Dietary and metabolic effects of a 2-year lifestyle intervention on overweight and obese children

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To Benjamin ♥
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Abstract

**Background** Childhood overweight and obesity have increased during the past decades and there is a need for effective intervention programs both for treatment and prevention to interrupt the increased trend. Overweight and obesity result from a combination of genetic predisposition and lifestyle where an imbalance in energy intake (EI) and total energy expenditure (TEE) is the key factor. The objective of this thesis is to evaluate the impact of a 2-year lifestyle intervention on food habits, anthropometry and metabolic markers on children with overweight and obesity.

**Methods** Overweight and obese children 8-12 years old were recruited to participate in a 2-year randomized controlled trial (RCT). One hundred and five children agreed to participate and were randomized into one intervention group and one control group. Both groups participated in the same measurements while the intervention group also participated in a lifestyle program aiming at improving food habits and increasing physical activity. The first year of the program consisted of 14 group sessions and the second year of the intervention was web-based. Food habits were assessed at baseline and at endpoint by a diet history interview (DHI) and by a 4-day food record at 1-year measurement. At baseline 22 randomly chosen children were included in a validation study to validate reported EI against TEE measured by doubly labeled water (DLW) method and SenseWear Armband Pro 2 and 3 (version 5.1) (SWA). Anthropometric and biochemical parameters were measured at baseline, 1-year and endpoint.

**Results** The DHI underestimated EI by 14% when validated against measured TEE by DLW and SWA. At the 1-year measurement the intervention group had a lower intake of fat (g and E%), monounsaturated fat (MUFA) (g) and polyunsaturated fat (PUFA) (g and E%) compared to the control group. At endpoint the intervention group had a lower intake of fat (g), MUFA (g) and cholesterol compared to the control group. Children in the intervention group consumed less sugar sweetened beverages at endpoint and had increased their intake of keyhole labeled foods compared to the control group. During the first year the growing children in both groups remained stable with respect to BMI and had decreased their BMI z-score.

**Conclusion** The 2-year lifestyle intervention resulted in some improvements regarding food habits, but overall the effects on anthropometrics and metabolic markers were limited. This strongly supports that efforts should primarily be aimed at primary prevention of childhood overweight and obesity.
### Abbreviations

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<tr>
<td>BMI</td>
<td>Body mass index</td>
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<td>BMR</td>
<td>Basal metabolic rate</td>
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<td>DHI</td>
<td>Diet history interview</td>
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<td>DLW</td>
<td>Doubly labeled water</td>
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<td>EI</td>
<td>Energy intake</td>
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<td>ITT</td>
<td>Intention to treat</td>
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<td>IOTF</td>
<td>International obesity task force</td>
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<td>MUFA</td>
<td>Monounsaturated fatty acids</td>
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<td>MW</td>
<td>Maria Waling</td>
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<td>PAL</td>
<td>Physical activity level</td>
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<td>PUFA</td>
<td>Polyunsaturated fatty acids</td>
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<td>RCT</td>
<td>Randomized controlled trial</td>
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<td>SWA</td>
<td>SenseWear Armband</td>
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<td>SFA</td>
<td>Saturated fatty acids</td>
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<td>TEE</td>
<td>Total energy expenditure</td>
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Svensk sammanfattning

**Bakgrund** Övervikt och fetma bland barn och ungdomar har ökat markant de senaste decennierna i Sverige och övriga världen. De senaste åren har dock den ökande trenden avstannat i vissa åldersgrupper och regioner i Sverige. Trots detta är förekomsten hög idag jämfört med för 20 år sedan. År 2006 var förekomsten av övervikt 18% och fetma 2,7% bland Sveriges 10 åringar. Övervikt och fetma orsakas av att energiintaget är högre än energiutgifterna. Många har även en genetisk predisposition som gör att de har lättare att utveckla övervikt och fetma. Övervikt och fetma i barnaåren kan leda till ökad risk för ohälsa och förtydliga död i vuxen ålder.

**Syfte** Det övergripande syftet är att utvärdera om barn 8-12 år med övervikt och fetma som deltar i en 2 årig livsstilsintervention förbättrar sitt kostintag, sin kroppssammansättning och metabola hälsa.


