scores between the different weight categories (Table 4).

Table 4 Associations between children's weight status and CHQ-PF28 scale scores (n=3,227)

	Overweight† (n=405)	p-value	Obesity† (n=50)	p-value	Severe obesity† (n=45)	p-value	Underweight† (n=449)	p-value
Physical summary								
Bootstrap unadjusted**	**-0.80(-1.61;-0.06)**	**0.038**	-1.04(-3.79;1.27)	0.424	**-2.72(-5.14;-0.65)**	**0.008**	**-1.15(-1.95;-0.42)**	**0.000**
Bootstrap adjusted**	-0.59(-1.37;0.17)	0.138	-1.12(-3.56;1.27)	0.380	**-2.60(-4.80;-0.57)**	**0.006**	**-1.11(-1.85;-0.39)**	**0.002**
Psychosocial summary								
Bootstrap unadjusted	-0.15(-0.92;0.66)	0.692	-1.70(-3.89; 0.30)	0.114	-0.57(-2.43;1.27)	0.564	0.22(-0.45;0.89)	0.506
Bootstrap adjusted	-0.13(-0.96;0.69)	0.734	-1.39(-4.00;0.91)	0.280	-0.28(-2.32;1.77)	0.794	0.27(-0.43;0.95)	0.454
Physical functioning								
Bootstrap unadjusted**	**-1.66(-3.12; -0.29)**	**0.014**	-3.95(-9.40; 0.16)	0.062	**-6.71(-11.47; -2.25)**	**0.000**	-1.16(-2.40; 0.06)	0.058
Bootstrap adjusted**	**-1.56(-3.04;-0.08)**	**0.040**	-3.78(-9.57; 0.96)	0.124	**-5.93(-10.32;-1.94)**	**0.002**	-1.00(-2.23;0.08)	0.060
Role funct.-emo/behav.								
Bootstrap unadjusted	0.03(-1.19;1.13)	0.930	-1.46(-6.00;1.98)	0.512	-1.34(-5.88;1.98)	0.526	0.59(-0.47;1.54)	0.268
Bootstrap adjusted	0.07(-1.40;1.38)	0.874	-1.37(-7.05;2.95)	0.624	-0.49(-4.96;3.02)	0.862	0.64(-0.38;1.65)	0.246
Role funct.-physical								
Bootstrap unadjusted	-0.69(-2.21;0.71)	0.340	-2.00(-6.66;1.82)	0.390	-1.19(-5.20;2.15)	0.572	-1.15(-2.52;0.17)	0.088
Bootstrap adjusted	-0.95(-2.82;0.65)	0.234	-2.32(-7.81;2.15)	0.396	-1.38(-5.75;2.28)	0.544	-1.18(-2.65;0.14)	0.082
Bodily pain								
Bootstrap unadjusted*	0.85(-0.89;2.40)	0.320	-3.19(-10.25;2.87)	0.344	**4.27(0.09;8.23)**	**0.048**	**-1.80(-3.68;-0.09)**	**0.034**
Bootstrap adjusted*	0.84(-0.93;2.53)	0.340	-3.15(-10.58;3.16)	0.360	1.85(-2.52;5.88)	0.400	**-2.42(-4.28;-0.65)**	**0.008**
General behavior								
Bootstrap unadjusted	-0.66(-2.23;0.76)	0.382	-3.60(-7.51;0.40)	0.080	0.48(-4.01;4.66)	0.808	0.48(-0.95;1.87)	0.520
Bootstrap adjusted	-0.56(-2.29;1.18)	0.526	-3.28(7.71;1.22)	0.156	1.19(-3.94;5.81)	0.632	0.28(-1.29;1.88)	0.718

Table 4 (*continued*)

	Overweight† (n=405)	p-value	Obesity† (n=50)	p-value	Severe obesity† (n=45)	p-value	Underweight† (n=449)	p-value
Mental health								
Bootstrap unadjusted	-0.24(-1.75;1.29)	0.790	-4.30(-9.29;0.43)	0.076	2.00(-2.09;5.69)	0.324	-0.48(-1.94;0.91)	0.488
Bootstrap adjusted	-0.27(-1.93;1.45)	0.782	-2.20(-7.23;2.81)	0.408	2.39(-2.04;6.30)	0.282	-0.03(-1.52;1.44)	1.000
Self-esteem								
Bootstrap unadjusted	0.29(-1.09;1.59)	0.684	**-3.93(-7.37;-0.35)**	**0.026**	-2.26(-5.91;1.25)	0.228	0.28(-1.09;1.58)	0.690
Bootstrap adjusted	0.25(-1.23;1.69)	0.736	**-4.18(-7.87;-0.78)**	**0.012**	-1.25(-4.96;2.59)	0.512	0.27(-1.29;1.67)	0.712
Gen. health perc.								
Bootstrap unadjusted***	**-2.68(-4.50;-0.90)**	**0.002**	**-7.06(-12.55;-1.89)**	**0.006**	**-7.65(-12.96;-2.58)**	**0.000**	**-2.62(-4.16;-1.07)**	**0.000**
Bootstrap adjusted**	-1.90(-3.67;0.005)	0.052	**-5.39(-10.33;-0.78)**	**0.018**	-4.41(-9.91;0.79)	0.090	**-2.07(-3.77;-0.45)**	**0.008**
Parental- emotional								
Bootstrap unadjusted*	0.32(-1.24;1.89)	0.670	-4.81(-10.01;0.20)	0.054	**-7.41(-13.79;-1.75)**	**0.008**	-0.68(-2.19;0.74)	0.378
Bootstrap adjusted	-0.18(-1.96;1.60)	0.852	-4.55(-10.43;0.71)	0.094	**-6.77(-13.45;-0.69)**	**0.020**	-0.60(-2.15;0.89)	0.450
Parental- time								
Bootstrap unadjusted	**-1.65(-3.47;-0.08)**	**0.042**	-1.04(-4.55;1.92)	0.610	**-5.09(-10.87;-0.34)**	**0.034**	-1.00(-2.34;0.34)	0.160
Bootstrap adjusted	-0.53(-2.22;1.04)	0.548	-0.06(-4.08;3.32)	0.980	**-5.35(-11.92;-0.24)**	**0.046**	-1.41(-2.91;0.07)	0.060
Family activities								
Bootstrap unadjusted	-0.13(-1.90;1.68)	0.870	0.82(-3.72;4.93)	0.728	-0.43(-5.20;4.02)	0.894	-0.49(-2.17;1.17)	0.572
Bootstrap adjusted	-0.004(-1.86;1.98)	0.996	1.90(-3.08;6.61)	0.434	0.85(-4.80;5.55)	0.736	-0.44(-2.22;1.26)	0.628
Family cohesion								
Bootstrap unadjusted	-0.55(-2.60;1.54)	0.564	-3.45(-8.01;0.88)	0.134	-2.62(-7.30;2.67)	0.316	1.41(-0.36;3.16)	0.116
Bootstrap adjusted	0.07(-2.08;2.13)	0.962	-4.43(-9.31;0.51)	0.082	-1.56(-7.34;4.91)	0.594	0.74(-1.31;2.78)	0.504
Change in health								
Bootstrap unadjusted	1.08(-0.57;2.91)	0.214	1.20(-3.38;6.38)	0.652	3.89(-1.76;10.20)	0.202	0.28(-1.15;1.80)	0.726
Bootstrap adjusted	0.43(-1.30;2.35)	0.642	-0.06(-5.18;5.49)	0.970	0.86(-4.73;7.21)	0.814	0.15(1.44;1.71)	0.832

Note: bootstrap analyses were performed for the general linear model; values are beta coefficients relative to the normal weight reference group with 95% Confidence Intervals. Bold numbers indicate a significant beta-coefficient. Unadjusted bootstrap: weight category as independent variable and the CHQ-PF28 scale as dependent variables, no correction for potential confounding variables. Adjusted bootstrap: the model corrected for potential confounding variables; weight category, child characteristics (gender, age, ethnic background, number of chronic conditions) and maternal characteristics (age, country of birth, education level, marital status and overweight yes/no) as independent variables and the CHQ-PF28 scales as dependent variables.

† Subgroups of weight categories based on international age and gender specific BMI cut-off values, for severe obesity cut-off values of BMI: 20.00 in boys and BMI: 21.00 in girls were used.

* Represents significance level of weight category in the overall bootstrapped model, * p< 0.05, ** p< 0.01, *** p< 0.001.

CHQ-PF28 profile scales

Parents of overweight, obese and severely obese children reported statistically significant lower scores on the physical functioning scale (p< 0.05, p< 0.001 and p< 0.001 respectively)

compared to parents of normal-weight children (Table 3); for overweight and severely obese children, this was also found with the general linear model (Table 4).
Parents of obese children reported significant lower scores on self-esteem scales ($p< 0.05$, adjusted model beta -4.18, 95% CI -7.87 to -0.78) (Table 4). Parents of severely obese children reported lower scores regarding the parental impact-emotional and parental impact- time scale ($p< 0.05$) (Table 3).
Obese and underweight children both had lower parent-reported scores on the general health perception scale ($p< 0.05$ and $p< 0.01$ respectively) (Table 3). For underweight children, an association with lower parent-reported scores on the bodily pain (adjusted model beta -2.42, 95% CI -4.28 to -0.65, $p< 0.01$) was found compared to normal-weight children (Table 4).

Effect modification

The physical and psychosocial summary scale showed a significant interaction between weight and child ethnic background ($p< 0.05$); Dutch children showed on average lower parent-reported scores than the non-Dutch children across all weight categories. In similar direction, we found an interaction between weight and child ethnic background ($p< 0.05$) for the physical functioning and the self-esteem scale.
Additionally, a significant interaction was found between weight and gender for the scale of general health ($p< 0.05$); parent-reported scores for boys were on average lower than for girls across weight categories.

DISCUSSION

Our findings showed lower parent- reported physical health-related quality of life scores of severely obese and underweight children entering elementary school compared to normal-weight children. Parent- reported psychosocial health-related quality of life scores were not significantly different across weight categories in the present study.

Overweight, obesity and health-related quality of life

After adjusting for potential confounding factors such as child gender and child age, the CHQ parent-reported physical summary score was lower among severely obese children. These findings of 5–6-year-old children are in line with findings among adolescents and older school-aged children [9, 11, 14-15, 19-20, 27, 45-46].
The mechanisms underlying the association between BMI and health-related quality of life are not clear yet. It is possible that parents suspect that their overweight children are not able to join their peers in the same level of physical activity, for example during playtime, which thus may contribute to low scores for overweight children on the physical summary

scales in our study. It has been hypothesized that physical activity has a BMI-independent positive effect on health-related quality of life [19, 47]. Shoup et al [10] reported that compared to overweight children who did not meet the recommended physical activity guidelines older overweight children reported better overall health-related quality of life when they met the recommended physical activity guidelines. Additional analyses (data not shown) in which we studied the association between health-related quality of life and playing outside showed that the amount of outside play (more than 1 hour per day) was associated with higher scores on health-related quality of life ($p < 0.01$). However, the association between weight status and health-related quality of life remained statistically significant after the adjustment for the amount of outside play (data not shown). So, parents of overweight and obese children report lower health-related quality of life, independent of the level of physical activity of their children.

Our finding that the presence of overweight and obesity in 5–6-year-old children is not associated with the psychosocial summary scale of health-related quality of life- is comparable with the findings reported by others [18, 20, 48]. Decrements to the psychosocial dimension of health-related quality of life seem to become more pronounced during adolescence as young teens become more aware of their physical appearance [25]. Additionally, the use of parent reports might influence the results on psychosocial health-related quality of life in our study. Literature suggests that only few parents realize that their child is overweight or obese at this age [49]; perhaps, parents are therefore not keen on problems that may impact their child's psychosocial health. On the other hand, parents might ignore psychosocial problems or not take them seriously because they suppose the child is not old enough to be unhappy due to his or her weight.

When exploring the results on the profile scales, it is noteworthy that the parental impact-emotional and parental impact-time scales had significantly lower parent-reported scores for severely obese children. Lower scores can be interpreted as parents having more concerns and less personal time due to their child's weight, than do parents of normal-weight children. This finding has been reported by Wake et al [20].

Underweight and health-related quality of life

Parents of underweight children reported lower physical health-related quality of life as compared to parents of normal-weight children. These findings are in accordance with previously reported findings among older underweight children and adolescents [20, 24, 27]. Additionally, although analyses were exploratory, significantly more impairment was reported by parents on the bodily pain scale for underweight children. This has been reported only for boys in the study of Wake et al [20].

We have no explanation for the low health-related quality of life scores reported by parents on the physical domain for underweight young children. In our study, there were no differences in the number of chronic health conditions experienced by underweight children. We

have not measured short-term infections such as having the flu or a cold, which might have more impact or influence the amount of energy and physical functioning in underweight children.

There were no impairments reported by the parents of underweight children on the psychosocial dimension, contrary to what has been reported among adolescents [50-51]. Lower school functioning scores [25] and lower self-esteem scores [11] have been reported among underweight children. We hypothesize that the psychosocial domains of health-related quality of life in young children with overweight may be unaffected or that parents do not recognize impairments on this domain. The impact of lower psychosocial health-related quality of life may have more consequences when children enter early and/or late adolescence.

Effect modification in the association between health-related quality of life and weight status

On average, parents reported children of 'Dutch' origin, relative to 'non-Dutch' children, to have lower scores on both the physical and psychosocial summary scales and on the physical functioning and self-esteem scales across all weight categories. The findings for the lower physical scale scores are consistent with previous studies documenting differences among white adolescents and adolescents of African heritage [50]. In the current study, difference in culture between Dutch and non-Dutch parents may have resulted in different reporting. Future research specifying ethnic subgroups instead of a broad ethnic group will have to provide more insight into the relation between ethnic background, weight status and health-related quality of life.

Significantly lower parent-reported scores for boys compared to girls regarding the general health scale were found across all weight categories. Griffiths [18] emphasized gender differences on psychosocial measures of health-related quality of life. However, this review was primarily based on studies among older children. In our study, the use of parent report in combination with the young age of the children might have contributed to a more equal scoring for both genders on the psychosocial and physical health-related quality of life summary scales across all weight categories.

Methodological considerations

Some methodological issues are worth noting. Strength of the current study is the large population-based sample available to investigate and compare health- related quality of life of overweight, obese, severely obese and underweight children with normal-weight children. Limitations of the current study include the cross-sectional data that were used to investigate the relationship between weight status and health-related quality of life, and longitudinal research is needed to make any assumptions regarding the causality of the associations found. The choice of confounding variables corrected for in the general linear models was based on pre-existing knowledge about social and biological determinants of weight. Not

all potential confounders were measured; for example, no assessment regarding specific conditions or diseases, for example, Coeliac disease [52], was available. The number of common chronic conditions was included as potential confounder. The average number of common chronic conditions was not significantly different between weight categories and was no effect modifier in the association between weight status and health-related quality of life.
The parent form of the CHQ was a feasible measure within this large population-based study. However, the use of parent-proxy reports on a child's health-related quality of life should be taken into account when interpreting the findings [45, 51, 53-54].

Conclusion

This study highlights that as early as elementary school, parents report lower physical health-related quality of life of underweight and severely obese children. Although the decreases in health-related quality of life at this young age are relatively small, they might indicate more decreases in health-related quality of life when children are older. As such, it suggests that nutrition; health education and other interventions must be focused on both parents and children at early ages. Longitudinal studies to evaluate natural and intervention induced developments in body weight and BMI, and the associations with health-related quality of life in childhood are recommended. In the meantime, we recommend physicians, parents and teachers to be aware of the potential negative impact on health-related quality of life in both overweight and underweight children.

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SUPPLEMENTAL MATERIAL

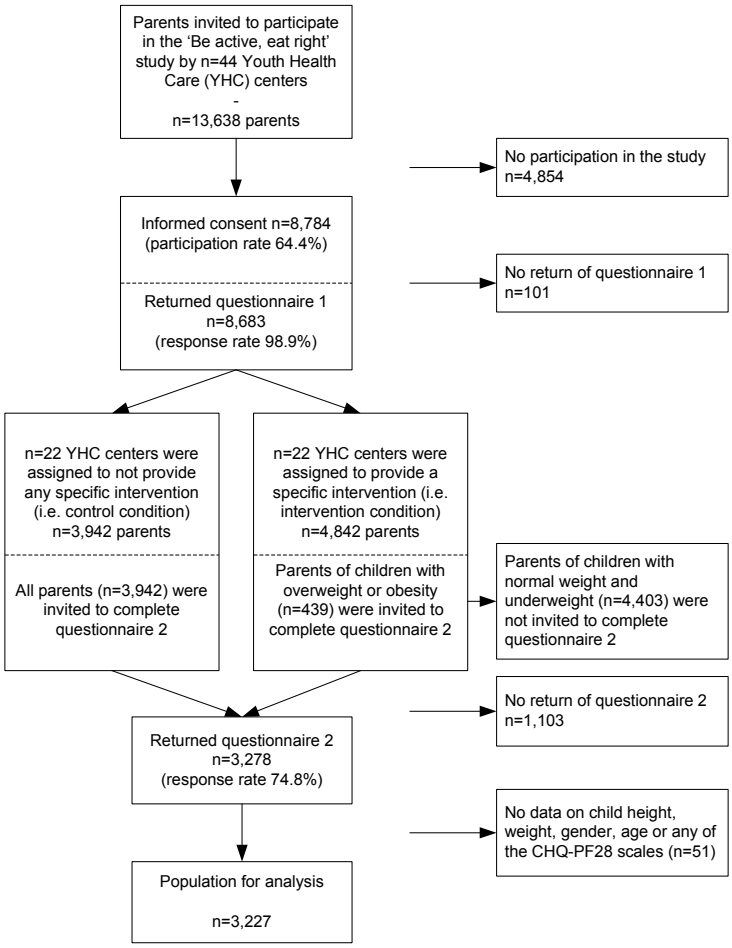

Figure S1 Flow chart of the data collection process in the present study

6

Overweight, obesity and underweight is associated with adverse psychosocial and physical health outcomes among 7-year-old children: the 'Be active, eat right' study

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ABSTRACT

Purpose

Limited studies have reported on associations between overweight, and physical and psychosocial health outcomes among younger children. This study evaluates associations between overweight, obesity and underweight in 5-year-old children and parent-reported health outcomes at age 7 years.

Methods

Data were used from the 'Be active, eat right' study. Height and weight were measured at 5 and 7 years. Parents reported on child physical and psychosocial health outcomes (e.g. respiratory symptoms, general health, happiness, insecurity and adverse treatment). Regression models, adjusted for potential confounders, were fitted to predict health outcomes at age 7 years.

Results

The baseline study sample consisted of 2,372 children: mean age 5.8 (SD 0.4) years, 6.2% overweight, 1.6% obese and 15.0% underweight. Compared to normal-weight children, overweight and obese children had an odds ratio (OR) of 5.70 (95% CI 4.10 to 7.92) and 35.34 (95% CI 19.16 to 65.17), respectively, for being treated adversely. Compared to children with a low BMI, children with a high stable BMI had an OR of 3.87 (95% CI 1.75 to 8.54) for visiting the general practitioner once or more, an OR of 15.94 (95% CI 10.75 to 23.64) for being treated adversely, and an OR of 16.35 (95% CI 11.08 to 24.36) for feeling insecure.

Conclusion

This study shows that overweight and obesity at 5 years of age is associated with more child insecurity and adverse treatment. Qualitative research examining underlying mechanisms is recommended. Healthcare providers should be aware of the possible adverse effects of childhood overweight and provide parents and children with appropriate counseling.

INTRODUCTION

The prevalence of overweight and obesity is increasing worldwide and has become a public health challenge [1]. The tracking of childhood overweight and associated health consequences into adulthood is of concern [2-4]. Several serious physical conditions are associated with overweight and, especially obesity, among children including asthma, sleep problems, cardiovascular diseases and type-2 diabetes [4-5]. Also psychosocial conditions such as lower self-esteem, depressive feelings and body dissatisfaction [6-13] are associated with overweight or obesity in childhood and adolescence.

Weight-related teasing or bullying that might start in childhood and continue into adolescence could cause a decrease in self-esteem or depressive symptoms [10-11, 13-17]. Children can experience different types and varying amounts of weight-related teasing [6, 8, 10, 12, 15-18]. For example, teasing may be peer-related or parent-related and may be daily or sporadic. Moreover, girls and boys report differences in the type and amount of teasing they experience [11].

Most studies have evaluated psychosocial outcomes of overweight and obesity in adolescents and older children (7-12 years) [10-11, 13-17] whereas few have evaluated the association between overweight and health outcomes in younger children aged e.g. 5-8 years [18-20]. Studying the association among younger children, and evaluating changes in weight and potential changes in health outcomes with longitudinal studies, may help to develop appropriate (preventive) interventions for children and parents to deal with both overweight and associated psychosocial/physical consequences.

Similarly, the association between underweight and health outcomes has rarely been assessed, and seldom among younger underweight children [2, 4, 7]. Moreover, ambiguous results are reported on young underweight children and the associations with health outcomes. For example, one study reported decreases in physical health for underweight children compared to normal-weight or obese children [4] whereas another reported diminishing associations after controlling for confounding variables [7].

This study aimed to evaluate two questions 1) what are the associations between childhood underweight, overweight and obesity at age 5 years and physical and psychosocial health outcomes at age 7 years, and 2) what is the association between change in body mass index (BMI) measured at age 5 and 7 years and health outcomes at age 7 years.

METHODS

Study design

In order to answer both study questions two types of study design were used. For the first study question a prospective design was used, investigating the association between determinants at age 5 years and parent-reported health outcome at age 7 years. For the second

study question longitudinal data, obtained at age 5 and age 7, was summarized into one variable defining weight trajectories at age 7 years. Subsequently a cross-sectional design was used to study the association between weight trajectories and health outcomes both at the age of 7 years. Data to evaluate the study questions originated from the 'Be active, eat right' study.

Study population

Data was obtained from the 'Be active, eat right' study, a cluster randomized controlled trial which aims to assess the effects of an overweight prevention protocol, described in detail elsewhere [21]. The Medical Ethics Committee of Erasmus MC University Medical Center Rotterdam approved the study protocol (reference number MEC-2007-163). A total of 13,638 parents visiting one of the 44 participating youth health care (YHC) centers for their 5-year-old child's regular well-child visit between 2007 and 2008 were invited to participate in the study. Of the parents who were present at their child's health visit, 64.4% provided informed consent (n= 8,784) and 98.9% (n= 8,683) returned a first questionnaire. At 2-year follow-up a questionnaire was distributed among all parents that had given informed consent, for which the response rate was 62.9%.

For this specific study we excluded study participants that were allocated to the intervention condition (n= 4,842) to prevent interference of the intervention with regard to the associations under study. Records with missing data on child height, weight, gender and age at baseline (n= 30) were excluded. In addition, records with missing data for all of the outcomes of interest (n= 1,540) were excluded; these are records from parents that did not return the questionnaire at 2-year follow-up, which included the health outcome measures.

Two study populations were created. The first study question was answered using the population of n= 2,372 children that remained after excluding abovementioned missing data. To evaluate the second study question children with missing data on height, weight, age and gender at age 7 years were additionally excluded; a study population of n= 1,995 remained for the analysis (Figure S1 in the supplemental material presents the data selection process).

Weight status of the child

During the regular preventive health visit, the weight, height and waist circumference of each child was measured by YHC professionals using standardized methods [22]. At 2-year follow-up, research assistants measured child height and weight according to the same methods. BMI was calculated by the researchers as weight in kilograms divided by height in meters squared. Children were categorized into one out of four weight categories according to their age- and gender-specific BMI: underweight, normal-weight, overweight (not obesity) and obesity [23-24]. Children were categorized in weight trajectories to describe changes in weight status. Based on the child's age- and gender-specific categorization at 5-years and 7-years, children were allocated to one of four trajectories (n= 1,995): low-stable, increasing, high-stable and

decreasing. The first trajectory (low-stable) consisted of children maintaining a categorization of normal or underweight BMI, and children moving from the underweight category to the normal-weight category or vice versa (n= 1,732). The second trajectory (increasing) consisted of children changing from a normal-weight or overweight BMI categorization to the overweight or obesity BMI category (n= 115). The third trajectory (high stable) consisted of children maintaining the categorization of an overweight or obesity BMI (n= 103). The final trajectory (decreasing) consisted of children changing from an obesity or overweight BMI category to an overweight or normal-weight BMI category (n= 45). Children changing from an underweight to an overweight or obese BMI category or vice versa were excluded (n= 1).

Health outcomes

Data on children's health outcomes (age 7 years) were obtained by questionnaires completed by parents. Table 1 presents the items assessing the indicators of psychosocial health outcomes. The items measuring psychosocial health outcomes were based on existing studies and developed by the researchers to fit the population under study [25-27].

Parents were invited to fill in the number of visits to the general practitioner (GP) due to issues with the child's weight in the past two years, which was categorized as none versus one or more visits. The presence of common health conditions was assessed by the item: "Does your child have one of the following conditions?". Parents could choose 'yes' or 'no' to each of the following conditions: hearing difficulties, seeing difficulties, abdominal pain, headaches or migraine, allergies, and eczema. The presence of asthma symptoms was assessed with the wheezing and dyspnea questions from the International Study of Asthma and Allergies in Childhood (ISAAC) questionnaire [28]: "Has your child suffered from wheezing or a whistling noise in the chest/shortness of breath or breathlessness in the past 12 months?" and "How often in the past 12 months has your child suffered from wheezing or a whistling noise in the chest/shortness of breath or breathlessness?". Answers were dichotomized into 'symptoms' versus 'no symptoms'.

Health-related quality of life of the child was assessed with the General Health scale from the Child Health Questionnaire Parent Form 28 (CHQ-PF28) [29]. The General Health scale was

Table 1 Overview of items assessing wellbeing

Item name	Question/assessment	Scoring
Happiness	How often, in the past four weeks, was your child happy?	1= always 5= never
Insecurity	I sometimes feel that my child feels insecure due to his/her weight	1= totally disagree 5= totally agree
Adverse treatment	I sometimes feel that my child is treated adversely due to his/her weight (for example being teased, left behind or ignored)	1= totally disagree 5= totally agree
Parental concern	Sometimes, I am concerned about my child's weight and the consequences thereof for his/her health	1= totally disagree 5= totally agree

dichotomized (mean: 86.40 (SD 15.43)) into low scoring (< 71.97) or average to high scoring (≥ 71.97).

Child and maternal characteristics

Information on child gender, age (years) and ethnic background (Dutch, non-Dutch) was obtained at enrolment. Child ethnic background was determined by the parents' country of birth: if both parents were born in the Netherlands the child was classified as 'Dutch', otherwise the child was classified as 'non-Dutch' [30].

In our study sample most of the questionnaires were completed by mothers (90.3%). Information on maternal age (years), height (meters), weight (kilograms), country of birth (the Netherlands, other) and educational level was obtained at enrolment. Maternal BMI was calculated as weight in kilograms divided by height in meters squared. Maternal level of education consisted of four levels: low (no education, primary school, or ≤ 3 years of general secondary school), mid-low (> 3 years of general secondary school), mid-high (higher vocational training, undergraduate programs, or bachelor's degree), and high (higher academic education) [31].

Statistical analysis

Normal-weight, overweight, obese and underweight children were compared with regard to baseline child (gender, age, ethnic background, BMI) and maternal characteristics (age, country of birth, education level and BMI) by means of one-way analysis of variance and chi-square tests.

The non-normal distribution of the data required ordinal regression analyses to be performed for the items on happiness, insecurity, adverse treatment and parental concern. Logistic regression models were fitted for all other health outcomes: GP visits, ISAAC items, health conditions, and general health.

For both study questions regression models were fitted. First a model with BMI in categories at age 5 years as independent variable was fitted; secondly a model with weight trajectories as independent variable was fitted. Underweight, overweight and obese children were compared with normal-weight children (reference category) and the high-stable, increasing and decreasing weight trajectories were compared with the low-stable weight trajectory (reference category). All regression models were corrected for potential confounding variables gender, ethnic background of the child and education level of the mother [12].

The ordinal regression model provides the estimated odds ratio (OR) with 95% confidence interval (95% CI) for having a higher score on the outcome variable, if the independent variable would increase with one unit. An OR is estimated for each category of the independent variable compared to the reference category; the model assumes that all other factors stay constant. Tests of parallel lines were performed to check the use of the ordinal regression model. A multinomial regression model was fitted when the parallel lines test was significant;

coefficients of the ordinal and multinomial regression models were compared. All ordinal regression models coefficients were in line with the coefficients of the multinomial models.
Effect modification was explored for gender, ethnic background and maternal education level: an interaction term with weight category was added to the above- described models [12]. Interaction terms were evaluated at p< 0.10. Wardle et al [12] recommended presenting results stratified. Due to the number of and inconsistency in the results of the models including the interaction terms, an overview of analyses stratified for child's gender, child's ethnicity and maternal education is provided in the supplemental material Table S1.
Demographic characteristics of mothers (age, country of birth, education level and BMI) with missing data on the outcomes (n= 1,540) were compared with characteristics of mothers with no missing data (n= 2,372) by means of descriptive statistics.
Analyses were performed using SPSS version 20.0 for Windows (International Business Machines (IBM) Corp., SPSS statistics, version 20.0, Armonk, New York, USA).

RESULTS

The mean age of the included children was 5.8 (SD 0.4) years, 50.0% were boys and 89.9% were Dutch (Table 2). There was a significant difference in the distribution of boys (p< 0.001)

Table 2 General characteristics of the study population, stratified by children's weight status (n=2,372)

	Total (n=2,372)	Underweight† (n=355)	Normal weight† (n=1,830)	Overweight† (n=148)	Obesity† (n=39)	p-value*
Child characteristics						
Age in years, mean (SD) (missing n=0)	5.8 (0.4)	5.8 (0.4)	5.7 (0.4)	5.8 (0.4)	5.8 (0.6)	0.396
Gender, % boys (missing n=0)	50.0	47.9	51.5	37.2	43.6	0.005
Ethnic background, % Dutch (missing n=34)	89.9	89.2	90.6	87.8	68.4	<0.001
BMI, mean (SD) (missing n=0)	15.4 (1.5)	13.4 (0.5)	15.4 (0.9)	18.2 (0.7)	21.1 (1.2)	<0.001
Characteristics of the mother						
Age in years, mean (SD) (missing n=251)	36.7 (4.2)	36.6 (4.1)	36.7 (4.2)	36.8 (4.4)	37.6 (5.7)	0.581
Born in the Netherlands, % yes (missing n=2)	92.9	93.0	93.6	88.5	74.4	<0.001
Educational level (missing n=6)						
% low	3.0	2.0	3.1	3.4	5.1	0.050
% mid- low	16.7	17.2	16.0	20.9	28.2	
% mid- high	45.6	45.4	45.2	52.0	46.2	
% high	34.7	35.5	35.8	23.6	20.5	
BMI mean (SD) (missing n=64)	23.7 (3.7)	23.0 (3.9)	23.6 (3.5)	24.8 (4.5)	27.9 (5.6)	<0.001

† Categories based on international age- and gender-specific BMI cut-off values.
* P-value from Chi-square tests for categorical variables and ANOVA for continuous variables, comparing general characteristics across weight categories.

and non-Dutch children (p< 0.001) across the weight categories; more girls were categorized having overweight and more non-Dutch children were categorized as having obesity. Table S1 (available in the supplemental material) presents the baseline distribution of health conditions. Compared to mothers with no missing outcome data, the mothers of children with missing outcome data were younger (mean 35.6 (SD 4.6) years versus 36.7 (SD 4.2) years, p< 0.001), more often non-Dutch (56.1% versus 37.4%, p< 0.05), less often higher educated (32.5% versus 67.5%, p< 0.001) and had a higher BMI (mean 24.0 (SD 4.4) versus 23.7 (SD 3.7), p< 0.01).

Associations between underweight, overweight or obesity at age 5 years and health outcomes at age 7 years

Table 3 presents the results of the regressions analysis predicting health outcomes at age 7 years with BMI at age 5 years as independent variable.

The OR for visiting the GP once or more was 2.64 (95% CI 1.37 to 5.00) for underweight children. Compared to normal-weight children, underweight children had an OR of 1.39 (95% CI 1.05 to 1.84) for being treated adversely according to their parents. Their parents had an OR of 1.84 (95% CI 1.48 to 2.30) for being concerned (Table 3).

Table 3 Health outcomes at age 7 years, predicted by BMI status at age 5 years

		Underweight (n=355)†	Normal weight (n=1,830)†	Overweight (n=148)†	Obesity (n=39)†
	n	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
One or more visits to GP (yes)[1]	2,316	**2.64 (1.37; 5.00)****	1.00	**3.41 (1.51; 7.69)****	**13.39 (5.43; 33.03)*****
Respiratory symptoms (yes) – wheezing[1]	2,328	1.25 (0.79; 1.99)	1.00	1.57 (0.84; 2.94)	2.40 (0.91; 6.36)
Respiratory symptoms (yes) – dyspnea[1]	2,322	1.06 (0.67; 1.67)	1.00	0.96 (0.47; 1.93)	1.74 (0.60; 5.04)
Hearing difficulties (yes)[1]	2,301	1.14 (0.73; 1.78)	1.00	1.14 (0.60; 2.17)	1.18 (0.35; 3.94)
Seeing difficulties (yes)[1]	2,295	1.32 (0.53; 3.26)	1.00	1.63 (0.48; 5.54)	4.48 (0.99; 20.34)
Abdominal pain (yes)[1]	2,298	**1.44 (1.02; 2.03)***	1.00	1.00 (0.57; 1.76)	1.00 (0.35; 2.89)
Headaches or migraine (yes)[1]	2,296	1.25 (0.57; 2.74)	1.00	1.51 (0.52; 4.35)	1.40 (0.18; 10.71)
Allergies (yes)[1]	2,301	**1.81 (1.32; 2.49)*****	1.00	1.22 (0.71; 2.07)	1.07 (0.37; 3.08)
Eczema (yes)[1]	2,292	0.65 (0.42; 1.00)	1.00	1.15 (0.68; 1.97)	0.72 (0.22; 2.38)
Lower score on general health[1]	2,333	**1.47 (1.12; 1.94)****	1.00	1.31 (0.87; 1.98)	**2.60 (1.32; 5.13)****
Lower score on happiness[2]	2,306	0.99 (0.77; 1.26)	1.00	1.21 (0.84; 1.75)	0.80 (0.41; 1.55)
Higher score on feeling insecure[2]	2,330	1.12 (0.85; 1.47)	1.00	**6.37 (4.62; 8.78)*****	**23.81 (13.05; 43.42)*****
Higher score on adverse treatment[2]	2,329	**1.39 (1.05; 1.84)***	1.00	**5.70 (4.10; 7.92)*****	**35.34 (19.16; 65.17)*****
Parental concern[2]	2,331	**1.84 (1.48; 2.30)*****	1.00	**7.22 (5.31; 9.87)*****	**26.10 (14.21; 47.94)*****

[1] Odds ratio (OR) and 95% confidence interval (95% CI) from logistic regression analysis.

[2] Odds ratio (OR) and 95% confidence interval (95% CI) from ordinal regression analysis.

† Categories based on international age- and gender-specific BMI cut-off values.

Note: all models are corrected for confounding by gender and ethnic background of the child and education level of the mother. Numbers printed **bold** indicate a statistically significant OR and asterisk represent significance level; * p<0.05, ** p<0.01,***p<0.001.

For overweight children the OR for visiting the GP once or more was 3.41 (95% CI 1.51 to 7.69). Compared to normal-weight children, overweight children had an OR of 6.37 (95% CI 4.62 to 8.78) for feeling insecure and 5.70 (95% CI 4.10 to 7.92) for being treated adversely, as reported by their parents. Compared to normal-weight children, the OR for parental concern was 7.22 (95% CI 5.31 to 9.87) for overweight children (Table 3).

The OR for visiting the GP once or more was 13.39 (95% CI 5.43 to 33.03) for obese children. Compared to the reports of parents of normal-weight children, obese children had an OR of 35.34 (95% CI 19.16 to 65.17) for being treated adversely. Compared to normal-weight children, the OR was 26.10 (95% CI 14.21 to 47.94) for parental concern about obese children (Table 3).

Associations between weight trajectories and health outcomes at age 7 years

Table 4 presents the results for the regression model predicting health outcomes at age 7 years using the weight trajectories as independent variable.