**Resultat** Den kosthistoriska intervjuen underskattade barnens energiintag med 14% i jämförelse med energiomsättning mätt med dubbelmärkt vatten metod. Efter 1 års deltagande i studien hade interventionsgruppen ett lägre intag av fett (gram och E%), enkelomättat fett (g) och fleromättat fett (g and E%) i jämförelse med kontrollgruppen. Vid studiens slut hade interventionsgruppen fortfarande ett lägre intag av fett (g) och MUFA (g) men även kolesterol. Efter 2 års deltagande konsumerade barnen i interventionsgruppen mindre sötade drycker (ex. läsk och saft) och åt mer näckehålsmärkta livsmedel i jämförelse med kontrollgruppen. Under det första året var barnens BMI i båda grupper oförändrat och i jämförelse med en svensk referensgrupp så minskade barnens BMI.

**Slutsats** Den tvååriga interventionen förbättrade delar av barnens matvanor men hade begränsad effekt på barnens kroppssammansättning och metabola hälsa. Det är därför av stor vikt att utföra insatser i ett tidigt skede för att förhindra uppkomsten av övervikt och fetma i barndomen.
Original papers

This thesis is based on the following papers:


Papers 1 and 2 are reprinted with permission from the publisher American Society for Nutrition.
Prologue

When I look back at these years I realize this journey I am now about to end, includes so much more than this book can comprise. I started this journey as a newly examined food and nutrition student but I was well prepared since I had already started to plan the study in a student thesis. I often think how privileged I was to be given the opportunity to perform the study I had a part in planning.

During the first years the most time was devoted to planning sessions, taking measurements, making new contacts, and starting to recruit children. I think this was the time when reality first struck me- not enough families were interested in participating as we had planned for. It never occurred to me that it would be that difficult to find families to participate in a study like ours. I started to realize part of the recruiting difficulties when I first met the children. If I had not known their body mass index I could not have pointed them out as overweight in a group of children. I now understand that this was something that I shared with many parents and this was one reason for the difficulties in recruiting children. The next reality check came when the children we had recruited started to drop out of the study. We worked hard trying to keep all of the participants, but I realized more and more that our study was only a little part of their hectic lives. One of the biggest insights from performing this study is that when humans are involved, things do not always go as you planned! Despite the different challenges we encountered along the way, the one thing I will remember the most from these years are the many meetings with the great children who participated. I really hope that this study can contribute something positive in helping overweight and obese children to become healthier and feel better about themselves.

At the last meeting with the children involved in the intervention program we reminded them about the journey that they had just begun and all the tools they had collected along the way that they could use whenever needed. When I think about it, those words describe the situation I am in at the moment. I see this as a beginning of a long journey where I can use all the experience and knowledge that I have gained, not only professionally but also in many other situations in life.

Sincerely,
Maria Waling
Introduction

Children’s food habits
Dietary intake of children is a key determinant of growth and development throughout childhood. Together with the other Nordic countries (Norway, Finland, Denmark and Iceland) Sweden has recommendations on dietary intakes with the aim to provide a base for good health. The recommendations are based on the current scientific knowledge with respect to energy and nutrient requirements for various groups of the population but also take food habits into account and give some recommendations on meal planning as well as physical activity (1). The Swedish recommendations are based on these recommendations (2). The latest national food survey in Sweden was done in 2003 by the National Food Administration (3). The survey included 4, 8 and 11-year-old children and it revealed that 25% of their energy intake (EI) came from foods rich in energy but low in nutrients (energy dense foods). As a consequence the children had too high intakes of saturated fat (SFA) and refined sugar to meet national recommendations (1). Further, they consumed too little fruit and vegetables which resulted in a too low intake of dietary fiber in relation to the recommendations (1).

Assessment of dietary intake
Dietary assessment methods are usually divided into retrospective and prospective methods and can cover shorter or longer time periods. Retrospective dietary assessment methods go back in time to find out what individuals or groups have consumed. Examples of these kinds of methods are: diet history interviews (DHI), 24 hour recalls and food frequency questionnaires. Prospective methods, on the other hand, are performed by the respondent each day in close connection to the consumption of food and beverage. The most commonly used prospective method is food records.

What method should be used depends mainly on the aim of the study but also on practical issues like target group, time and economic resources. A review of the literature concluded that the most accurate dietary assessment method for children 4-11 years old was a 24 hour recall repeated at least three times and including parents as respondents. For adolescents 16 years and older DHI was the most valid method (4).