Compared to children with a low stable weight, parents of children with an increasing weight trajectory reported significantly higher ORs for their child feeling insecure (OR 5.61, 95% CI 3.88 to 8.11) and being treated adversely (OR 4.72, 95% CI 3.23 to 6.90). Compared to parents of children with a low stable BMI, parents of children with an increasing weight trajectory reported a higher OR for concern (OR 5.55, 95% CI 3.91 to 7.89) (Table 4).

Table 4 Health outcomes at age 7 years, predicted by BMI-trajectory between the age of 5 and 7 years

		Low stable (n=1,732)	Increasing (n=115)	High stable (n=103)	Decreasing (n=45)
	n	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
One or more visits to GP (yes)[1]	1,951	1.00	0.88 (0.21; 3.74)	**3.87 (1.75; 8.54)****	1.86 (0.42; 8.17)
Respiratory symptoms (yes) – wheezing[1]	1,959	1.00	0.88 (0.38 2.07	1.93 (0.99; 3.76)	0.78 (0.19; 3.27)
Respiratory symptoms (yes) – dyspnea[1]	1,953	1.00	0.37(0.11; 1.17)	0.99 (0.45; 2.20)	0.65 (0.16; 2.73)
Hearing difficulties (yes)[1]	1,939	1.00	1.67 (0.89; 3.15)	1.52 (0.77; 3.04)	0.32 (0.04; 2.33)
Seeing difficulties (yes)[1]	1,934	1.00	0.00 (0.00; ---)	2.56 (0.74; 8.85)	1.86 (0.24; 14.21)
Abdominal pain (yes)[1]	1,937	1.00	1.07 (0.58; 1.95)	1.06 (0.56; 1.99)	0.81 (0.29; 2.31)
Headaches or migraine (yes)[1]	1,935	1.00	1.46 (0.44; 4.88)	2.23 (0.76; 6.54)	1.26 (0.17; 9.49)
Allergies (yes)[1]	1,940	1.00	1.05 (0.58; 1.92)	1.24 (0.68; 2.28)	0.84 (0.30; 2.39)
Eczema (yes)[1]	1,935	1.00	0.99 (0.52; 1.89)	0.98 (0.50; 1.94)	1.57 (0.68; 3.59)
Lower score on general health[1]	1,964	1.00	1.09 (0.52; 2.29)	1.28 (0.79; 2.07)	1.14 (0.71; 1.84)
Lower score on happiness[2]	1,940	1.00	1.10 (0.73; 1.67)	1.19 (0.76;1.85)	0.76 (0.41; 1.40)
Higher score on feeling insecure[2]	1,961	1.00	**5.61 (3.88; 8.11)*****	**16.35 (11.08; 24.36)*****	**4.38 (2.48; 7.73)*****
Higher score on adverse treatment[2]	1,961	1.00	**4.72 (3.23;6.90)*****	**15.94 (10.75; 23.64)*****	**2.82 (1.53; 5.20)*****
Parental concern[2]	1,963	1.00	**5.55 (3.91; 7.89)*****	**14.54 (9.91; 21.33)*****	**3.61 (2.10; 6.18)*****

[1] Odds ratio (OR) and 95% confidence interval (95% CI) from logistic regression analysis.

[2] Odds ratio (OR) and 95% confidence interval (95% CI) from ordinal regression analysis.

Note: all models are corrected for confounding by gender and ethnic background of the child and education level of the mother. Numbers printed **bold** indicate a statistically significant OR and asterisk represent significance level; * p<0.05, ** p<0.01,***p<0.001.

Compared to children with a low stable trajectory, children with a high-stable weight trajectory had a significantly higher OR for visiting the GP once or more (OR 3.87, 95% CI 1.75 to 8.54). Children with a high stable weight trajectory had higher ORs for feeling insecure (OR 16.35, 95% CI 11.08 to 24.36) and being treated adversely (OR 15.94, 95% CI 10.75 to 23.64), according to their parents. Compared to children with a low stable weight trajectory, parents of children with a high-stable weight trajectory showed a higher OR for parental concern (OR 14.54, 95% CI 9.91 to 21.33) (Table 4).
Compared to parents of children with a low stable weight trajectory, parents of children with a decreasing weight trajectory reported their child having a higher OR for feeling insecure (OR 4.38, 95% CI 2.48 to 7.73) and being treated adversely (OR 2.82, 95% CI 1.53 to 5.20). Compared to low stable weight children, parents of children with a decreasing weight reported more concern (OR 3.61, 95% CI 2.10 to 6.18) (Table 4).

DISCUSSION

This study first prospectively evaluated the association between the weight status of children aged 5 years and parent-reported health outcomes at age 7 years. The study shows that overweight and obese children visit the GP more often; there was no indication that overweight or obese children have more physical health conditions such as asthma symptoms or allergies. According to their parents, overweight and obese children experience more insecurity and are more often being treated adversely. Underweight children also appeared to experience more adverse treatment and lower general health. Parents of both underweight and overweight or obese children reported more concern about their child's weight compared to parents of normal-weight children.
Secondly this study evaluated the association of weight status trajectory, based on the weight status of the child at age 5 years and at age 7 years, with parent-reported health outcomes at child age 7 years. Overweight or obesity at 5 and 7 years of age was associated with more insecurity and adverse treatment compared to children with a normal weight at both ages.

Associations between overweight and obesity, and health outcomes

According to their parents, overweight and obese children had a higher risk of feeling insecure or being treated adversely due to their weight. This concurs with other studies on children of a similar age (5-9 years) [18-20]. For example, one study that also evaluated the association between weight status and wellbeing in a longitudinal sample of general population children (but did not report on adverse treatment experienced by children), reported significantly higher odds for 4-5 year old overweight/obese children to have emotional and peer problems at age 8-9 years [19].

Parents of children with overweight and obesity reported more concern with regard to their child's weight. Although our study did not indicate that overweight and obese children experience more health conditions (e.g. asthma symptoms, allergies), several health conditions are reported to be potentially associated with overweight and obesity (e.g. type 2 diabetes, sleep problems) [32]. Hypothetically, parents and children may have visited the GP for conditions unmeasured in the current study. Also, the smaller number of children with specific conditions may have created a lack of power to detect an effect of weight status in the current study. Nevertheless, other researchers have reported that parents are more aware and likely to identify the overweight of their 6-year-old child, compared to parents with younger children, and therefore concern with regard to the child's weight may have increased among these parents [33].

Associations between underweight and health outcomes

Underweight children had slightly higher odds for being treated adversely compared to normal-weight children. Two studies reported that adverse treatment was associated with both underweight and overweight [13 15]. Although their results indicate that the odds for experiencing adverse treatment are much greater for overweight/obese children compared to the odds for underweight children, future studies will need to include underweight as a separate subgroup to further explore the associations with health outcomes.

Parents of underweight children reported slightly higher odds for higher levels of concern compared to parents of normal-weight children. Also, a higher frequency of GP visits and lower scoring on the general health scale of the Child Health Questionnaire at age 7 years was observed. Hypothetically, underweight children may be more prone to seasonal diseases (such as influenza or a cold) which may partly explain the increased risk for visits to the GP and the overall lower scores on general health.

Although we observed some interesting associations between underweight in children and parent-reported health outcomes, these associations are to be interpreted with caution. We, for example, did not measure whether these children had specific diseases during preschool. Because children with relative underweight may develop a normal weight when they grow older [34], longitudinal data needs to provide more insight in weight patterns of these children. Health care practitioners may be attentive to health problems associated with childhood underweight so that appropriate advice can be given; however, more research is needed before reliable advice with regard to counseling for underweight children and their parents can be given.

Associations between weight status trajectories and health outcomes

Our study indicates that children with an increasing BMI between the age of 5 and 7 years have higher odds for being treated adversely and feeling insecure, as also reported by other studies [18-20]. Weight patterns have been associated with lower school functioning among

elementary school-aged children [35]. The association between weight patterns and lower school functioning has been found to be mediated by internalizing factors (e.g. loneliness, low self-esteem) [35-36]. This emphasizes the need to develop and evaluate appropriate interventions for overweight/obese children at young ages to prevent further decreases in school performance, social participation, health outcomes and quality of life. Also, the pathways and environmental characteristics through which health outcomes are affected by overweight or obesity need further clarification; qualitative studies are required to gain more insight into these mechanisms. Combining multiple resources, such as child, parent report and teacher reports, or performing observational studies, may help to elucidate the association between weight and health outcomes.

Based on the methods used in other studies we categorized children in weight status trajectories using the international cutoff values at age 5 and age 7 years, which may result in a relatively crude categorization [35-36]. Children may decrease or increase within a weight category, but not reach the criterion to be categorized in another weight category. We explored whether gain in BMI was associated with higher risk for adverse psychosocial outcomes (data not shown). Children that gained BMI had a higher risk for being treated adversely and feeling insecure at age 7, as reported by their parents. Also, parents reported more concern with regard to their child's weight. Considering the physical outcomes, children had a higher parent-reported OR for having one or more health conditions or visits to the GP when they gained BMI between age 5 and 7. This is in line with the results we observed using the trajectories approach for high stable and increasing weight status. Longitudinal studies having access to multiple BMI measures may be able to create individual pathways of BMI development using statistical models [37-39]. These longitudinal trajectories or developmental pathways may reveal more distinct patterns of for example, late or early onset BMI gain, and can be related to health outcomes [37-39].

Methodological considerations

Strengths of this study include the large sample size, the ability to create subgroups based on the international cut-off values for BMI, inclusion of a large group of underweight children and the availability of data at child age 5 years and child age 7 years.

Limitations include the missing data at child age 7 years and parents self-report of the children's health outcomes. Also, mothers of children with complete outcome measures differ from mothers with missing outcome data; however, this does not necessarily influence the associations under study. With regard to the items used to measure psychosocial health outcomes of the child, these have not been examined with regard to validity and reliability. Additional analyses (data not shown) were performed to gain insight in the validity of the items used. These analyses showed that normal-weight mothers reported a higher OR for their overweight or obese child to be treated adversely and feel insecure, normal-weight mothers also reported more concern for their overweight or obese child compared to

normal-weight children (data not shown). Nevertheless, we recommend future research to evaluate the validity and reliability of the items measuring psychosocial health outcomes.
The use of parent self-report may have led to over- or underestimation of the children's health outcomes and needs to be taken into account when interpreting the findings. Measures of depression and self-esteem of the child were not included in the questionnaire because of the already reasonably high respondent burden. Although child report may have provided more accurate estimates of consequences on health outcomes, measuring concepts such as self-esteem and depression is known to be challenging among young children [40]. Also, at younger age self-concept indicators, such as teasing and insecurity, may be more informative compared to self-esteem questionnaires due to the developmental stage of the children [40].

Conclusion

In conclusion, parents reported their overweight, obese and underweight children to be more often treated adversely or feel insecure due to their weight. Parents of overweight, obese and underweight children expressed more concern about health outcomes associated with their child's overweight or underweight. These concerns seem to be reflected in the more frequent parent-reported visits to the GP of children with overweight, obesity and underweight.
Future studies need to follow-up on the associations between weight status and health outcomes when children develop and reach adolescence and adulthood. Also, underlying mechanisms and pathways associated with weight status and health outcomes need to be assessed in, preferably, longitudinal research.
In the meantime, we recommend that healthcare providers be alert to early signs of adverse treatment and insecure feelings in both overweight and underweight children. Appropriate counseling for teasing and insecure feelings should be offered in addition to, or as part of, interventions aiming at a positive change in weight status.

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SUPPLEMENTAL MATERIAL

Table S1 Results of stratified regression analyses predicting health outcomes at age 7 years with BMI-status at age 5 years as predictor

			Underweight†	Normal weight†	Overweight†	Obesity†
		n	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
One or more visits to GP (yes)[1]	Boy	1173	**4.03 (1.51;10.74)****	1.00	**7.57 (2.29; 24.99)****	**46.35 (13.40; 160.37)*****
	Girl	1180	2.08 (0.90; 4.83)	1.00	2.09 (0.70; 6.29)	**7.19 (1.96; 26.37)****
	Dutch	2088	**2.45 (1.19; 5.05)***	1.00	**3.34 (1.34; 8.32)***	**9.10 (2.55; 32.47)****
	Non-Dutch	231	**4.03 (1.02; 15.82)***	1.00	4.03 (1.02; 15.82)	**26.83 (6.09; 118.29)*****
	Low educated	453	0.74 (0.09; 6.09)	1.00	**4.631 (1.14; 18.81)***	4.79 (0.54; 42.66)
	High educated	1895	**3.41 (1.72; 6.74)*****	1.00	**3.14 (1.17; 8.47)***	**24.32 (9.28; 63.72)*****
Respiratory symptoms- wheezing (yes)[1]	Boy	1180	1.47 (0.80; 2.71)	1.00	1.31 (0.46; 3.77)	**5.04 (1.59; 15.99)****
	Girl	1186	1.02 (0.51; 2.06)	1.00	1.70 (0.78; 3.72)	0.85 (0.11; 6.46)
	Dutch	2097	1.15 (0.69; 1.91)	1.00	1.48 (0.75; 2.91)	**3.22 (1.09; 9.55)***
	Non-Dutch	235	1.98 (0.65; 6.01)	1.00	1.87 (0.38; 9.20)	1.19 (0.14; 10.01)
	Low educated¶	460	0.52 (0.15; 1.77)	1.00	0.33 (0.04; 2.52)	0.00 (0.00; …)¤
	High educated¶	1900	1.52 (0.92; 2.51)	1.00	**2.11 (1.09; 4.11)***	**4.58 (1.68; 12.48)****
Respiratory symptoms- dyspnea (yes)[1]	Boy	1176	1.07 (0.56; 2.03)	1.00	1.11 (0.39; 3.17)	2.97 (0.83; 10.62)
	Girl	1183	0.99 (0.52; 1.88)	1.00	0.82 (0.32; 2.10)	0.68 (0.09; 5.13)
	Dutch	2094	0.97 (0.59; 1.58)	1.00	1.05 (0.52; 2.12)	2.56 (0.87; 7.55)
	Non-Dutch	231	1.82 (0.54; 6.16)	1.00	0.00 (0.00; …)¤	0.00 (0.00; …)¤
	Low educated	456	0.33 (0.08; 1.42)	1.00	0.65 (0.15; 2.86)	0.00 (0.00; …)¤
	High educated	1898	1.25 (0.77; 2.03)	1.00	1.01 (0.46; 2.24)	2.73 (0.92; 8.10)
One or more conditions (yes)§[1]	Boy	840	1.33 (0.91; 1.93)	1.00	1.04 (0.54; 2.00)	1.61 (0.55; 4.70)
	Girl	858	0.93 (0.65; 1.33)	1.00	0.94 (0.57; 1.55)	1.08 (0.41; 2.81)
	Dutch	1787	1.12 (0.85; 1.47)	1.00	1.08 (0.71; 1.64)	1.75 (0.74; 4.15)
	Non-Dutch	195	0.89 (0.39;2.94)	1.00	0.51 (0.13; 1.93)	0.73 (0.18; 2.94)
	Low educated	387	1.05 (0.58; 1.91)	1.00	0.67 (0.27; 1.62)	2.00 (0.57; 7.07)
	High educated	1620	1.12 (0.84; 1.49)	1.00	1.13 (0.73; 1.77)	1.08 (0.45; 2.59)
Lower scores for general health[2]	Boy	1184	**1.75 (1.20; 2.55)****	1.00	1.46 (0.77; 2.78)	2.57 (0.94; 7.04)
	Girl	1186	1.15 (0.77; 1.72)	1.00	1.22 (0.72; 2.08)	**3.29 (1.38; 7.84)****
	Dutch	2100	**1.45 (1.09; 1.95)***	1.00	1.10 (0.70; 1.75)	1.79 (0.75; 4.31)
	Non-Dutch	236	1.46 (0.65; 3.31)	1.00	**3.27 (1.20; 8.94)***	**5.73 (1.71; 19.19)****
	Low educated	464	0.97 (0.49; 1.91)	1.00	0.28 (0.56; 2.96)	**5.26 (1.71; 16.19)****
	High educated	1901	**1.56 (1.15; 2.11)****	1.00	1.32 (0.82; 2.11)	2.15 (0.92; 5.00)
Lower scores for happiness[2]	Boy¤	1166	**1.51 (1.04;2.18)***		0.71 (0.41; 1.23)	0.69 (0.26; 1.83)
	Girl¤	1177	**0.72 (0.52;1.00)***	1.00	1.62 (0.99; 2.66)	0.66 (0.28; 1.55)
	Dutch	2074	0.92 (0.71; 1.19)	1.00	0.66 (0.30; 1.46)	1.26 (0.85; 1.89)
	Non-Dutch	235	2.00 (0.93; 4.29)	1.00	0.64 (0.32; 1.67)	1.06 (0.32; 3.46)
	Low educated¶	461	1.36 (0.80; 2.33)	1.00	1.14 (0.57; 2.28)	0.45 (0.15; 1.38)

Table S1 (*continued*)

			Underweight†	Normal weight†	Overweight†	Obesity†
		n	OR (95% CI)	OR (95% CI)	OR (9w5% CI)	OR (95% CI)
	High educated¶	1877	0.93 (0.71; 1.22)	1.00	1.20 (0.78; 1.85)	0.92 (0.40; 2.10)
Higher scores for feeling insecure[2]	Boy	1183	**1.51 (1.01; 2.25)***	1.00	**5.67 (3.35; 9.61)*****	**35.30 (14.45; 86.31)*****
	Girl	1186	0.88 (0.61; 1.28)	1.00	**7.00 (4.67; 10.49)*****	**19.63 (8.97; 42.99)*****
	Dutch¶	2098	1.26 (0.95; 1.68)	1.00	**8.22 (5.85; 11.58)*****	**19.24 (9.47; 39.06)*****
	Non-Dutch¶	237	0.51 (0.21; 1.24)	1.00	2.21 (0.88; 5.58)	**29.93 (9.09; 98.59)*****
	Low educated	462	0.68 (0.35; 1.30)	1.00	**6.40 (3.36; 12.22)*****	**12.48 (4.51; 34.57)*****
	High educated	1901	1.28 (0.95; 1.72)	1.00	**6.96 (4.83; 10.03)*****	**34.19 (16.54; 70.74)*****
Higher scores for adverse treatment [2]	Boy¤	1183	**1.75 (1.18; 2.58)*****	1.00	**3.58 (2.05; 6.25)*****	**44.12 (17.85; 108.96)*****
	Girl¤	1184	1.11 (0.75; 1.64)	1.00	**8.00 (5.26; 12.13)*****	**34.19 (15.35; 76.25)*****
	Dutch	2097	**1.52 (1.13; 2.04)****	1.00	**6.86 (4.83; 9.74)*****	**37.41 (18.12; 84.44)*****
	Non-Dutch	236	0.79 (0.35; 1.81)	1.00	**3.03 (1.20; 7.61)***	**24.34 (7.68; 77.01)*****
	Low educated	462	0.96 (0.52; 1.77)	1.00	**3.81 (1.97; 7.35)*****	**17.50 (6.23; 49.21)*****
	High educated	1899	**1.54 (1.13; 2.10)****	1.00	**7.09 (4.86; 10.32)*****	**48.91 (23.45; 102.00)*****
Parental concern[2]	Boy	1183	**2.04 (1.48; 2.81)*****	1.00	**7.51 (4.56; 12.37)*****	**43.42 (17.39; 108.31)*****
	Girl	1185	**1.64 (1.21; 2.23)*****	1.00	**7.32 (4.91; 10.89)*****	**19.39 (8.82; 42.69)*****
	Dutch	2098	**1.96 (1.55; 2.48)*****	1.00	**8.42 (6.04; 11.74)*****	**28.53 (13.85; 58.79)*****
	Non-Dutch	236	1.21 (0.62; 2.37)	1.00	**3.76 (4.23; 9.09)****	**16.76 (5.42; 51.83)*****
	Low educated	462	1.33 (0.80; 2.21)	1.00	**5.83 (3.10; 10.98)*****	**24.31 (8.50; 69.48*****
	High educated	1900	**1.97 (1.54; 2.51)*****	1.00	**8.25 (5.78; 11.78)*****	**28.30 (13.68; 58.62)*****

[1] Odds ratio (OR) and 95% confidence interval (95% CI) from logistic regression analysis.

[2] Odds ratio (OR) and 95% confidence interval (95% CI) from ordinal regression analysis.

§ Chronic conditions was dichotomized into none versus one or more conditions for the stratified analyses.

† Categories based on international age- and gender-specific BMI cut-off values.

¶ Significant interaction term (weight category times potential moderating variable) in regression model corrected for potential confounding variables $p<0.10$

¤ OR could not be computed due to low cell counts.

Note: No correction for potential confounding variables in stratified analyses. Education level of the mother was dichotomized due to low cell counts in the stratified analyses. Numbers printed **bold** indicate statistically significant ORs and asterisk represents significance level; * $p< 0.05$, ** $p< 0.01$, *** $p< 0.001$.

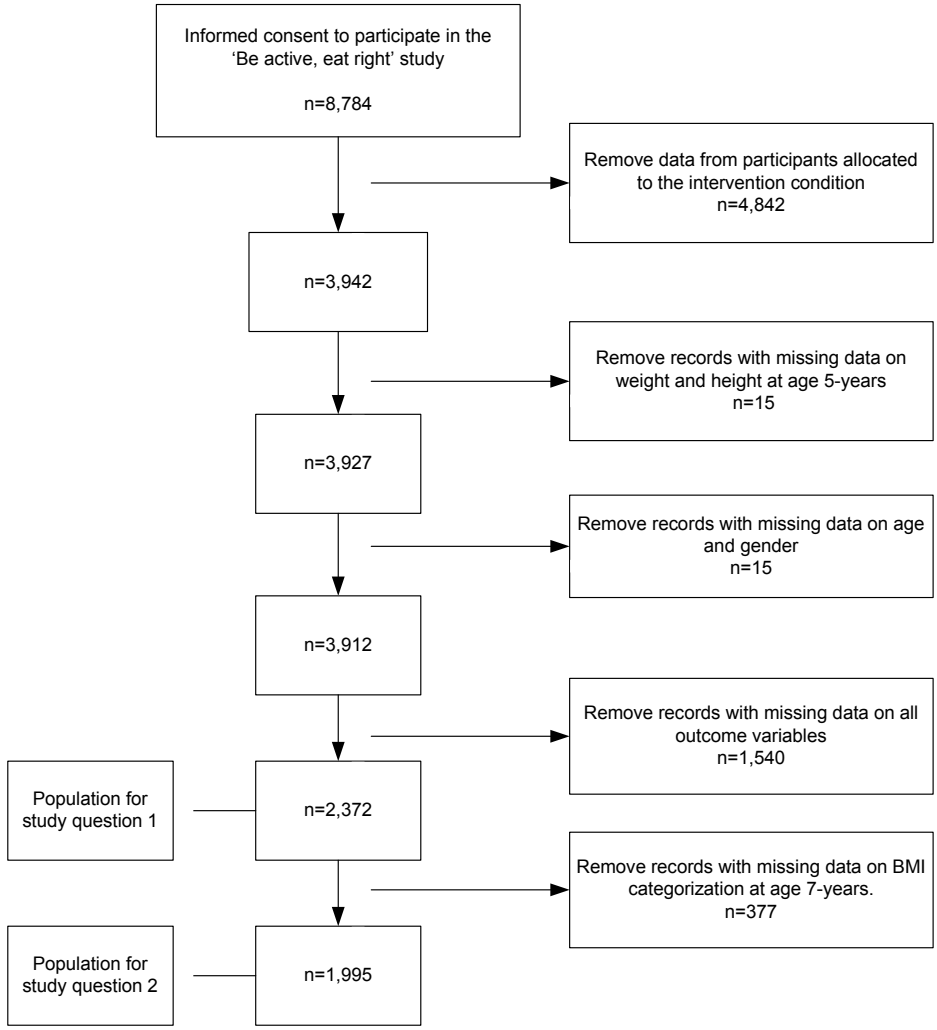

Figure S1 Flow chart of the data selection process

Part III

The home environment and children's sweet beverage consumption

7

Associations between the home environment and children's sweet beverage consumption at two-year follow-up: the 'Be active, eat right' study

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Submitted

ABSTRACT

Purpose

This study evaluates the association of parental beliefs and parenting practices with regard to their 7-year-old child's sweet beverage consumption with reported consumption of the child.

Methods

Data from the population-based 'Be active, eat right' study were used. The population-for-analysis consisted of n= 2047 parents and their children. Data on socio-demographic characteristics, parental beliefs, parenting practices and child sweet beverage consumption at child age 5 and 7 years were obtained by parental report with questionnaires. Regression analyses were performed.

Results

Parents reported that the 5-year-old child drank on average 3.0 (SD 1.4) sweet beverages a day. Parental discouragement of consumption at age 5 years (OR 1.24, 95% CI 1.07 to 1.43) was associated with a decreasing consumption pattern between ages 5 and 7 years. Availability of sweet beverages at home was associated with an increasing consumption pattern (OR 0.70, 95% CI 0.59 to 0.83) and a high stable consumption (OR 0.61, 95% CI 0.54 to 0.70). Less increase in available sweet beverages at home was associated with a decreasing consumption pattern (OR 1.26, 95% CI 1.11 to 1.44).

Conclusion

The availability of sweet beverages at home is associated with the child's sweet beverage consumption; not increasing the availability is associated less sweet beverage consumption. Interventions should include components to enhance healthy parenting practices.

INTRODUCTION

The prevalence of overweight and obesity among children in developed countries has been increasing [1]. Moreover, childhood overweight is associated with a higher risk for morbidity and mortality in adulthood [2]. Weight gain is caused by a higher energy intake mainly due to dietary behavior compared to energy expenditure by (physical) activity behaviors. Sweet beverages often have a high caloric value and may contribute to the development of overweight among children [3-4]. Reviews conclude that there may be an association between sweet beverage consumption and overweight development [5-6]. Two randomized controlled trials (RCTs) have shown that drinking sweet beverages leads to an increase in body mass index (BMI) in children and adolescents [7-8]. Therefore, reducing the consumption of sweet beverages may be an opportunity for prevention of overweight.

Theories suggest that, besides the individual determinants such as attitude, subjective norm or behavioral control that a person perceives about a behavior, factors in the social and physical environment influence health behavior [9-12]. For young children the social and physical environment is for the larger part determined by their parents. With regard to sweet beverage consumption, parents may limit accessibility or set rules about the amount or type of beverages the child can consume during the day. These practices are often referred to as parenting practices [13-14] and are associated with less sweet beverage consumption among adolescents [15-16].

This study aims to evaluate whether socio-demographic characteristics, parental beliefs and parenting practices about sweet beverage consumption, assessed at child age 5 years, are associated with the amount of sweet beverage the child consumes two years later. Also, we evaluate to what extent parental beliefs and parenting practices about sweet beverage consumption are associated with an increasing, decreasing or stable sweet beverage consumption of the child when comparing consumption at age 5 and 7 years. In addition, we explored whether changes in parenting practices (comparing assessments at child age 5 and 7 years) are associated with child sweet beverage consumption patterns.

METHODS

Study population and procedure

The present study was embedded in the 'Be active, eat right' study, a cluster RCT assessing the effects of an overweight prevention protocol, which is described in detail elsewhere [17].

In short, a total of 13,638 parents visiting one of the 44 participating youth healthcare centers for their 5-year-old child's regular preventive health check were invited to participate, 64.4% (n= 8,784) provided written informed consent for participation in the 2-year study and 98.9% (n= 8,683) returned the first questionnaire. Two years after enrolment a follow-up question-

naire was sent; the response rate of the parents participating at enrolment was 62.9%. Socio-demographic characteristics, parental beliefs and parenting practices were assessed at child age 5 years. A selection of the parenting practices was assessed at child age 7 years.
For the analyses in the present study, participants allocated to the intervention condition (n=4,842) were excluded to prevent interference of intervention effects with regard to the associations under investigation. Also excluded were records with missing data on the outcomes of interest, i.e. sweet beverage consumption at child age 5 years and 7 years (n=1,895). Therefore, the population for analysis consisted of n=2,047 parents and children (see Figure S1 in the supplementary material).

Measures

Socio-demographic characteristics

The child's gender (boy/girl), age (years) and ethnic background (Dutch/non-Dutch) were assessed. A child was considered of 'Dutch' ethnic background when both parents were born in the Netherlands[18]. Height and weight of the child were measured using standardized protocols at child age 5 years by healthcare professionals [19]. BMI was calculated by dividing child's weight in kilograms by height in meters squared.
Information on respondent's age (years), height (m), weight (kg), country of birth (the Netherlands/other) and educational level was obtained by questionnaire. Respondent's BMI was calculated as weight in kilograms divided by height in meters squared. Respondent's level of education consisted of four levels: low (no education, primary school, or ≤3 years of general secondary school), mid-low (>3 years of general secondary school), mid-high (higher vocational training, undergraduate programs, or Bachelor's degree), and high (higher academic education) [20].

Parental beliefs

A full description of scales, scale properties, items, response scales and time of assessment is available in the supporting information: Table S1. Parental attitude (three items) and family attitude (three items) towards sweet beverage consumption of the child was assessed and a scale score was computed (Cronbach's α 0.80 and 0.80, respectively). Self-efficacy and confidence of the parent to limit the sweet beverage consumption of the child was assessed using two separate items. Both items were accompanied by a 5-point response scale; a higher score indicated a higher parental self-efficacy or self-confidence to limit the child's sweet beverage consumption. Whether the parent considered letting the child consume few sweet beverages was a habitual parenting behavior was assessed using one item. Parental intention to let the child drink less sweet beverages in the coming 6 months was assessed with one item. Habitual behavior and intention to change were both assessed with a 5-point response scale.

Parenting practices

Rules with regard to sweet beverage consumption of the child were assessed, parents responded whether a rule was present and rules were added up to create an index (three items, range 0-3). Parental monitoring of sweet beverages consumption (one item) and active discouragement of sweet beverage consumption (one item) was assessed. A scale was created of three items assessing whether the parents allowed the child to decide for him/herself to consume sweet beverages (Cronbach's α 0.81). Another scale was created (two items) assessing whether parents bought sweet beverages for the child (Cronbach's α 0.79). Availability of sweet beverages in the home was assessed using one item, a higher score on this item indicating less availability in the home. All abovementioned items were accompanied by 5-point response scales.

At child age 7 years the items of monitoring, discouraging, buying and the availability at home were re-assessed in like manner via questionnaire. For these items a mean change score was calculated.

Sweet beverages consumption

Sweet beverages were defined as beverages containing (added) sugar such as fruit juices (e.g. apple juice) and soft drinks (e.g. cola). Parents were provided with this definition and various examples of sweet beverages. Soft drinks with sugar substitutes (i.e. 'diet' drinks) were not considered to be sweet beverages.

Parents indicated how many glasses of sweet beverages the child consumed per day on a weekday and on a weekend day on a 10-point scale ranging from 'none or less than one sweet beverage a day' to 'nine or more sweet beverages a day'. The lowest level of consumption was categorized as 0.5 beverages/day and the highest was categorized as 9.5 beverages/day. An average number of sweet beverages per day was calculated In addition, sweet beverage consumption was dichotomized into ≤ 2 beverages per day versus > 2 beverages per day based on the distribution in the data [21].

Based on the consumption at age 5 years and at 7 years children were categorized into one of four patterns; i) low stable sweet beverage consumption (≤ 2 beverages a day at 5 and at 7 years of age), ii) high stable sweet beverage consumption (> 2 beverages a day at 5 and at 7 years of age), iii) increasing sweet beverage consumption (≤ 2 sweet beverages a day at age 5 years, but > 2 sweet beverages a day at age 7 years), and iv) decreasing sweet beverage consumption (> 2 sweet beverages a day at age 5 years, but ≤ 2 sweet beverages a day at age 7 years).

Statistical analysis

Characteristics of the population for analysis at child age 5 years were evaluated with descriptive statistics. Chi-square tests and t-tests were used to evaluate the distribution and mean scores between children drinking ≤ 2 beverages versus children drinking > 2 beverages.

A general linear regression model was fitted with independent variables assessed at child age 5 years and sweet beverage consumption of the child as dependent variable assessed at child age 7 years (a cross-sectional model using the child age 5-year assessment of independent and dependent variables is available in supplemental material: Table S2). First, independent variables were entered in blocks, corrected for the other variables within this block. The blocks were the socio-demographic characteristics (gender, ethnic background of the child, respondent education level), parental beliefs, parenting practices, and habitual behavior. Second, a final model with all independent variables was fitted. Nagelkerke's R squares are presented to estimate the amount of explained variance for each model.

To evaluate the associations of parental beliefs, parenting practices, habitual behavior and intention to change at child age 5 years with child sweet beverage consumption patterns, multinomial regression model were fitted. Independent variables were entered in blocks: socio-demographic characteristics, parental beliefs, parenting practices, habitual behavior and intention to change, and a model including all independent variables was fitted. Odds ratios (OR) and 95% confidence intervals (95% CI) were estimated. The estimated OR represents the odds for a child to be allocated to a consumption pattern, compared to the reference pattern of low stable consumption, when the parent would have scored one point higher on the independent variable.

The associations between changes in parenting practices and the four patterns of sweet beverage consumption were explored using multinomial regression analyses. The low stable pattern was the reference category. The presented OR's represents the estimated odds for belonging to a consumption pattern if there would be one unit change (e.g. improvement) in the parenting practice. Models were corrected for child gender, ethnic background and educational level of the respondent.

Socio-demographic characteristics were compared between the population for analysis and the remainder of participants in the control condition of the 'Be active, eat right' study using t-tests and Chi-square tests. All analyses were performed with SPSS version 20.0 (IBM Corp., NY, USA).

RESULTS

Children in the population for analysis were aged (mean) 5.7 (SD 0.4) years, 50.5% were boys and 13.5% of the children had a non-Dutch ethnic background (Table 1). According to the parents, the average number of sweet beverages the child consumed at age 5 years was 3.0 (SD 1.4) per day; 67.3% of the children consumed > 2 sweet beverages a day (Table 1).

Compared to the remainder of participants in the control condition of the 'Be active, eat right' study the children included in our population for analyses more often had a Dutch ethnic background (9.3% versus 18.7% non-Dutch, $p < 0.001$). In addition, the respondents in our

Table 1 Characteristics of the study population at child age 5 years (n=2,047)

	Total (n=2,047)	≤2 sweet beverages per day (n=670)	>2 sweet beverages per day (n=1,377)	p-value[1]
Child characteristics				
Age in years, mean (sd) (missing n=7)	5.7 (0.4)	5.7 (0.4)	5.8 (0.4)	0.270
Gender (% boy) (missing n=0)	50.5	50.1	50.7	0.428
Ethnic background (% Dutch) (missing n=29)	86.5	92.7	90.7	<0.001
BMI, mean (sd), kg/m^2 (missing n=7)	15.4 (1.5)	15.4 (1.5)	15.3 (1.4)	0.167
Respondent characteristics				
Gender (% female) (missing n=18)	90.6	90.5	90.7	0.464
Age, mean (sd), in years (missing n=18)	37.1 (4.4)	37.3 (4.3)	37.0 (4.5)	0.130
Country of birth (% Dutch) (missing n=1)	94.9	91.5	96.6	<0.001
Education level (missing n=2)				0.027
Low	2.7	3.0	2.5	
Mid-low	14.7	13.3	15.3	
Mid-high	45.2	41.9	46.8	
High	37.5	41.9	35.3	
BMI, mean (sd), kg/m^2 (missing n=11)	23.8 (3.7)	23.9 (4.1)	23.8 (3.6)	0.542
Child health behavior				
Amount of sweet beverages a day, number of glasses, mean (sd) (missing n=0)	3.0 (1.4)	1.6 (0.5)	3.6 (1.2)	<0.001
Parental beliefs with regard to limiting sweet beverage consumption of the child				
Parental attitude, mean (sd) (missing n=72)	3.4 (0.9)	3.3 (1.0)	3.4 (0.9)	<0.001
Family attitude, mean (sd) (missing n=304)	2.9 (0.9)	2.8 (1.0)	3.0 (0.9)	<0.001
Self-efficacy, mean (sd) (missing n=63)	3.6 (1.1)	3.9 (1.0)	3.5 (1.1)	<0.001
Response efficacy, mean (sd) (missing n=105)	3.3 (1.0)	3.3 (1.1)	3.3 (1.0)	<0.001
Parenting practices concerning child sweet beverage consumption				
Rules, mean (sd) (missing n=111)	2.0 (1.1)	2.2 (1.1)	1.9 (1.1)	<0.001
Monitoring, mean (sd) (missing n=9)	4.1 (1.0)	4.3 (0.9)	4.0 (1.0)	<0.001
Discouraging, mean (sd) (missing n=33)	2.4 (1.0)	2.5 (1.1)	2.4 (1.0)	0.005
Not allowing, mean (sd) (missing n=38)	4.2 (0.9)	4.4 (0.8)	4.1 (0.9)	<0.001
Not buying, mean (sd) (missing n=24)	3.6 (0.8)	3.7 (0.9)	3.5 (0.8)	<0.001
No sweet beverages in the home, mean (sd) (missing n=6)	2.0 (1.0)	2.4 (1.1)	1.9 (0.8)	<0.001
Habit, mean (sd) (missing n=35)	3.7 (0.9)	4.4 (0.8)	3.5 (0.9)	<0.001
Intention to change, mean (sd) (missing n=54)	3.2 (1.1)	3.1 (1.1)	3.2 (1.0)	0.018

[1] P-value from Chi-square test for categorical variables and from t-tests for continuous variables.