Diet history interview
The DHI is a method that assesses a person’s usual dietary intake and meal pattern during a relatively long period of time. So far there is no standardized way of performing the interview and many different ways of the performance have been described (5-7). Sometimes the method involves a
questionnaire, an interview and a food record. Other times the method only includes a questionnaire or an interview. Furthermore, the time period which the interview covers may vary from weeks to years. Positive aspects of the DHI are that it gives a good estimate of a person’s general food habits during a longer period of time and that the children do not have to be able to read or write (8). The negative aspects are that the method relies on the subject’s memory and that it may be too complex for a child to comprehend (8).

**Food records**
A food record is performed by the respondent who records and describes everything eaten as well as assesses the amount eaten. Food records are usually divided into either estimated or weighed food records depending on how portion sizes are assessed (9). In the estimated food record portion sizes are assessed by the help of for example food portion photographs (10), household measurements and standard weights of food items. In the weighed food record on the other hand, all food and beverages consumed are weighed on a household scale. A food record is very demanding for the respondent which limits the number of days the dietary assessment can include. Further, habitual eating patterns may be influenced by the recording process and it requires that the child can read and write or that a parent is involved. The positive aspects are that it does not rely on memory and it gives a good estimate of dietary intake at the time when the food record was performed.

**Validity of dietary assessment methods**
All methods have advantages and disadvantages. Common errors that occur when assessing dietary intake are; under- or over reporting of EI, selective under- or over-reporting of different food groups, respondent memory lapses, incorrect estimation of portions sizes, interviewer biases and nutritional calculation programs that do not include all food items or correct nutritional content of food items (9).

When assessing dietary intake among children there are also some difficulties beyond those in studies of adults (11). Children have not fully developed their cognitive ability which may affect their capacity to remember what has been consumed as well as to assess portion sizes. Other issues to take into consideration that vary with age are short attention spans, social desirability and search for approval (12). It is not unusual that parents are included when assessing dietary intake among children, and so far most studies show that parents are reliable reporters of their child’s dietary intake in the home setting and during a 24 h period (13). However, with an increased age and more meals eaten away from home, parent’s reports are
less reliable. From 8 years of age a rapid increase in the capacity of the child regarding reporting dietary intake takes place (12).

When assessing dietary intake it is of great importance to take the validity into consideration. A valid reported dietary intake is one that measures the true intake during the intended measuring period, i.e. an accurate report of food and beverage consumption that corresponds to the person’s habitual dietary intake (14). Further, an accurate report should not be influenced by memory or the fact that the person is participating in a dietary assessment method. In real life this is not possible and so far there are no objective ways of measuring dietary intake. Because of the difficulties in measuring dietary intake it is important to try to minimize errors and assess the validity of reported dietary intake, preferably by biological markers. Last, but not least, it is of significant importance to take measurement errors into consideration when drawing conclusions based on dietary assessment methods.

**Assessment of total energy expenditure**

A common way of assessing the validity of reported EI is to compare it against estimated or measured total energy expenditure (TEE) (14). This comparison is done on the assumption that EI equals TEE when the body weight of the subject is stable. This assumption may be a problem among children since they are growing, however, during a shorter period of time weight stability can still be assumed (5). There are both subjective and objective ways of assessing TEE and the most common objective ones are; doubly labeled water (DLW) method, accelerometers, pedometers and heart rate monitors (14).

**Doubly labeled water method**

DLW method is known as the “golden standard” and is an objective measuring method of TEE in free living persons (15). The DLW method measures carbon dioxide production, and the principle used is that the stable isotopes deuterium equilibrates with body water, and oxygen 18 with both body water and carbon dioxide. Urine samples are collected before the administration of the dose as well as at repeated times (multi-point method) or at the beginning and at the end of the measuring period (two-point method) during a period of one to two weeks (15). The urine samples are analysed to measure the rate of disappearance of the isotopes and the difference of the elimination rates of the two isotopes gives an estimate of carbon dioxide production. With DLW it is possible to obtain an estimate of TEE with a precision of 2-8% (15). Limitations of the DLW method are that it is very expensive and requires advanced laboratory equipment.
**SenseWear Armband**

Other objective alternatives to assess TEE are registration of body movements (e.g. accelerometers and pedometers) or the physiological effects of body movements (e.g. heart rate monitoring) (14). SenseWear Pro 2 and Pro 3 Armband (SWA) (BodyMedia, Inc., Pittsburgh, PA) is a portable device which can measure TEE based on data from a 2-axis accelerometer and four different sensors capturing skin temperature, near-body temperature, heat flux, and galvanic skin response. With data collected from the armband, and information about the participant’s age, sex, weight, height and handedness TEE can be calculated through algorithms in the software program InnerView Professional (version 5.1). The TEE measured by the armband (together with software version 5.1) has been validated against the TEE measured by DLW method on overweight and obese children in the age 8-12 years and was considered valid on group level (16).