Table 2 Results from the multivariable general linear models evaluating the association of sociodemographic characteristics, parental beliefs and parenting practices (child age 5 years) with sweet beverage consumption of the child (glasses a day) at age 7 years

	Model 1	Model 2	Model 3	Model 4	Model 5
	beta (95%CI)	**beta (95%CI)**	**beta (95%CI)**	**beta (95%CI)**	**beta (95%CI)**
n	2,017	1,669	1,861	2,056	1,519
Sociodemographic					
Gender child, boy	0.10 (-0.21; 0.22)				**0.15 (0.02; 0.27)***
Ethnic background of the child, Dutch	-0.03 (-0.25; 0.18)				0.00 (-0.24; 0.24)
Respondent education level					
Low	0.01 (-0.46; 0.46)				-0.22 (-0.82; 0.37)
Mid-low	**0.35 (0.16; 0.54)*****				**0.29 (0.08; 0.49)****
Mid-high	**0.26 (0.13; 0.40)*****				**0.22 (0.08; 0.36)****
High	reference				
Parental beliefs[1]					
Parental attitude		0.03 (-0.06; 0.13)			0.06 (-0.03; 0.15)
Family attitude		-0.04 (-0.14; 0.06)			-0.07 (-0.17; 0.03)
Self-efficacy		**-0.26 (-0.33; -0.20)*****			**-0.14 (-0.21; -0.07)*****
Self confidence		-0.002 (-0.07; 0.07)			0.05 (-0.02; 0.12)
Parenting practices[1]					
Rules			**-0.10 (-0.16; -0.04)****		-0.04 (-0.10; 0.03)
Monitoring			**-0.10 (-0.17; -0.03)****		-0.05 (-0.13; 0.02)
Discouraging			**-0.08 (-0.14; -0.02)***		**-0.10 (-0.17; -0.03)****
Not allowing			**-0.21 (-0.28; -0.13)*****		**-0.18 (-0.27; -0.10)*****
Not buying			-0.04 (-0.11; 0.04)		-0.06 (-0.14; 0.02)
No sweet beverages in the home			**-0.22 (-0.28; -0.15)*****		**-0.16 (-0.24; -0.09)*****
Habit[1]				**-0.40 (-0.47; -0.34)*****	**-0.23 (-0.31; -0.14)*****
Nagelkerke R2(adjusted)[2]	0.009	0.038	0.093	0.076	0.149

[1] For details on the measures used see the supplemental material table S1. Increases on parental beliefs, parenting practices or habit indicate beliefs, practices or habit towards limiting the sweet beverage consumption of the child.

[2] Nagelkerke R square statistic represents the level of variance explained by the general linear model.

Note: number printed **bold** indicate a statistically significant association between independent variable at child age 5 years and mean child sweet beverage consumption at age 7 years. Asterisks indicates the level of significance of the independent variable: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

population for analysis were somewhat older [mean 36.8 (SD 4.2) years versus 35.7 (SD 4.6) years, p< 0.001], had a lower BMI [mean: 23.8 (SD 3.7) versus 24.3 (SD 4.2), p< 0.001], were more often born in the Netherlands (5.1% versus 12.0% outside the Netherlands, p< 0.001) and were higher educated (high level 37.5% versus 28.1%, p< 0.001).

Table 3 Results from the multinomial regression analyses evaluating associations of parental beliefs, parenting practices, habitual behavior and intention to change with the pattern of child sweet beverage consumption

	High stable consumption[1]	Increasing consumption[1]	Decreasing consumption[1]	Low stable consumption[1]
	OR (95% CI)[3]	OR (95% CI)[3]	OR (95% CI)[3]	
Sociodemographic (n=2,017)				
Gender child, boy	1.00 (0.81; 1.25)	0.81 (0.60; 1.09)	0.89 (0.69; 1.16)	1.00
Ethnic background of the child, Dutch	1.30 (0.89; 1.89)	**1.97 (1.09; 3.56)**	1.26 (0.80; 1.97)	1.00
Respondent education level				
Low	2.22 (0.88; 5.60)	1.62 (0.45; 5.85)	2.91 (1.09; 7.78)*	1.00
Mid-low	**2.00 (1.40; 2.86)*****	1.12 (0.68; 1.83)	**1.91 (1.27; 2.85)****	1.00
Mid-high	**1.61 (1.27; 2.05)*****	1.03 (0.74; 1.41)	1.06 (0.79; 1.42)	1.00
High	1.00	1.00	1.00	1.00
Parental beliefs[2] (n=1,669)				
Parental attitude	1.12 (0.94; 1.34)	1.04 (0.83; 1.32)	1.21 (0.97; 1.50)	1.00
Family attitude	1.11 (0.93; 1.35)	0.86 (0.67; 1.11)	1.23 (0.98; 1.53)	1.00
Self efficacy	0.66 (0.58; 0.75)*****	0.76 (0.64; 0.91)****	0.90 (0.77; 1.06)	1.00
Self confidence	0.95 (0.83; 1.09)	0.98 (0.83; 1.17)	0.89 (0.76; 1.04)	1.00
Parenting practices[2] (n=1,861)				
Rules	0.78 (0.69; 0.89)*****	0.82 (0.70; 0.95)*	0.82 (0.70; 0.95)****	1.00
Monitoring	0.77 (0.66; 0.89)*****	0.86 (0.71; 1.05)	0.80 (0.68;0.96)*	1.00
Discouraging	1.01 (0.89; 1.14)	1.02 (0.87; 1.21)	**1.24 (1.07; 1.43)****	1.00
Not allowing	**0.67 (0.56; 0.79)*****	0.88 (0.71; 1.11)	0.76 (0.63; 0.93)****	1.00
Not buying	**0.79 (0.68; 0.92)****	0.94 (0.76; 1.15)	0.84 (0.70; 1.00)	1.00
No sweet beverages in the home	**0.61 (0.54; 0.70)*****	**0.70 (0.59; 0.83)*****	0.81 (0.69; 0.93)****	1.00
Habit[2] (n=2,012)	**0.36 (0.31; 0.42)*****	**0.60 (0.50; 0.72)*****	**0.50 (0.43; 0.59)*****	1.00
Intention to change[2] (n=1,993)	1.11 (1.00; 1.24)*	0.93 (0.81; 1.07)	1.11 (0.98; 1.25)	1.00

[1] Consumption compared at child age 5 and age 7 years and categorized in four patterns.

[2] For details on the measures used see the supplemental material table S1. Increases on parental beliefs, parenting practices or habit indicate beliefs, practices or habit towards limiting the sweet beverage consumption of the child.

[3] The multinomial model estimates the odds ratio (OR) and 95% confidence interval (CI) for being allocated to one of the consumption patterns, compared to the reference pattern of low stable consumption, when the score on the independent variable would increase one unit. Independent variables were entered in blocks. Asterisks represent significance level of the independent variable: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

Note: numbers printed **bold** indicate that the OR was statistically significant at $p<0.05$ in the model including all independent variables (n=1,513).

Table 2 presents the results of the regression analyses, evaluating associations between socio-demographic characteristics, parental beliefs and parenting practices at child age 5 years, and sweet beverage consumption of the child at age 7 years. After including all independent variables in the model, the explained variance was 14.9%. Significant independent variables in this model were: gender of the child (boy), education level of the respondent (higher level), parental self-efficacy, not allowing the child to get sweet beverages, no sweet

Table 4 Results of the multiple multinomial regression model with change in parenting practices as predictor of patterns of sweet beverage consumption of the child (n=1,910)

	High stable consumption[1]	Increasing consumption[1]	Decreasing consumption[1]	Low stable consumption[1]
	OR (95% CI)[2]	OR (95% CI)[2]	OR (95% CI)[2]	
Increase in monitoring sweet beverages consumption[2]	1.02 (0.91; 1.13)	1.02 (0.88; 1.18)	1.04 (0.92; 1.18)	1.00
Increase in discouraging drinking sweet beverages[2]	1.10 (0.99; 1.21)	0.99 (0.87; 1.13)	1.07 (0.96; 1.21)	1.00
Increase in not buying soda for the child[2]	0.97 (0.84; 1.12)	0.93 (0.77; 1.13)	1.02 (0.86; 1.21)	1.00
Increase in not having sweet beverages in the home[2]	1.01 (0.90; 1.13)	0.92 (0.79; 1.07)	**1.26 (1.11; 1.44)****	1.00

[1] Consumption compared at child age 5 and age 7 years categorized in four patterns.

[2] The multinomial model estimates the odds ratio (OR) and 95% confidence interval (CI) for being allocated to one of the consumption patterns, compared to the reference pattern of low stable consumption, when the score on the independent variable would increase one unit. Independent variables represent the change in practices, with an increase indicating a positive change in this practice. The model is corrected for child gender, ethnic background and educational level of the respondent.

Note: numbers printed **bold** indicate statistically significant association; asterisk represents the significance level: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

beverages available in the home, and parental habit of letting the child consume few sweet beverages.

Table 3 presents the estimated ORs for the child to belong to a pattern of sweet beverage consumption. The OR for belonging to the increasing consumption pattern was 0.70 (95% CI 0.59 to 0.83) when parents had less sweet beverages in the home and was 0.60 (95% CI 0.50 to 0.72) when the parent reported that it was a habit to let the child drink few beverages (Table 3). The OR for belonging to the decreasing consumption pattern was 1.24 (95% CI 1.07 to 1.43) when the parent scored higher on discouraging sweet beverage consumption at child age 5 years. When letting the child drink few sweet beverages was a habit of the parent the OR for belonging to the decreasing pattern was 0.50 (95% CI 0.43 to 0.59) (Table 3).

Table 4 presents explorative analyses for the associations of a positive change scores (e.g. improvement) on the parenting practices with the allocation to a sweet beverage consumption pattern. Only an increase in not having sweet beverages in the home was significantly associated with the child belonging to the decreasing consumption pattern, compared to the low stable pattern (OR 1.26, 95% CI 1.11 to 1.44) (Table 4).

DISCUSSION

This study evaluated whether sociodemographic characteristics, parental beliefs and parenting practices with regard to sweet beverage consumption of the child, are associated with child sweet beverage consumption at age 5 and 7 years. The results show that children of parents with a higher self-efficacy and parents that limited accessibility to sweet beverages had the lowest parent-reported sweet beverage consumption at child age 7 years. Also,

children of parents reporting that it was a habit for them to let the child consume few sweet beverages, consumed less sweet beverages. A high availability at home was associated with increasing or high stable consumption patterns among the children. Active discouragement of consumption by the parents was associated with a decreasing consumption pattern. The explorative analysis indicated that decreasing availability of sweet beverages in the home was associated with decreasing consumption.

The association between sweet beverage consumption and both the availability at home and parenting practices, is in line with studies performed among adolescents [15-16]. Interventions may focus on providing parents with the knowledge and skills to resist contextual influences and create a home environment that discourages the consumption of sweet beverages [14, 22, 23]. Higher parental self-efficacy for decreasing child sweet beverage consumption was associated with less consumption of the child. Intervention elements such as education, training and role-playing may contribute to gaining self-efficacy in order to perform beneficial parenting practices related to child health behaviors [24]. The development of a parental habit for letting the child drink less sweetened beverages may be the ultimate goal [16, 25], which is also suggested by the findings of the present study.

Intervention programs may need to focus not only on sweet beverage consumption, but on the promotion of an overall healthy lifestyle of the family [26]. These interventions can benefit child health behavior on the long term by promoting the development of healthy lifestyle habits [14]. During adolescence, there is increasing exposure to sweet beverages outside the home, e.g. through availability at school [27, 28]. Adolescents with stricter parental rules at home may be better able to resist consumption outside the home [29]. Longitudinal studies, with measurements covering the preschool period into adolescence, can provide insight into consumption patterns in combination with availability and parenting practices.

Nevertheless, regulations on national level may contribute to healthier sweet beverage consumption patterns on a larger scale [30, 31, 32]. Parents may be misled by advertisements emphasizing 'healthy' components of a drink (such as vitamin C) while it also contains large amounts of sugar. Advertisements for unhealthy products, such as snacks, have been directly associated with overweight development in children [33, 34]. Strict regulation, as is the case, for example, in Sweden [34, 35] may be an opportunity for overweight prevention; however, the effectiveness of these regulations has not yet been established.

Methodological considerations

The embedding of this study in the 'Be active, eat right' trial allowed to include a large sample of parents and children and evaluate associations longitudinal. The study revealed patterns of sweet beverage consumption, and parental beliefs and parenting practices were compared alongside these patterns.

The following limitations should be considered when interpreting the results. Data were missing on the outcome variables at child age 7 years, which decreased the sample size.

The self-report of parents on their child's health behavior, and on their own beliefs and practices, may lead to socially desirable answers. Also, the associations under study may be bi-directional, e.g. the amount of sweet beverages consumed by the child may influence the parental beliefs and parenting practices.

Conclusions

Sweet beverages are a source of energy contributing to the development of overweight in children [3]. The present study showed that the availability of sweet beverages at home and performed parenting practices are associated with consumption of the child. Overall, longitudinal studies including measures during preschool, primary school and adolescence are recommended to evaluate the sweet beverage consumption patterns and interactions between (changes in) the home environment and child sweet beverage consumption. Intervention development and healthcare practitioners need to encourage and assist parents in developing practices that discourage the consumption of sweet beverages by the child.

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SUPPLEMENTAL MATERIAL

Table S1 Items assessing parental beliefs and parenting practices with regard to their child's sweet beverage consumption

Scale	Scale properties	Scale description	Translated item	Item response scale	Item assessed at child age (years)
Parental beliefs					
Parental attitude	Cronbach's alpha 0.80	Parental attitude towards limiting sweet beverage consumption of the child	I think it is important for my child to drink few sweet beverages	1=totally disagree to 5= totally agree	5
	Scale range 1-5		I think it is good for my child to drink less sweet beverages	1=totally disagree to 5=totally agree	5
			I think it is healthy for my child to drink less sweet beverages	1=totally disagree to 5=totally agree	5
Family attitude	Cronbach's alpha 0.80	Family attitude towards limiting sweet beverage consumption of the child	I think my the child should drink less sweet beverages	1=totally disagree to 5=totally agree	5
	Scale range 1-5		My partner thinks our child should drink less sweet beverages	1=totally disagree to 5=totally agree	5
			My family thinks my child should drink less sweet beverages	1=totally disagree to 5=totally agree	5
Self-efficacy	-	Parental confidence in their own ability to let the child drink less sweet beverages	It is difficult to let the child drink less sweet beverages	1=totally agree to 5=totally disagree	5
Self-confidence	-	Parental perception of their ability to actually perform behavior to let the child drink less sweet beverages	I can let the child drink less sweet beverages	1=totally agree to 5=totally disagree	5
Habit	-	Parental perception of whether letting the child drink less sweet beverages is a habit for them	It is a habit for me to let my child drink few sweet beverages	1=totally disagree to 5=totally agree	5
Intention to-change	-	Parental intention to decrease sweet beverage consumption of the child	I am planning to let my child consume less sweet beverages in the upcoming 6 months	1=totally disagree to 5=totally agree	5
Parenting practices					
Rules	Index range 0-3	Number of rules parents report with regard to child sweet beverage consumption	Do you have rules in your home about		
			- how many sweet beverages your child can consume	0= no 1= yes	5
			- when your child can consume sweet beverages	0= no 1= yes	5
			- what type of sweet beverage your child can consume	0= no 1= yes	5
Monitoring	-	Parental monitoring of the consumption of sweet beverages of the child	To what extent do you monitor how many sweet beverages your child consumes?	1=never to 5=always	5 and 7
Discouraging	-	Parental discouragement of consumption of sweet beverages of the child	How often do you tell your child not to consume sweet beverages	1=never to 5=always	5 and 7
Not allowing	Cronbach's alpha 0.81	Parental regulation of sweet beverage consumption of the child	How often can your child decide him/ herself		
	Scale range 1-5		- to get sweet beverages without asking	1=always to 5=never	5
			- when to consume sweet beverages	1=always to 5=never	5

Table S1 (*continued*)

Scale	Scale properties	Scale description	Translated item	Item response scale	Item assessed at child age (years)
			- how many sweet beverages he or she will consume	1=always to 5=never	5
Not buying	Cronbach's alpha 0.79	Parental compliance to the child when the child requests sweet beverages	When your child would tell you he/she liked a specific type of soft drink, would you buy this?	1=always to 5=never	5 and 7
	Scale range 1-5		Do you buy certain types of soft drinks because your child asks you to?	1=always to 5=never	5 and 7
Availability		Availability of sweet beverages in the home	Usually there are sweet beverages available in our home	1=totally agree to 5=totally disagree	5 and 7

Table S2 Results from the multivariable general linear models evaluating the association of sociodemographic characteristics, parental beliefs and parenting practices (child age 5 years) with sweet beverage consumption of the child (glasses a day) at age 5 years

	Model 1	Model 2	Model 3	Model 4	Model 5
	beta (95% CI)	**beta (95% CI)**	**beta (95% CI)**	**beta (95% CI)**	**beta (95% CI)**
n	2,017	1,669	1,861	2,012	1,519
Sociodemographic					
Gender child, boy	0.04 (-0.08; 0.16)				0.09 (-0.04; 0.21)
Ethnicity child, Dutch	**0.20 (0.01; 0.42)***				0.15 (-0.08; 0.38)
Respondent education level					
Low	0.18 (-0.29; 0.64)				-0.22 (-0.79; 0.35)
Mid-low	**0.39 (0.20; 0.57)*****				**0.35 (0.15; 0.54)****
Mid-high	**0.28 (0.15; 0.42)*****				**0.23 (0.10; 0.36)****
High	reference				
Parental beliefs[1]					
Parental attitude		0.06 (-0.04; 0.15)			**0.09 (0.002; 0.18)***
Family attitude		0.01 (-0.09; 0.11)			-0.02 (-0.12; 0.07)
Self-efficacy		**-0.23 (-0.30; -0.17)*****			-0.05 (-0.11; 0.02)
Self-confidence		-0.04 (-0.11; 0.03)			0.05 (-0.02; 0.11)
Parenting practices[1]					
Rules			**-0.11 (-0.17; -0.05)****		-0.06 (-0.12; 0.01)
Monitoring			-0.05 (-0.12; 0.02)		0.06 (-0.02; 0.13)
Discouraging			-0.05 (-0.11; 0.01)		-0.05 (-0.12; 0.01)
Not allowing			**-0.27 (-0.34; -0.19)*****		**-0.21 (-0.29; -0.13)*****
Not buying			**-0.10 (-0.17; -0.02)***		**-0.10 (-0.17; -0.02)***
No sweet beverages in the house			**-0.37 (-0.44; -0.31)*****		**-0.28 (-0.35; -0.21)*****
Habit[1]				**-0.58 (-0.64; -0.52)*****	**-0.41 (-0.49; -0.33)*****
Nagelkerke R2 (adjusted)[1]	0.012	0.151	0.037	0.151	0.240

[1] For details on the measures used see the supplemental material table S1. Increases on parental beliefs, parenting practices or habit indicate beliefs, practices or habit towards limiting the sweet beverage consumption of the child.

[2] Nagelkerke R square statistic represents the level of variance explained by the general linear model.

Note: numbers printed **bold** indicate statistically significant association between independent variable at child age 5 years and mean child sweet beverage consumption at age 7 years. Asterisks represent the level of significance of the independent variable: * $p<0.05$, ** $p<0.01$, *** $p<0.001$.

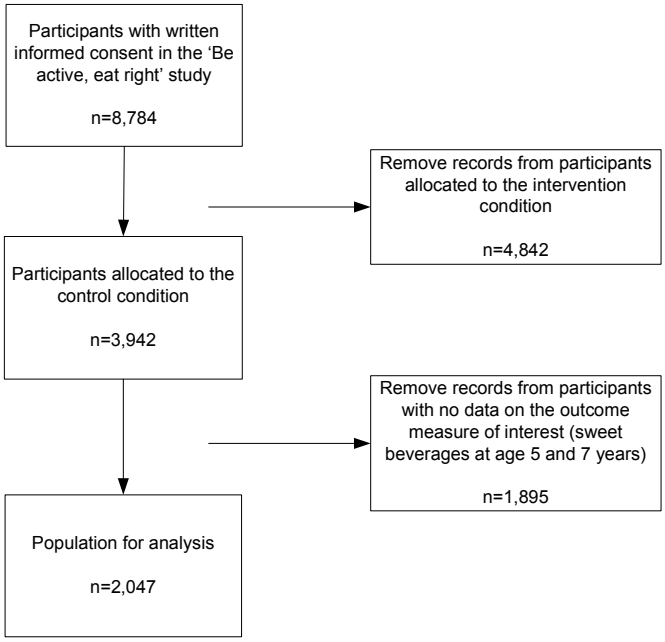

Figure S1 Flow chart showing the selection of participants for analysis

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General discussion

This thesis described studies evaluating the effects of interventions promoting a healthy weight and lifestyle among children. In addition, associations between weight status and health outcomes were evaluated and the determinants of sweet beverage consumption of children were explored. The study questions were:

1. What are the effects of interventions promoting a healthy weight and lifestyle among children?
   1.1. Effects of a prevention protocol for parents of overweight children on child BMI, waist circumference and health behaviors (chapter 2 and 3)
   1.2. Effects of interventions aiming to decrease sedentary behavior of children in the general population on child BMI and sedentary behavior (chapter 4)
2. What indicators of psychosocial and physical health are associated with child weight status?
   2.1. Associations between overweight and obesity and health-related quality of life in childhood (chapter 5)
   2.2. Associations between overweight and obesity and psychosocial and physical health outcomes in childhood (chapter 6)
3. What socio-demographic characteristics, parental beliefs and parenting practices are associated with children's sweet beverage consumption? (chapter 7)

In this general discussion, the results of the studies presented in the thesis are summarized and interpreted alongside the existing literature. Methodological considerations with regard to the presented studies are discussed. Recommendations for future research and implications for policy and practice are presented. An overall conclusion is given.

MAIN FINDINGS AND INTERPRETATION

What are the effects of interventions promoting a healthy weight and lifestyle among children?

Effects of a prevention protocol for parents of overweight children on child BMI, waist circumference and health behaviors.

In **chapter 2** and **chapter 3** the effects of the prevention protocol performed in the Dutch youth health care were described. The evaluated prevention protocol provided parents of 5 to 7 year old children with overweight additional healthy lifestyle counseling. There was no overall difference between intervention and control condition with regard to Body Mass Index (BMI), waist circumference or health behaviors after two years of follow-up. We did observe a smaller increase in BMI for children with mild overweight (BMI 17.25 and 17.50) in the intervention

condition. Children in both intervention and control condition consumed less sweet beverages at follow-up compared to baseline. The use of the prevention protocol may be improved.

Overall, similar minor effects have been reported by studies evaluating interventions offering additional health counseling visits in well-child clinics and primary care [1-5]. Parents are often unaware or misperceive their child's weight status, or parents are unaware of the consequences associated with childhood overweight and obesity [6-8]. The prevention protocol is a low intensive intervention and during the health counseling some awareness of the child's overweight may be created among parents. However, for obese children, more intensive, multidisciplinary interventions have proven to be more effective in changing health behaviors [9-11]. We observed a falling attendance of parents to the additional counseling sessions, this has also been reported for health counseling interventions performed in comparable settings [1-2]. Health care professionals in our study reported that it was difficult to motivate parents to attend additional sessions and change health behavior[12]. Parents of overweight children may be challenging to motivate because the child's overweight is not very visible to the parents [6, 13]. Also, parents may believe the child will grow and loose the excess weight, or has a genetic predisposition that cannot be changed [14]. In addition, parents may not see the benefits of participating in an intervention [15].

To increase participation of parents in health counseling interventions, health care professionals can be trained in using motivational interviewing techniques [2, 16-17]. Motivational interviewing techniques have been shown to be effective when working with parents of obese children [2, 17-18]. Due to time and budget restraints, the youth health care professionals using the prevention protocol were given a half a day training in motivational interviewing techniques. To acquire profound motivational interviewing skills, practice, feedback on performance and refreshment sessions are recommended [16-17].

Youth health care has a high reach among parents and their children [19]. There are frequent and planned appointments with parents and children, especially in the first years of life. With the regular appointments, youth health care has the opportunity to monitor child growth and development and detect overweight in an early stage; the individual setting creates an opportunity to provide subsequent tailored care to parents. The latest guideline for youth health care on overweight among children incorporates the prevention protocol [20-21].There may be opportunities to adjust and improve the prevention protocol. The regular well-child visit may be used to integrate elements of the prevention protocol. To increase participation in the additional sessions social media, text messages, or e-mail to remind parents of their upcoming visit may be used. Internet-based tailored advice may be used to complement the well-child visit or the additional sessions [22-23]. Effects of these adjustments will need to be evaluated. Implementation of the prevention protocol in the youth health care structure may be considered part of a broader approach to overweight prevention. We recommend the promotion of a healthy weight and lifestyle on local level, including professionals from both prevention and care to create an integrated approach [24-26].

Effects of interventions aiming to decrease sedentary behavior of children in the general population on child BMI and sedentary behavior.

In **chapter 4**, a systematic literature review including a meta-analysis provided an overview of interventions aiming to reduce sedentary behavior to contribute to childhood overweight prevention. With the meta-analysis the reported effects of each intervention on sedentary behavior and BMI, were combined to provide an estimated overall intervention effect. The estimated overall effect post-intervention was 20 minutes decrease in sedentary behavior a day and 0.14 points decrease in BMI. The findings showed that there was no difference in the estimated effect when comparing interventions focusing solely on sedentary behavior and interventions targeting multiple health behaviors.

Sedentary behavior is increasing across the population [27-28]. Research has shown that sedentary behavior, especially TV viewing, is associated with overweight [29-31]. The findings from our study showed that efforts to reduce sedentary behavior of children can contribute to overweight prevention.

The lack of difference between an intervention solely focusing on sedentary behavior and the multiple health behavior interventions has previously been reported [32]. Multiple health behavior interventions had program elements focusing both on sedentary behavior as well as physical activity or dietary behaviors. In the sedentary behavior interventions the program focused entirely on sedentary behavior. With regard to the intervention elements focusing on sedentary behavior, both types of interventions often included a component that required the child to identify alternative activities for the time usually spent in sedentary behavior (e.g. outside play) [33-35]. Herewith both interventions became more alike. Moreover, these elements could have caused children to change related health behaviors. Owen and colleagues [36] have suggested that replacing sedentary activities with light physical activity can be effective for improving musculoskeletal and metabolic health. Therefore the inclusion of health-related behaviors is recommended for future research. Also, we recommend objective measures of activity such as accelerometers to identify different levels of activity. For example, Healy and colleagues [37] have suggested that a positive effect on metabolic health may be achieved by increasing the number of breaks during sedentary behavior.

Interventions were often implemented in the school setting. Besides having a broad reach, the school setting offers the opportunity to combine health education with environmental changes (e.g. healthy school cafeteria or school play grounds) to potentially enhance effects of the intervention [38]. Moreover, involvement of parents with the intervention by using newsletters or organizing meetings was an often reported intervention element. Especially in younger children, parents have an important role in creating sustainable health behavior change among the child [39-40]. In order to disentangle the association between sedentary behavior and weight we recommend detailed reports of intervention designs and elements.

To summarize, in the first part of this thesis (chapter 2 and 3) the effects of an intervention performed in youth health care were described. In the intervention condition smaller increases in child BMI, for children who were mildly overweight, were observed. There were no effects of the intervention on overweight related health behaviors when intervention and control condition were compared. In chapter 4 a systematic review with meta-analysis showed that interventions aiming to decrease sedentary behavior, can achieve decreases in sedentary behavior and BMI among the general population of children. To promote a healthy weight and lifestyle among children an integrated approach is recommended, combining individual tailored interventions and interventions performed among the general population.

What indicators of psychosocial and physical health are associated with child weight status?

Associations between overweight and obesity and health-related quality of life in childhood.

In **chapter 5,** the health-related quality of life of 5 to 6-year old children with overweight, obesity and severe obesity was explored. Children who were severely obese showed lower parent-reported health-related quality of life scores on the physical functioning domain, when compared to normal-weight children. Parent-reported health-related quality of life on the psychosocial domain was not statistically different for children with normal weight, overweight or (severe) obesity.

The results of our study, being that obese children entering elementary school have lower scores with regard to the physical functioning domain of health-related quality of life, are in line with findings among older overweight and obese children and adolescents [41-44]. It is unclear which mechanisms are underlying the association between BMI and lower physical health-related quality of life. A suggestion by Shoup and colleagues [45], that there may be an independent association between physical activity level of the child and health-related quality of life, could not be confirmed in our study.

We observed no association between overweight or obesity and psychosocial health-related quality of life. This is in line with studies performed among school-aged children [46-47]. Among adolescents, lower psychosocial health-related quality of life has been reported[48]. When children become older, hypothetically especially during adolescence, bullying by peers increases, leading to negative self-evaluation and lower self-esteem [49]. We did observe lower parent-reported self-esteem scores for obese children with the explorative analyses.

Overall, relatively small decreases in health-related quality of life among overweight and obese children were observed in our study. However, keeping in mind the more pronounced findings among older children and adolescents, physicians, teachers and parents are recommended to be aware of the potential negative impact overweight may have among young children. We recommend the inclusion of health-related quality of life measures in

longitudinal research studies to evaluate the association between changes in weight status and health-related quality of life.

Associations between overweight and obesity and psychosocial and physical health outcomes in childhood.

The study in **chapter 6**, described the association of overweight and obesity in 7-year-old children and indicators of psychosocial and physical health outcomes. Children who were overweight or obese visited the general practitioner more often, but there was no difference between overweight, obese and normal-weight children with regard to reported physical health conditions such as asthma symptoms, abdominal pain or migraine. According to their parents, 7-year-old overweight and obese children experienced more insecure feelings and adverse treatment. Children who were overweight or obese at age 5-years and at 7-years had a higher risk for experiencing weight-related adverse treatment and insecure feelings, as reported by their parents, compared to children who were normal-weight.

The parent-reported insecure feelings and adverse treatment of overweight and obese 7-year-old children concur with findings observed among children of similar age range (5 to 9 years) [50-52]. Moreover, children who are overweight or obese at age 4-5 years have been reported to have more emotional and peer problems at age 8-9 years [51].

With regard to indicators of physical health, the literature suggests several physical consequences related to overweight among children [53-55]. In our study we could not confirm an association between being overweight or obese at age 5 years and measured health consequences at age 7 years. However, children who were overweight or obese visited the general practitioner more frequent than normal-weight children. From the age of 6 years, parents seem to become more aware of the overweight of their child [56]. This increased awareness may have been reflected in the more frequent visits to the general practitioner observed in our study.

Our findings add to the literature by evaluating weight trajectories, based on weight status at age 5-years and at age 7-years, in relation to indicators of psychosocial and physical health outcomes [50-52]. Children with overweight or obesity at age 5 and 7 years, or children with an increasing weight status and categorized as being overweight or obese at age 7 years, showed the highest odds for being treated adversely or feeling insecure. Research has shown that teasing and adverse treatment can lead to lower self-esteem and negative self-evaluation among adolescents [49]. Moreover, these internalizing factors have been associated to lower school functioning [57-59]. Therefore, early interventions promoting a healthy weight and lifestyle among children are recommended. Moreover, awareness for potential adverse treatment or insecure feelings the children are experiencing is needed, and appropriate counseling should be available.

The second part of this thesis focused on indicators of psychosocial and physical health outcomes of children who are overweight or obese at 5 and 7 years of age. According to their parents, severely obese children have lower physical health-related quality of life. Overweight and obese children experience more adverse treatment and insecure feelings at age 7 years compared to their normal-weight peers. Health care practitioners need to be aware of possible adverse health outcomes and provide parents and children with appropriate counseling as part of interventions to normalize weight.

Findings with regard to children with relative underweight

Chapter 5 and chapter 6 described the short-term health outcomes of children categorized, according to their BMI, as having relative underweight. Findings showed that underweight children experienced lower parent-reported physical health-related quality of life at age 5 years (chapter 5). Moreover, according to their parents, underweight children had higher odds to be treated adversely or to feel insecure compared to normal-weight children at age 7 years (chapter 6).

There is limited research available with regard health outcomes related to underweight in children; the few studies evaluating health-related quality of life among underweight children and adolescents report similar lower scores for physical health-related quality of life [47, 60-61].

With regard to indicators of psychosocial health outcomes, our finding that adverse treatment is associated with underweight, has been reported in studies performed among adolescents [49, 62]. Among underweight children, lower physical health outcomes have been reported in the study by Wake and colleagues [55].

Young underweight children may develop a healthy or normal weight when they grow older, if no diseases are present [63]. Nevertheless, the findings indicate that health care professionals monitoring growth and weight of children should also be attentive to signals from the child with relative underweight with regard to adverse treatment and insecure feelings.

What socio-demographic characteristics, parental beliefs and parenting practices are associated with children's sweet beverage consumption?

The third part of this thesis, **chapter 7,** described the association between parental beliefs, parenting practices and sweet beverage consumption of the child. Results showed that children of parents with a high self-efficacy to limit child sweet beverage consumption, and children of parents limiting the availability of sweet beverages at home, had the lowest parent-reported sweet beverage consumption at age 7 years. A high availability of sweet beverages at home at child age 5 and 7 years, was associated with increasing or high child sweet beverage consumption.

The association between sweet beverages and overweight suggests that this is a health behavior promising to target with health promotion interventions [64-67]. Our finding, that accessibility of sweet beverages at home is associated with higher consumption, is in line

with findings observed among adolescents [68-69]. We observed that children of parents that reported to more often allow the child to consume sweet beverages, drank more sweet beverages.

During childhood, the home environment contributes to the health behaviors children develop [70-71]. In line with advertisements for types of snacks, parents may not be aware of the unhealthy components of specific sweet beverages (e.g. sugar) [72-73]. Complementary, parents need to acquire parenting practices or parenting skills that can help them in limiting child sweet beverage consumption at home [74]. Intervention elements such as education, training and role-playing may contribute to gaining self-efficacy in order to perform beneficial parenting practices related to child health behaviors [75]. Parents that report limiting sweet beverage consumption of the child as a habitual parenting practice had children consuming less sweet beverages a day. Therefore, the goal of interventions should be to create a healthy home environment with habitual parenting practices limiting child sweet beverage consumption [69, 71].

Our results emphasize the need for interventions when children are young, focusing on the home environment and parenting practices [70-71]. Besides targeting an overall healthy family lifestyle, policies may be in place to inform parents on the content of sweet beverages and to discourage parents buying sweet beverages [76-78].

In summary, the third part of this thesis showed that parents reluctant to have sweet beverages available at home reported their children to consume less sweet beverages. Intervention elements may focus on the home environment to decrease availability of sweet beverages; parents need to be assisted in developing and performing parenting practices limiting child sweet beverage consumption.

METHODOLOGICAL CONSIDERATIONS

There are some methodological considerations that need to be taken into account when interpreting the findings of the discussed studies. All studies, except for the systematic review and meta- analysis (chapter 4), were based on data collected in the 'Be active, eat right' study. Firstly, methodological considerations with regard to the 'Be active, eat right' study will be discussed. Secondly, methodological considerations with regard to the systematic review and meta-analysis will be discussed.

The 'Be active, eat right' study

Setting and population

The 'Be active, eat right' study was performed among multiple youth health care centers in the Netherlands [79]. At the start of the study, all Dutch youth health care centers were informed about the study and invited to participate. Not all youth health care centers could participate; an inclusion criteria was the possibility to include a 'usual care' control condition (some centers already used the prevention protocol). Nevertheless, the participating youth health care centers were located across the Netherlands.