**Overweight and obesity among children**

**Definition**

The World Health Organization’s definition of overweight and obesity is “abnormal or excessive fat accumulation that may impair health” (17). The most common way of classifying adults into overweight or obese is to calculate the person’s body mass index (BMI) (BMI=weight in kg/length in m x length in m) and use specific cut-off values. Adult BMI 25-29.9 kg/m² is regarded as overweight and ≥ 30 kg/m² as obese (17). The cut-offs give useful information on increased health risks on a population-based level. However, these BMI cut-offs cannot be used in children since natural age and sex-specific variations in body composition take place during different maturational stages. So far there is no worldwide accepted way of defining overweight and obesity among children (18, 19). The most commonly used classification in Europe is the International Obesity Task Force (IOTF) definition where the corresponding cut-offs as for adults are used (≥ 25 and ≥ 30 kg/m²) but adjusted for age and sex (19). Other commonly used cut-offs for overweight and obesity are 110 and 120%, respectively, of ideal weight for height, BMI at the 85th and 95th percentile, respectively, or weight for height z scores (or BMI standard deviation score) where a child that lies above + 2 SDS are classified as overweight or obese (20).

**Prevalence**

The prevalence of overweight and obesity has increased rapidly in most countries (21), including Sweden. Studies from three different regions of Sweden show a 200-250% increase in prevalence of childhood overweight and obesity from the mid-1980’s to the beginning of 2000 (22-24). However, since the beginning of year 2000 the rapid increase of overweight and
obesity among children seems to have levelled off (25-28) and from 2004 - 2006 a minor decrease (1.4%) in prevalence among 10-year-old children was noted in four different Swedish cities, including Umeå (25). In 2006 about 18% of 10-year-old children in Umeå were overweight and 2.7% were obese (25). The same tendency has been noticed among 4-year-old children in Umeå where the prevalence of overweight decreased during a 5-year period (2002/2003- 2007/2008) from 17.2% to 14.2% among boys and 22.3% to 19.0% among girls (29). During the same period the prevalence of obesity decreased among girls from 5.7% to 3.1%. Similar trends have been observed in some other European countries (30, 31). Even though a stabilizing and decreasing trend has been noticed in the prevalence of overweight and obesity it is high compared to 20 years ago.

**Causes and risk factors**

Overweight and obesity is caused by an imbalance in EI and TEE where the EI from food and beverages exceeds TEE. Some individuals are predisposed to overweight and obesity due to their genetic background and may respond differently to environmental factors like dietary habits and physical activity than those not predisposed (32). Risk factors that have been associated with development of childhood overweight and obesity are low socioeconomic status in industrialized countries, high socioeconomic status in developing countries (20), ethnic origin (33), parental overweight and obesity (34), low levels of physical activity (35), television viewing (36) and lack of sleep (37).

Because of methodological difficulties in measuring dietary intake (8) there is little evidence that overweight and obese children have a higher EI (20, 34, 38, 39) in relation to TEE or have a different macronutrient composition in the diet they consume compared to their normal weight peers (38). Furthermore, there is little evidence that overweight and obese children eat different kinds of foods than normal weight children (20, 34, 40).

**Physiological and psychological health consequences**

Childhood overweight and obesity have the potential to negatively affect almost every organ system in the body (41). The negative health consequences of childhood overweight and obesity can be divided into immediate and long-term (42). Immediate consequences, most commonly seen in severely obese children, are neurological, pulmonary, endocrine, gastroenterological and orthopaedic problems (42). Long term consequences are cardiovascular disease, type 2 diabetes and cancer (42, 43). A recent prospective study showed that an elevated BMI in adolescent, but still within the range that is currently considered to be normal weight, increases the risk of coronary heart disease in adulthood (44). Further, being overweight or obese as a child is an independent risk factor of becoming an obese adult (45, 46).
Singh et al. reported that an overweight child has at least a 50% risk of becoming an overweight adult and for obese children the risk is even higher (45). Another study concluded that obese 10-14 year old children with at least one obese parent have a 79% risk of remaining obese as an adult (47).