Of the parents invited to participate, 64.4% returned the written informed consent for participation in the study [80-81]. Often, higher educated people take part in health-related research [80-82]. In the current study no specific actions were undertaken to encourage participation of non-Dutch or lower educated parents. The distribution of education level of the parents in our study sample was comparable to the distribution in the general Dutch population in 2009 (Statistics Netherlands). However, both the selection of youth health care centers and the selection of participating parents, may have limited the inclusion of specific subgroups and therefore the possibility to perform specific analysis with regard to these subgroups.

Missing data

After two years 62.9% of the 'Be active, eat right' study baseline participants completed a follow-up questionnaire. In cohort studies, retention and loss-to-follow up is a common issue [83]. In the 'Be active, eat right' study efforts were made to retain parents throughout the study (e.g. reminder messages, telephone contact) [84-85].

For each of the studies described in this thesis a population of analysis was created from the total study sample. These populations for analyses differed due to missing data on the variables of interest. Missing data does not necessarily influence the associations under study; however, it does decrease sample size and therefore possibilities to perform an evaluation among specific subgroups based on socio-demographic characteristics or relevant child characteristics [83, 86].

Imputation of missing data using multiple imputation techniques was explored for the studies described in chapter 2 and 3 [87]. The results from these analyzes, performed in a complete, imputated, dataset, were comparable to those performed in the original datasets with missing data. Therefore, results from the analyses based on the original data, including missing data, were presented.

Measurements

In the 'Be active, eat right' study two types of measurements were performed to assess determinants and outcomes. To start, parent-report questionnaires were used. Parent-report may lead to over- or underestimation of certain health behaviors; hypothetically parents provide

socially desirable answers. In addition, parents were required to recall and report their own and their child's past behavior, which may lead to recall bias. We recommend future research to use, for certain behaviors, objective measures, such as accelerometers for measuring physical activity, among a subsample of the children participating in the study. With these objective measures the accurateness of the parent-reported physical activity of the children can be evaluated. Also, parents may not be aware of the child's behavior outside the home, at child day-care or after school care. To investigate child behavior in these settings, observational data could be collected. Parent-report questionnaires may be used to complement these objective and observational measures.

Height, weight and waist circumference of the children were measured following standardized protocols. The protocols used for these measures are similar to those used in the Dutch nationwide growth studies [88-89]. The use of these protocols contributed to minimizing measurement error; it can be considered a strength of the study. The international cut-off values were used to categorize children into weight categories [90]. We recommend future research specifying subgroups of overweight, obese and severe obese children, using the by Cole et al recommended criteria [91]. Our research has shown different effects on health outcomes for these groups. Subsequently, it should be studied whether interventions should use a different approach for parents of, and children who are, overweight, obese or severely obese. Moreover, if groups are combined in an intervention study, effects should preferably be presented separately for each group.

Evaluation of the effectiveness of the prevention protocol

In chapter 2 and 3 the effects of the prevention protocol for overweight children and their parents were evaluated. This evaluation was performed within the 'Be active, eat right' study. The 'Be active, eat right' study was set up as a cluster randomized controlled trial. Clusters, the youth health care teams, were assigned to either intervention or control condition. This randomization procedure limited contamination of the control condition; youth health care professionals within a team performed either intervention or usual care. However, children visiting one health care team may have similar characteristics, influencing the outcomes of the study. Therefore, at the level of analyses the clustered design of the study was taken into account [92-93].

Almost half of the parents attended an additional counseling session. Youth health care professionals reported difficulties motivating parents to attend the sessions. Although motivational interviewing techniques have been shown to be effective in motivating parents of overweight and obese children [2, 16-18], the training in motivational interviewing techniques provided to youth health care professionals in this study may not have been sufficient to acquire effective motivational interviewing skills. Implementing feedback on performance and refreshment sessions with regard to motivational interviewing techniques may be recommended to enhance future use of the prevention protocol [16].

The difficulty the youth health care professionals experienced in motivating parents to attend the additional sessions was reflected in the relatively low attendance rate and high attrition from the first to the third additional session. Few parents received all three additional counseling sessions. Specifically, parents participating in the additional counseling sessions of the intervention were often Dutch and higher educated. We recommend studying what kind of interviewing techniques can be used, to support youth health care professionals using the prevention protocol for all subgroups.
The prevention protocol is an intervention designed for implementation in the youth health care structure and the evaluation study was set up and performed within this structure. In the Netherlands and among the youth health care professionals in the control condition, the prevention of overweight among children received much attention, this may have limited the contrast between the intervention and control condition. Unfortunately, there was limited information available on the actions undertaken by youth health care professionals in the control condition.

Considerations with regard to the studies evaluating association between weight status and health outcomes, and the home environment and sweet beverage consumption of the child (chapter 5, 6 and 7)

In chapter 5 a cross-sectional design is used to explore associations between weight status and health-related quality of life. In chapter 6 and chapter 7 firstly a cross-sectional design and secondly a prospective design was used to explore associations.
The prospective evaluations in chapter 6 and 7 were based on the baseline and follow-up measurements. A longitudinal design with multiple measurements may provide additional information about patterns of change. Especially because there are possible bi-directional influences in the associations under study parenting practices may be adapted to changes in child sweet beverage consumption (chapter 7). Future studies are recommended to include multiple time points to assess associations on the longer term [94-95].

Systematic review and meta-analysis

Search strategy and study inclusion

A systematic literature review was conducted. Two authors independently assessed collected references, abstracts and full-text articles using transparent in- and exclusion criteria to select intervention studies. Studies that were included were reviewed with a quality assessment described by the Cochrane collaboration [95], which gives information about the quality of reporting and can be used to direct future reporting of intervention studies.
Although we searched multiple literature databases to find relevant interventions studies to be included in the review and meta-analysis, publication bias may have influenced the studies we were able to identify; more interventions that are effective in changing the outcomes measured are published than studies that do not show an effect.

Reporting of intervention outcomes

The meta-analysis highlighted the heterogeneity of the outcomes of sedentary behavior the different intervention studies reported. Therefore, we were not able to provide effect estimates for specific types of sedentary behavior (e.g. DVD viewing, computer gaming). Our effect estimate of sedentary behavior was mainly based on TV viewing time. Research has suggested that TV viewing represents only one third of the time spent sedentary [97]. Nevertheless, TV viewing has been associated with several negative health outcomes [29-30].
Our meta-analyses also showed that studies were often reluctant in reporting long-term follow-up measurements of intervention effects. This limited the possibility to draw conclusions on the sustainability of the intervention effects observed.

Combining intervention effects using meta-analysis

The estimated overall intervention effect on sedentary behavior and BMI was estimated using both a random and a fixed model. With a random effects model, variance is expected across the intervention studies included in the comparisons [98]. We provided both estimates of the overall effect with a random and a fixed effects model. Also, effect estimates were provided for intervention effects without using a correction for baseline value of the outcome and with correction for the baseline value of the outcome.
In our meta-analysis, age of the children and setting of the intervention were evaluated as variables moderating the intervention effects observed. For these variables no moderating effects were observed. The variability of characteristics of the interventions limited the possibility to evaluate other moderator variables.

RECOMMENDATIONS FOR FUTURE RESEARCH

Study design and measurements

- Longitudinal study designs are recommended with the inclusion of multiple time points of measurement. This may provide further understanding of associations between determinants of health behavior or weight status and outcomes. Moreover, studies evaluating mediating mechanisms between the home environment, health behaviors, weight status and health outcomes are needed.
- To adequately investigate child health behavior, complementary use of objective measurements, observational research and (parental) self-report is recommended.
- Differentiation in subgroups of overweight, obese and severely obese children is recommended to evaluate determinants of health behavior and health outcomes specifically for these subgroups. In addition, specification of the subgroup of children with relative underweight in research is recommended.

Intervention development and evaluation

- Interventions designed to change health behavior among high-risk groups should be implemented alongside interventions designed to promote a healthy lifestyle among the general population of children and families.
- Interventions may target both the child and the parents to create a healthy family lifestyle and home environment. Home environmental determinants should be studied within the broader context of the local neighborhood (e.g. food stores, sports and regular activity opportunities). Evaluation of these determinants and their interplay, can contribute to the development of interventions tailored to the family and environment.
- Evaluation of the implementation process of interventions is recommended.
- Qualitative research may identify opportunities to improve the prevention protocol and the implementation of the protocol; parents, children and youth health care practitioners should be included in these studies.

IMPLICATIONS FOR PRACTICE AND POLICY

Use of the prevention protocol in youth health care

- Youth health care can contribute to childhood overweight prevention by monitoring child growth and development. This creates the opportunity for youth health care to identify children who are at risk to develop overweight and to detect overweight or obesity among children at an early stage. Subsequently, youth health care may guide parent and child to an intervention that suits the family.
- The prevention protocol can be implemented in the youth health care structure and may contribute to the promotion of a healthy lifestyle for children and parents. However, the effects of the prevention protocol on health behaviors and measures of body composition in its current form may be minor and only for the specific group of children with mild overweight.
- Youth health care has the opportunity to reach the group of children at risk to develop overweight or obesity. The prevention protocol may be used to create awareness among parents of their child's overweight, associated risks and health behaviors. Specifically, the results in this thesis suggest that to enhance parental motivation and awareness and to offer appropriate counseling, youth health care professionals may inform parents about the insecure feelings and adverse treatment children can experience when they are overweight or obese. The results in this thesis also suggest that the home environment is important with regard to the health behavior children perform. Therefore, we recommend youth health care professionals to support parents with advice regarding on how to develop and maintain a healthy home environment.

- The use of e-mail, text messages or other social media is recommended to remind parents of upcoming additional sessions. Tailored advice may be offered through the Internet, complementing or replacing the additional sessions.
- We recommend providing youth health care professionals with training in motivational interviewing techniques. These techniques can help youth health care professionals motivate parents to change family health behavior and support parents in what they need to develop a healthy family lifestyle. Rehearsal, refreshment sessions and feedback on performance may need to be scaled up in order for professionals to acquire skills and feel confident in performing these techniques.

Local care for children with overweight and obesity

- A local approach to overweight prevention is recommended. Both overweight prevention initiatives targeting the local community of children (e.g. healthy school cantinas) and interventions for high-risk groups (e.g. prevention protocol) should be implemented. A local approach to prevention and care for children with (risk of) overweight and obesity is recommended to minimize drop-out of parents and children from the programs and making it easier for parents and children to continue the activities after the program finishes.
- In addition, an integrated care approach for overweight and obese children is recommended. Youth health care may here play an important role because the professionals working in this setting have the opportunity to early detect overweight and obesity. Implementing an integrated care approach includes all health care professionals agreeing upon a set of actions that describe what to do when a child with overweight or obesity is detected. These actions describe detection, referral, treatment and follow-up for children with overweight and obesity. The care that is provided to children is well coordinated and adapted between different care providers. Moreover, parents and children are referred to a local intervention program that suites them.
- We recommend an integrated approach to involve both professionals from both prevention and care for overweight and obese children (for example, general practitioners, social workers, sports clubs trainers or physiotherapists).
- Monitoring of such an integrated care approach is recommended to evaluate progress and make adjustments if needed. Moreover, results from monitoring can be used to inform and motivate all people involved.

Policies to stimulate collaboration and integrated care

- The municipalities can have a coordinating and leading role in implementing local health policy to prevent overweight among children and their families. Health policy contributing to overweight prevention should take place on neighborhood or community level, such as providing opportunities for children to play outside or ride a bicycle to school.

Intervention programs promoting a healthy lifestyle for both the general population and high-risk groups should be available on a local level. In addition, in their health policy the municipalities can support and coordinate an integrated care approach for children with overweight and obesity.

GENERAL CONCLUSION

This thesis aimed to describe interventions promoting a healthy weight and lifestyle among children and provide insight in elements that may be related to intervention improvement. Youth health care has an important role in the early detection of overweight and obesity among children. The prevention protocol is an intervention that can be implemented in the youth health care setting. The in this thesis described evaluation of the prevention protocol showed limited effects of the intervention on health behaviors and BMI of the children.

Some recommendations can be made for future use of the prevention protocol. The prevention protocol may be used to create awareness of the child's overweight among parents and motivate them to change health behavior. The prevention protocol offers the opportunity to discuss potential negative health outcomes such as insecure feelings the child may be experiencing. Also, parents may be assisted in learning skills to promote healthy behavior of the child and to create a healthy home environment. Youth health care has the opportunity to, an individual level, discuss with the family what they need in order to develop a healthy family lifestyle. Moreover, youth health care may guide the child to an intervention that suits the family.

Individual focused interventions such as the prevention protocol, should be implemented in combination with interventions targeting the general population. A study in this thesis showed that interventions among the general population of children can help decrease sedentary behavior and BMI.

A local integrated approach to prevent and care for children with overweight and obesity is recommended; care providers have working arrangements with regard to detection, care and follow-up of children with overweight and obesity and all health care professionals are committed to providing local prevention and care. This integrated approach will promote sustainable health behavior change and the development of a healthy lifestyle among children and their families.

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Summary
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SUMMARY

Overweight and obesity among children has become a public health issue. Both short and long term adverse health outcomes have been associated with overweight and obesity among children. Interventions during childhood are initiated and evaluated to promote the development of healthy lifestyle habits. This thesis aimed to describe interventions promoting a healthy weight and lifestyle among children and provide insight in elements that may be related to intervention improvement. The following research questions were addressed:

1. What are the effects of interventions promoting a healthy weight and lifestyle among children?
   - 1.1. Effects of a prevention protocol for parents of overweight children on child BMI, waist circumference and health behaviors (chapter 2 and 3)
   - 1.2. Effects of interventions aiming to decrease sedentary behavior of children in the general population on child BMI and sedentary behavior (chapter 4)
2. What indicators of psychosocial and physical health are associated with child weight status?
   - 2.1. Associations between overweight and obesity and health-related quality of life in childhood (chapter 5)
   - 2.2. Associations between overweight and obesity and psychosocial and physical health outcomes in childhood (chapter 6)
3. What socio-demographic characteristics, parental beliefs and parenting practices are associated with children's sweet beverage consumption? (chapter 7)

The first part of the thesis focused on interventions promoting a healthy lifestyle among children. We started with the evaluation of the prevention protocol with regard to effects on BMI, waist circumference and health behaviors of 5 to 7 year old children in **chapter 2** and **chapter 3**. In 2004 a protocol was developed for youth health care to uniformly detect children who are overweight or obese. The prevention protocol was presented in 2005, it describes a set of actions that can be undertaken when a child with overweight is detected when visiting youth health care. Youth health care in the Netherlands monitors growth and development of all children from birth to 18 years of age during regular well-child visits. The prevention protocol is used in youth health care by offering healthy lifestyle counseling to parents of overweight children during the regular well-child visit, and during up-to-three optional additional sessions. The prevention protocol describes five behaviors that can be targeted during the counseling: promotion of breast feeding for infants, having daily breakfast, playing outside, limiting sweet beverage consumption and limiting television viewing and computer gaming. The effects of the prevention protocol on BMI, waist circumference and health behaviors of 5-year-old children were evaluated in a cluster randomized controlled trial. **Chapter 2**

describes that children' with mild overweight (BMI 17.25 en 17.50) in the intervention condition (in which parents received the prevention protocol) had less BMI increase between age 5 and 7 years. No clear differences were reported when comparing the intervention and control condition with regard to child health behaviors, described in **chapter 3**. We did observe that children in both intervention and control condition consumed less beverages at 7-years compared to 5-years. Some opportunities for improvement of the prevention protocol were suggested, specifically, participation in the additional sessions could be increased.

The individual approach described in the second and third chapter may be complementary to interventions implemented among children in the general population. In **chapter 4** a systematic review and meta-analysis is described, evaluating interventions aiming to reduce sedentary behavior for childhood overweight prevention. Sedentary behavior is one of the health behaviors associated with overweight; a reduction in sedentary behavior may contribute to overweight prevention. The evaluated interventions were performed among the general population of children. Individual intervention effects were combined to provide an estimated overall intervention effect. The results showed that together the interventions could achieve a decrease in both sedentary behavior and BMI of children in the general population.

In the second part of this thesis, associations between child weight status and indicators of health were evaluated. While there is literature describing psychosocial and physical health outcomes associated with overweight and obesity among older (8-12 years) children and adolescents this is limited for the association among younger children. In **chapter 5** the association between overweight, obesity and severe obesity and health-related quality of life of 5-year-old children is evaluated. Children who were severely obese experienced lower parent-reported health-related quality of life on the physical functioning domain, when compared to normal-weight children. Parent-reported health-related quality of life on the psychosocial domain was not statistically different for children with normal-weight, overweight, obesity, or severe obesity in our study.

In **chapter 6**, associations between indicators of psychosocial and physical health and overweight and obesity in 7-year-old children are described. The findings showed that overweight and obese children visited the general practitioner more often, but there was no difference between overweight, obese and normal-weight children with regard to reported physical health conditions such as asthma symptoms, abdominal pain or migraine. Overweight and obese children were reported to experience more insecure feelings and adverse treatment. In addition, children who were overweight or obese at age 5-years and at 7-years had a higher risk for experiencing weight-related adverse treatment and insecure feelings, as reported by their parents, compared to children who had a normal weight.

The third part of this thesis focused on sweet beverage consumption. Sweet beverage consumption is also a health behavior associated with overweight among children and may promising to target with health promotion interventions. **Chapter 7** describes home

environmental determinants that are associated with sweet beverage consumption of young children. Especially the availability of sweet beverages at home showed to be associated with child consumption. Parents are for the larger part responsible for the sweet beverages available to the child at home. Our results suggest that interventions might include elements that can help parents in acquiring skills with regard to actively discouraging and limiting children's sweet beverage consumption

In **chapter 8** findings are summarized and interpreted alongside the literature. Methodological considerations of the discussed studies are presented and recommendations for research, practice and policy are provided. We conclude that health care has an important role in early detection of overweight and obesity among children. The prevention protocol is an intervention that can be implemented in the youth health care setting. The in this thesis described evaluation of the prevention protocol showed limited effects of the intervention on health behaviors and BMI of the children.

Some recommendations can be made for future use of the prevention protocol. The prevention protocol may be used to create awareness of the child's overweight among parents and motivate them to change health behavior. The prevention protocol offers the opportunity to discuss potential negative health outcomes such as insecure feelings the child may be experiencing. Also, parents may be assisted in learning skills to promote healthy behavior of the child and to create a healthy home environment. Youth health care has the opportunity to, on individual level, discuss with the family what they need in order to develop a healthy family lifestyle. Moreover, youth health care may guide the child to an intervention that suits the family.

Individual focused interventions such as the prevention protocol, should be implemented in combination with interventions targeting the general population. A study in this thesis showed that interventions among the general population of children can help decrease sedentary behavior and BMI.

A local integrated approach to prevent and care for children with overweight and obesity is recommended; care providers have working arrangements with regard to detection, care and follow-up of children with overweight and obesity and all health care professionals are committed to providing local prevention and care. This integrated approach will promote sustainable health behavior change and the development of a healthy lifestyle among children and their families.

SAMENVATTING

Overgewicht en obesitas bij kinderen is een publiek gezondheidsprobleem. Zowel op de korte als op de lange termijn zijn verschillende gezondheidsproblemen het gevolg van overgewicht bij kinderen. Om overgewicht te voorkomen of aan te pakken worden interventies ontwikkeld en uitgevoerd, deze interventies richten zich voornamelijk op het realiseren van een gezonde leefstijl binnen een gezin, zoals dagelijks samen gezond ontbijten en weinig tv kijken.
Het doel van dit proefschrift was het evalueren van interventies die zich richten op het bevorderen van een gezond gewicht en een gezonde leefstijl van kinderen en aanvullend inzicht bieden in elementen die mogelijk kunnen bijdragen aan het verbeteren van deze interventies. De volgende onderzoeksvragen werden gesteld:

1. Wat zijn de effecten van interventies die een gezond gewicht en gezonde leefstijl bij kinderen willen bewerkstelligen?
    1.1. Effecten van het Overbruggingsplan Overgewicht op de Body Mass Index (BMI), middelomtrek en gezondheidsgedragingen van kinderen (hoofdstuk 2 en 3)
    1.2. Effecten van interventies die zich richten op het verminderen van zittend gedrag, op de BMI en het zittend gedrag van kinderen (hoofdstuk 4)
2. Welke indicatoren van psychosociale en fysieke gezondheid zijn geassocieerd met de gewichtsstatus van het kind?
    2.1. Associaties tussen overgewicht, obesitas en gezondheid gerelateerde kwaliteit van leven bij kinderen (hoofdstuk 5)
    2.2. Associaties tussen overgewicht, obesitas en psychosociale en fysieke gezondheidsuitkomsten bij kinderen (hoofdstuk 6)
3. Welke sociaal demografische karakteristieken, overtuigingen van de ouders en opvoedpraktijken zijn geassocieerd met de zoete dranken consumptie van kinderen? (hoofdstuk 7)

In het eerste deel van dit proefschrift zijn interventies die zich richten op het bevorderen van gezond gedrag bij kinderen geëvalueerd. Hierbij werden als eerste de effecten van het Overbruggingsplan Overgewicht op de BMI, middelomtrek en gezondheidsgedragingen van 5 tot 7 jarige kinderen beschreven. Het Overbruggingsplan Overgewicht werd in 2005 ontwikkeld en beschrijft een interventie die binnen de jeugdgezondheidszorg aan ouders kan worden aangeboden wanneer hun kind met overgewicht wordt gesignaleerd. De jeugdgezondheidszorg professionals in Nederland monitoren met regelmatige gezondheidsonderzoeken de groei en ontwikkeling van kinderen tot 18 jaar. In 2004 werd een protocol ontwikkeld waarmee de jeugdgezondheidszorg op een eenduidige manier overgewicht en obesitas bij kinderen kon signaleren. Het Overbruggingsplan Overgewicht sluit daarop aan en beschrijft een interventie voor ouders van kinderen met overgewicht. De interventie bestaat

uit het aanbieden van extra informatie en tot drie extra consulten. Het Overbruggingsplan Overgewicht beschrijft vijf gedragingen die kunnen worden aangepakt gedurende de consulten: stimuleren van borstvoeding bij zuigelingen, stimuleren van buitenspelen, dagelijks ontbijten, beperken van frisdrank en gezoete dranken, beperken van televisie kijken en computeren. Ouders bepalen zelf, samen met de jeugdgezondheidszorg medewerker, welke van de gedragingen worden aangepakt.

De effecten van het Overbruggingsplan Overgewicht op de BMI, middelomtrek en gezondheidsgedragingen van de kinderen, zijn geëvalueerd met een cluster gerandomiseerd gecontroleerd onderzoek. De in **hoofdstuk 2** beschreven resultaten lieten zien dat kinderen met mild overgewicht (BMI 17.25 en 17.50) in de interventie conditie (waar het Overbruggingsplan Overgewicht werd uitgevoerd) minder toenamen in BMI tussen 5 en 7 jaar. We vonden geen verschillen tussen de interventie en de controle conditie als het gaat om gezondheidsgedragingen van het kind (**hoofdstuk 3**). Wel werden er minder zoete drankjes gedronken in beide onderzoekscondities, wanneer consumptie op 5 jaar en 7 jaar werd vergeleken. De resultaten lieten een aantal verbeterpunten wat betreft het gebruik van het Overbruggingsplan Overgewicht zien, waaronder deelname aan extra consulten en het motiveren van ouders tot gedragsverandering.

Hoofdstuk 4 beschrijft een systematische review en meta-analyse waarin interventies die zich richtten op het verminderen van zittend gedrag (bijvoorbeeld tv kijken) bij kinderen worden samengevat. Deze interventies waren niet ontworpen voor een specifieke groep kinderen maar voor alle kinderen (bijvoorbeeld alle kinderen op een basisschool). Zittend gedrag is geassocieerd met overgewicht en afname van zittend gedrag zou daarom kunnen bijdragen aan de preventie van overgewicht bij kinderen. De effecten die werden gerapporteerd door elke individuele interventie werden in de meta-analyse gecombineerd tot een geschat totaal effect van alle interventies. De resultaten lieten zien dat de interventies tezamen het zittend gedrag en het BMI van de kinderen verminderden.

In het tweede deel van dit proefschrift werden associaties tussen de gewichtsstatus van het kind en indicatoren van de psychosociale en fysieke gezondheid van het kind geëvalueerd. Alhoewel er veel onderzoek beschikbaar is over de psychosociale en fysieke gezondheidsproblemen gerelateerd aan overgewicht en obesitas bij oudere kinderen (8-12 jaar) en adolescenten, is er weinig onderzoek gepubliceerd dat is uitgevoerd onder jongere kinderen. **Hoofdstuk 5** beschrijft de associaties tussen gezondheid gerelateerde kwaliteit van leven en de gewichtsstatus van 5-jaar oude kinderen. Vergeleken met kinderen die een normaal gewicht hadden, ervoeren kinderen met ernstige obesitas in onze studie een lagere gezondheid gerelateerde kwaliteit van leven op het fysieke domein. De door de ouder gerapporteerde psychosociale gezondheid gerelateerde kwaliteit van leven was niet verschillend tussen kinderen met een normaal gewicht, overgewicht of (ernstige) obesitas.

Aanvullend zijn in **hoofdstuk 6** indicatoren van psychosociale en fysieke gezondheidsuitkomsten bij 7-jarige kinderen geëvalueerd. De bevindingen waren dat kinderen met

overgewicht en obesitas de huisarts vaker bezochten, maar we zagen geen verschillen in de fysieke condities die konden worden gerapporteerd door de ouders (bijvoorbeeld astma symptomen of buikpijn). Kinderen met overgewicht en obesitas ervoeren volgens hun ouders vaker onzekere gevoelens over hun gewicht en werden vanwege hun gewicht vaker nadelig behandeld dan kinderen met een normaal gewicht. Kinderen die zowel op 5 jaar als op 7 jaar overgewicht of obesitas hadden, hadden een hoger risico om nadelig te worden behandeld vanwege hun gewicht (bijvoorbeeld gepest of achtergesteld) of zich onzeker te voelen over hun gewicht dan kinderen met een normaal gewicht op beide leeftijden.

Het derde deel van dit proefschrift richtte zich op een van de gezondheidsgedragingen geassocieerd met overgewicht bij kinderen: zoete dranken consumptie. De consumptie van zoete dranken kan mogelijk worden veranderd met interventies. **Hoofdstuk 7** beschrijft kenmerken van de thuisomgeving die geassocieerd zouden kunnen zijn met de zoete dranken consumptie van het kind. In het bijzonder bleek de beschikbaarheid van zoete dranken thuis geassocieerd te zijn met het drinken van zoete dranken door het kind. Ouders zijn verantwoordelijk voor de thuisomgeving en daarmee de beschikbaarheid van zoete dranken voor het kind. Interventies kunnen hierop inspelen door ouders vaardigheden te leren waarmee zij actief zoete dranken consumptie van het kind kunnen ontmoedigen en beperken.

Tot slot zijn in **hoofdstuk 8** de bevindingen van dit proefschrift samengevat en geïnterpreteerd. Hierbij zijn de methodologische beperkingen van de studies beschreven en zijn aanbevelingen voor onderzoek, praktijk en beleid gedaan. Tot slot zijn de volgende conclusies geformuleerd.

De jeugdgezondheidszorg heeft een belangrijke rol als het gaat om tijdige signalering van overgewicht en obesitas bij kinderen. Het Overbruggingsplan Overgewicht dat wordt gebruikt in de jeugdgezondheidszorg setting biedt de mogelijkheid tot individuele zorg op maat aan ouders en hun kind. Het Overbruggingsplan Overgewicht liet in de evaluatie zoals beschreven in dit proefschrift, kleine effecten zien op gezondheidsgedragingen en BMI van het kind.

Een aantal aanbevelingen kunnen worden gedaan voor toekomstig gebruik van het Overbruggingsplan Overgewicht. Het Overbruggingsplan Overgewicht biedt de mogelijkheid om ouders bewust te maken en te motiveren om gezondheidsgedragingen te veranderen. Daarnaast kunnen negatieve gevolgen van het gewicht van het kind, zoals onzekere gevoelens die het kind mogelijk ervaart, worden besproken. Bovendien kunnen ouders worden geholpen in het ontwikkelen van vaardigheden voor het bevorderen van gezond gedrag van het kind en het creëren van een gezonde thuisomgeving. Een van de studies in dit proefschrift liet zien dat de thuisomgeving een belangrijke invloed heeft op de zoete dranken die het kind drinkt. Samengevat kan de jeugdgezondheidszorg bijdragen om op individueel niveau met de ouders in gesprek te gaan over wat er nodig is om een gezonde leefstijl te ontwikkelen in het gezin. De jeugdgezondheidszorg kan daarbij obese kinderen doorverwijzen naar de juiste zorg en ook kinderen (met risico op) overgewicht begeleiden naar een passende interventie.

Individuele advies-op-maat interventies, zoals het Overbruggingsplan Overgewicht, moeten parallel aan interventies gericht op alle kinderen en families worden uitgevoerd. Interventies die zich richten op de algemene populatie van kinderen kunnen positief bijdragen aan het verminderen van zittend gedrag en BMI.

Een lokale integrale aanpak van preventie en zorg voor kinderen met overgewicht en obesitas wordt aanbevolen. Hierbij zijn er tussen zorgverleners afspraken over signalering, behandeling en nazorg voor kinderen met overgewicht en obesitas; de zorgverleners zijn betrokken en zetten zich in voor lokale preventie en zorg. Met deze aanpak is het mogelijk duurzame gedragsveranderingen en een gezonde leefstijl in het gezin te realiseren.

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En Frans…I love you!

CURRICULUM VITAE

Amy van Grieken was born 13 July 1985 in Moordrecht. After finishing secondary school in 2003 (Goudse Scholen Gemeenschap), she started a bachelor psychology at Leiden University. After graduating in 2006, she started with a Master in Health Psychology, also at Leiden University. After an additional research internship at the Dutch Nutrition Center she graduated in 2008.

In 2009 she started working at the department of Public Health of the Erasmus MC in Rotterdam, first as a research assistant and later as researcher on the 'Be active, eat right' study. During this project, she obtained a degree as Master of Public Health from the Netherlands Institute for Health Sciences (Nihes). In 2013 she worked at the department of Health Sciences of the VU University in Amsterdam for three months on a project on integrated care for children with overweight and obesity.

Currently, Amy is working as a researcher at the Erasmus MC department of Public Health in Rotterdam on several projects related to the prevention of overweight among children.

LIST OF PUBLICATIONS

2012

Van Grieken A, Ezendam NP, Paulis WD, van der Wouden JC, Raat H. Primary prevention of overweight in children and adolescents: a meta-analysis of the effectiveness of interventions aiming to decrease sedentary behaviour. *International Journal of Behavioral Nutrition and Physical Activity.* 2012; 9(61).

Van Grieken A, Veldhuis L, Renders CM, Landgraf JM, Hirasing RA, Raat H. Impaired parent-reported health-related quality of life of underweight and obese children at elementary school entry. *Quality of life research.* [Epub 2012 June 14] 2013; 22(4).

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Van Grieken A, Veldhuis L, Renders CM, Borsboom GJ, van der Wouden JC, Hirasing RA, Raat H. Population-based overweight prevention: outcomes of the 'Be active, eat right' study. *PLoS ONE.* 2013; 8(5).

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Submitted

Van Grieken A, Renders CM, Veldhuis L, Looman CW, Hirasing RA, Raat H. Promotion of a healthy lifestyle among 5-year-old overweight children: health behavior outcomes of the 'Be active, eat right' study. *Submitted.*

Van Grieken A, Renders CM, van de Gaar VM, Hirasing RA, Raat H. Associations between the family environment and children's sweet beverage consumption at two-year follow-up: the 'Be active, eat right' study. *Submitted.*

Remmers T, van Grieken A, Renders CM, Hirasing RA, Broeren SML, Raat H. Correlates of parental misperception of their child's weight status: The 'Be active, eat right' study. *Submitted.*

Veldhuis L, van Grieken A, Renders CM, Hirasing RA, Raat H. Parenting style, the home environment, and screen time of 5-year-old children; the 'Be active, eat right' study. *Submitted.*

Van Beelen MEJ, van Beeck EF, den Hertog P, van Grieken A, Beirens TMJ, Raat H. Effectiveness of web-based, tailored advice on psychosocial factors related to parents' child safety behaviors. *Submitted.*

Raat H, Struijk MK, Remmers T, Vlasblom E, van Grieken A, Broeren SML, te Velde SJ, Beltman M, Boere-Boonekamp MM, L'Hoir MP. Primary prevention of overweight in preschool children, the BeeBOFT study (Breastfeeding, Breakfast daily, Outside playing, Few sweet drinks, less TV viewing): design of a cluster randomized controlled trial. *Submitted.*

PhD PORTFOLIO

Name PhD student:	Amy van Grieken
Erasmus MC Department:	Public Health
Research School:	NIHES
PhD period:	2009-2013
Promotoren:	prof.dr. H. Raat, prof.dr. R.A. Hirasing
Supervisor:	prof.dr. H. Raat

	Year	Workload (Hours/ECTS)
1. PhD training		
General academic skills		
- Master of Public Health, Netherlands Institute for Health Sciences (NIHES), Erasmus MC, Rotterdam, the Netherlands	2010-2012	70.0 ECTS
Presentations		
- Interventies ter preventie van overgewicht bij kinderen, een literatuurreview. Workshop CIAO tweede fase, Utrecht	2011	12 hours
- Een systematische review en meta-analyse naar interventies gericht op vermindering van sedentair gedrag bij kinderen. NCVGZ, Rotterdam	2011	12 hours
- Primary prevention of overweight among children and adolescents: a meta-analysis of the effectiveness of interventions aiming to decrease sedentary behavior. Research seminar Department of Public Health, ErasmusMC, Rotterdam	2011	12 hours
- Effects of interventions aiming to decrease sedentary behavior among children and adolescents: a meta-analysis. ISBNPA conference, Melbourne, Australia	2011	12 hours
- Parenting styles, parenting practices and sedentary behavior of preschool children; the 'Be Active, Eat Right' study. ISBNPA conference, Melbourne, Australia (poster)	2011	12 hours
- 'Lekker bewegen, goed eten. Evaluatie van het Signaleringsprotocol en het Overbruggingsplan overgewicht in de jeugdgezondheidszorg'. CEPHIR seminar 'Van onderzoek naar praktijk: van effect evaluatie naar effectieve interventies', Erasmus MC, Rotterdam	2011	12 hours

- 'Lekker bewegen, goed eten. Evaluatie van het Overbruggingsplan overgewicht in de JGZ'. Georganiseerde bijeenkomst tussen Gemeente Rotterdam, Sport&Recreatie, GGD Rotterdam-Rijnmond. Rotterdam	2012	12 hours
- 'Lekker bewegen, goed eten. Evaluatie van het Overbruggingsplan overgewicht in de JGZ'. NCVGZ, Amsterdam	2012	12 hours
- 'A cluster randomized controlled trial to prevent obesity in overweight elementary school children: the 'Be active, eat right' study'. ISBNPA conference, Austin, USA	2012	12 hours

(Inter) national conferences

- Nederlands Congres Volksgezondheid (NCVGZ), Rotterdam	2010	8 hours
- Presentatie resultaten Vijfde Landelijke Groeistudie, Rotterdam	2010	8 hours
- Nederlands Congres Volksgezondheid (NCVGZ), Amsterdam	2011	8 hours
- 10th Conference of the International Society of Behavioral Nutrition and Physical Activity (ISBNPA), Melbourne, Australia	2011	24 hours
- 11th Conference of the International Society of Behavioral Nutrition and Physical Activity (ISBNPA), Austin, USA	2012	24 hours

Seminars and workshops

- Seminars at the Department of Public Health, ErasmusMC, Rotterdam	2009-2013	100 hours
- ISBNPA (International Society for Behavioral Nutrition and Physical Activity) Pre-conference meeting "Parenting measurement", Houston, USA	2012	16 hours
- CEPHIR seminars, Rotterdam	2011-2013	12 hours

2. Teaching

- Supervision of Erasmus MC medical students in writing assignment of 'The population as patient'. Assignment: 'Overweight among babies'	2009	4 hours
- Supervision of two bachelor students 'Health Sciences' VU University Amsterdam. Theses title: "Effects of the four seasons on child health behavior"	2009	20 hours
- Supervision of master student 'Health Sciences' VU University Amsterdam. Theses title: "Process evaluation of the ' Be active, eat right' study"	2010-2011	45 hours
- Supervision of master student 'Medicine' Erasmus University Rotterdam. Theses title: "Process evaluation of the 'BeeBOFT' study"	2011-2012	45 hours