Psychological consequences associated with overweight or obesity among children are distress connected to weight status (48), increased risk of depression (49), disordered eating (50), social rejection (51) and victimisation by peers (52). So far it has not been clear if low self-esteem and health related quality of life is more prevalent among children with overweight and obesity (53). A recent review did, however, conclude that self-esteem and health related quality of life is negatively impacted among children and adolescents with overweight and obesity (54).

Prevention

The first intervention programs with the aim to decrease the prevalence of overweight and obesity were developed over 25 years ago and have many similarities with programs today i.e. inclusion of the study components diet, physical activity and behavioural treatment (55). Since then the society has changed substantially and a large number of additional studies have been performed with the aim to improve food and physical activity habits among children. Several meta-analysis and systematic reviews have been conducted with the objective to evaluate what type of program is most effective (56-59). Most meta-analysis and reviews conclude that there is little evidence on what is most effective in preventing overweight and obesity as a consequence of different methodologies, outcomes, definitions of overweight and obesity, but also that there are limited amount of studies of high quality (57, 59). Lifestyle improvement is still the foundation of primary and secondary prevention of overweight and obesity (20) while lifestyle improvement in combination with pharmacological or surgical treatment is the foundation of tertiary prevention.

Most primary prevention actions have been conducted in schools to reach as many children as possible. In these studies the majority of the population which actions are aimed for are normal weight and the interventions often focus on improvement of school meals as well as foods and beverages served at school, but also increased physical activity. A recent meta-analysis of school based interventions reported reduced odds of overweight or obesity in intervention schools compared to control schools (60).

The latest Cochrane review on interventions focusing on secondary prevention i.e. prevent further development of overweight and obesity or decrease the prevalence concluded that family-based, life style interventions
with a behavioural program and the objective to change diet and physical activity provide meaningful decreases in overweight among children and adolescents (58). There is also some evidence that diet may be a more important factor than physical activity in the treatment of overweight and obesity (61). The effect on weight loss with different macronutrient compositions in diets have been evaluated but so far there is no evidence that one diet is more effective than another and it is not known what long term effects some of the diets have (e.g. low carbohydrate-high fat diets) (62).

As a complement to lifestyle intervention, pharmacological treatment (orlistat and sibutramine) is sometimes used in tertiary prevention aiming at treating severe childhood obesity where negative health consequences have occurred. There is some evidence that orlistat and sibutramine have positive effects in combination with lifestyle intervention in obese adolescents (58). However, the side effects from the drugs need to be considered before using this treatment complement (20). Among adults bariatric surgery has shown to be a successful long-term treatment of extreme obesity (63). So far there are no randomized controlled trials (RCT) on the effect of bariatric surgery among obese adolescents (58), which implies that there is a need for more studies on the long term effects as well as risks before it can be recommended as a potential treatment for childhood obesity.
Aims and objectives

The general aim of the work presented in this thesis was to evaluate how dietary intake, anthropometrics and metabolic markers were affected by a family based lifestyle intervention program on 8-12 year old overweight and obese children. Our hypothesis was that the children in the intervention group would improve food and physical activity habits and thereby improve anthropometrics and metabolic health.

The more specific objectives were:

- To evaluate the validity of reported EI from a DHI on overweight and obese children, against measured TEE by two objective assessment methods, SWA and DLW method (Paper 1).

- To evaluate the effect after 1 year of participation in a family based lifestyle intervention program on energy and macronutrient intake among overweight and obese children (Paper 2).

- To evaluate the effect after 1 year of participation in a family based lifestyle intervention program on anthropometrics and metabolic markers among overweight and obese children (Paper 3).

- To evaluate the intervention’s effect on food, energy and macronutrient intake among overweight and obese children after 2 years of participation in a family based lifestyle intervention program (Paper 4).

The physical activity part of the intervention program has been described and evaluated in a previous doctoral thesis (64).
Methods

Study design
The study is a RCT where the participating children were randomized into one intervention group and one control group (Figure 1). The study proceeded during a 2-year period and both intervention and control children participated in the same measurements. In addition to the measurements, the intervention group also took part in a 2-year lifestyle intervention program, which the control group did not. At baseline 22 children were randomly selected to a validation study of EI against TEE measured by DLW and SWA method.

Sample size
To detect a 1.6 kg/m² BMI difference between the intervention and control groups (the main outcome of the whole study) and to reach an 80% study power ($\alpha=0.05$), a total of at least 84 children was needed. However, due to an expected dropout rate of about 30% during the 2-year study, the goal was to recruit 120 children with 60 participants in each group.

Recruitment and randomization
When the study was planned the goal was to focus on secondary overweight prevention by recruiting children born 1995-1997, living in Umeå (a
university city located by the east coast in northern Sweden with about 114,000 inhabitants) and with overweight (age and sex specific BMI 25-29.9 kg/m²). However, a few months after the recruitment procedure started in August 2006, it was apparent that it would not be possible to recruit as many participants as needed to reach an acceptable study power. It was therefore necessary to expand the study criteria as well as to apply alternative recruitment procedures. Consequently the age range was widened to include children born 1995-1998 with either overweight or obesity (age and sex specific BMI ≥ 25 kg/m²) living in Umeå or municipalities around Umeå. The recruitment procedure was also revised from, at first, only asking school nurses to send invitation letters to families with children fulfilling the first inclusion criteria, to the following recruitment strategies:

1) All school nurses in Umeå were contacted and provided with information about the study and were asked to invite children who fulfilled the inclusion criteria. The school nurses either provided parents with an invitation letter or orally informed parents with children who fulfilled inclusion criteria. Families who were interested in participating were asked to send an e-mail or a letter to the research group who thereafter contacted the family.

2) Invitation letters were sent to parents of children participating in another study performed in Umeå including children 10-12 years of age (65).

3) Invitation letters (n=6290) were sent to all families with children born between 1995-1998 living in Umeå or nearby municipalities. Parents were provided with instructions on how to calculate their child’s age and sex adjusted BMI to determine if the child fulfilled the BMI inclusion criteria.

4) Two articles with information about the study were published in the local daily newspapers and parents were encouraged to contact the researches if they were interested in participating.

In total 112 parents contacted the researchers by e-mail, letter or phone to show their interest in participating in the study (Figure 2). The parents were interviewed through a phone call to find out if their child fulfilled all above mentioned study criteria. Exclusion criteria were presence of metabolic disorder or attention deficit disorder, lack of access to internet or that the child received treatment for their overweight or obesity elsewhere. Information about weight and height were given by the parents. Children who did not fulfil inclusion criteria were informed that they could not
participate in the study. In total 105 children fulfilled the inclusion criteria and were provided general information about the study including information about the randomization and what it would mean to be included in the intervention and control groups, and information about the measurements.

Figure 2 Flowchart over participants in a 2-year intervention study with 8-12 year old children with overweight and obesity.

The overall recruitment period lasted during 10 months from August 2006 to May 2007, and when a group of 20-30 participants had showed their interest in participating in the study they were randomized into one intervention group and one control group each including 10-15 participants. This procedure was repeated four times during the recruitment period which
resulted in four intervention groups and four control groups starting on four different occasions in time; October 2006, January 2007, March 2007 and May 2007. At the fourth randomization, 11 more children were randomized into the intervention group than in the control group since more dropouts had occurred in the intervention groups previously started. Consequently, a larger proportion of children were randomized to the intervention group (55%) than to the control group (45%). The randomization was stratified for gender with the aim to have an equal number of boys and girls in both groups. Three staff from the research team conducted the randomization of participants and thereafter the families were invited to a meeting. During the meeting the participants received more detailed information about the study and what was expected of them. This gave them additional information and could help them make a realistic decision about their ability to participate.

The time period between the first information meeting and the baseline measurements varied from one to five weeks depending on the group. Between the randomization and the baseline measurements 12 children dropped out with the following explanations; lack of time, too long a distance to drive to measurements and meetings: fear of eating disorders and unknown reasons (Figure 2).

The participants signed an agreement to participate in the study when they visited the research nurses for baseline measurements. Besides participating in the same measurements as the intervention group the control group only participated in one initial information meeting about the measurements.

**Lifestyle intervention program**

The program is based on principles of behavioural (66, 67) and solution-focused group work (68) with focus on reaching national recommendations for dietary intake and physical activity (1). The program was aimed at both the child and his or her parents, and is in concordance with other intervention studies (58, 67, 69). The overall goal of the intervention program was to prevent further development of overweight and obesity through secondary prevention and thus improve the children’s metabolic health. To reach the overall goal, the goal of the sessions and home assignments was to improve the children’s food and physical activity (Tables 1 & 2). In contrast to many other intervention studies we used a web platform (PINGPONG AB, Sweden) as a tool to enhance the intervention; this had not been widely used in the actual context at the time when the present study was planned (70).

When the intervention program was developed the intention was to make it possible to repeat by other health care professionals. Manuals were written
for each session with detailed information about session goals, what to prepare before each session, information about the activities during the session as well as supporting material (e.g. overhead pictures) and homework assignments. The focus during the sessions was on improvement of food and physical activity habits rather than weight reduction and the words “overweight” and “obesity” were seldom used in communication with the children. The aim was to rather focus on improving food habits, increase physical activity to prevent further weight gain and enabling the child to become thinner as they grow in height.
Table 1. Description and goal of group sessions in a lifestyle intervention program which overweight and obese children randomized to an intervention group was invited to participate in. Sessions concerning food habits are marked.

<table>
<thead>
<tr>
<th>Session</th>
<th>Goal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Introduction</td>
<td>To make the children and parents aware of what it means to participate in the study as well as to inspire them in wanting to participate. Another goal was to get to know the supervisors and the other participants better.</td>
</tr>
<tr>
<td>2</td>
<td>How to work with goals</td>
<td>To help children and parents reflect on realistic and reachable goals and how they can be used when improving lifestyle. Another goal was to help the participants understand the advantages of physical activity and healthy food habits.</td>
</tr>
<tr>
<td>3</td>
<td>Tasting of healthy breakfast foods and snacks</td>
<td>Eat breakfast and 1-3 snacks every day as well as to choose “keyhole”-labeled foods.</td>
</tr>
<tr>
<td>4</td>
<td>Why and how should I be physically active?</td>
<td>To achieve the physical activity goal, being active ≥ 60min/d in at least moderate activity and in addition participate in vigorous activity at least 3 times/w.</td>
</tr>
<tr>
<td>5</td>
<td>What are healthy food habits?</td>
<td>Eat breakfast, lunch, dinner and 1-3 snacks as well as to eat according to the “plate model”. Another goal was to get children and parents to reflect on how much food is enough to eat during a meal.</td>
</tr>
<tr>
<td>6</td>
<td>Hunger and craving</td>
<td>To make the children aware of the difference in feeling hungry and craving. Another goal was to make children and parents aware of who is responsible in achieving good physical activity and food habits.</td>
</tr>
<tr>
<td>7</td>
<td>Every step counts</td>
<td>To achieve the gender adjusted step recommendation; ≥ 12,000 steps/d for boys and ≥ 15,000 steps/d for girls. To minimize the screen time to ≤ 2h/d.</td>
</tr>
<tr>
<td>8</td>
<td>Tasting of fruits and vegetables (children)</td>
<td>To encourage the children to eat more fruit, berries, vegetables, root vegetables and to reach the daily recommendation of &gt;500 g.</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td></td>
<td>Cooking (parents)</td>
<td>To inspire the parents to cook meals that include key hole-labeled ingredients (where possible) and to serve a meal accordingly to the “plate model”*.</td>
</tr>
<tr>
<td>9</td>
<td>Handling stressful situations</td>
<td>To help the children and parents identify stressful and risk situations and encourage them to reflect on strategies to handle these situations.</td>
</tr>
<tr>
<td>10</td>
<td>Physical activity together is more fun</td>
<td>To achieve the physical activity goal, being active ≥ 60min/d in at least moderate activity.</td>
</tr>
<tr>
<td>11</td>
<td>Exhibition of sugar rich foods</td>
<td>To increase the awareness among children and parents on what commonly used foods are high in sugar but low in nutrients and what healthier alternatives there are to these foods. Another goal for the parents was to know how to interpret food labels.</td>
</tr>
<tr>
<td>12</td>
<td>More physical activity - exercise</td>
<td>To participate in vigorous physical activity ≥ 3 times/w.</td>
</tr>
<tr>
<td>13</td>
<td>Self-image and self perception</td>
<td>To make the children and parents aware of how inner thoughts affects our wellbeing and to help the children to think positive thoughts about themselves.</td>
</tr>
<tr>
<td>14</td>
<td>Ending session</td>
<td>To inspire the children and parents to continue working on improving food and physical activity habits during the second part of the program.</td>
</tr>
</tbody>
</table>

*The “keyhole” is a guide, created by the Swedish Food Administration, for consumers in finding food items that contain more dietary fiber and less salt, sugar and saturated fat compared to similar food items.

**The “plate model” is a pedagogic tool that shows a meal on a plate with the different proportions of the food groups of which a meal should include.
Table 2 Goal and description of home assignments given to overweight and obese children during the second year of the lifestyle intervention. Assignments regarding food habits are marked.

<table>
<thead>
<tr>
<th>Assignment</th>
<th>Goal</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Changes so far, changes to be</td>
<td>To make children and parents feel they are able to make lifestyle changes and to inspire them to continue making changes.</td>
</tr>
<tr>
<td>2</td>
<td>Healthy snacks</td>
<td>To make the children eat 1-3 snacks, choose “keyhole” labeled foods and to reach the daily recommended &gt;500 g of fruits and vegetables.</td>
</tr>
<tr>
<td>3</td>
<td>How do you do to be physically active at playtime? (children) Physical activity during school time (parents)</td>
<td>To make the children achieve the physical activity goal, being active ≥60 min/d in at least moderate activity and in addition participate in vigorous activity at least 3 times/w.</td>
</tr>
<tr>
<td>4</td>
<td>Meal planning</td>
<td>To make the children and parents to choose “keyhole” labeled foods and eat according to the “plate model”.</td>
</tr>
<tr>
<td>5</td>
<td>Food advertisement</td>
<td>To make the children aware of how the food industry works to get people to buy and eat their products.</td>
</tr>
<tr>
<td>6</td>
<td>Every day physical activities</td>
<td>To make the children achieve the gender adjusted step recommendation and to decrease the screen time to ≤2h/d.</td>
</tr>
<tr>
<td>7</td>
<td>Five a day (children)</td>
<td>To achieve the recommended daily fruit and vegetable intake of &gt;500 g.</td>
</tr>
<tr>
<td></td>
<td>Five a day (parents)</td>
<td></td>
</tr>
</tbody>
</table>
and vegetables are provided for the children at home as well as shared on the web-platform their best tip on how to get the children to eat more fruit and vegetables.

| 8 | Physical activity | To make the children achieve the physical activity goal, being active ≥60 min/d in at least moderate activity and to participate in vigorous physical activity ≥3 times/w. To make the children share examples of free physical activities that they do in their neighborhood and try out and comment on one of the others concrete suggestion. |
| 9 | Handling stressful situations | To make the children aware of stressful situations that could lead them into eating unplanned unhealthy foods or skip planned physical activity. Children and parents choose one stressful situation in their everyday life and used the tools from year 1 to improve the situation. |
| 10 | Unhealthy snacking | To make the children limit snack intake that is high in energy and low in nutrients to a maximum of 10 % of their total energy intake. Children register and reflect on when, why and with whom they eat food or snacks that are energy rich and low in nutrients. After that they reflected on if there is anything they could improve and if there is any advised they can use to make the change. |
| 11 | My physical activities 2013 – a prophecy (children) | To have a healthy physical activity level now and in the future. Children discuss about physical activity level today and tomorrow, which strategies are useful to be able to achieve the physical activity level. Parents discuss about physical activity level today and yesterday, how can and why does it change through life? |
| 12 | A healthy lifestyle | For the children to feel that it is possible to make lifestyle changes and give them self confidence in maintaining achieved changes and in making future lifestyle changes. Children shared three of their healthy lifestyle habits changes and report how they celebrated achieved goals. |

1 The “keyhole” is a guide, created by the Swedish Food Administration, for consumers in finding food items that contain more dietary fiber and less salt, sugar and saturated fat compared to similar food items.

2 The “plate model” is a pedagogic tool that shows a meal on a plate with the different proportions of the food groups of which a meal should include.
Year 1

The first year of the 2-year intervention consisted of 14 sessions 1-2 times/month with different themes concerning food habits, physical activity and behavioural change (Table 1). All sessions were held at the Department of Food and Nutrition at Umeå University and lasted 1-2.5 hours. Five sessions had a theme concerning improvement of food habits and the remaining sessions concerned physical activity and behavioural change. The present thesis focus on the dietary part of the intervention. Health professionals involved in the program as leaders were registered dieticians, a physiotherapist, a child psychologist and a paediatrician. A majority of the sessions were led by two leaders to enable activities and discussions with children and parents separately. The majority of the sessions included many practical activities to better suit the children. During the first year of the intervention the web platform was used for posting information to the participants as well as providing a place where the participants could contact the researchers or each other.

At the end of each session the children together with their parents received a home assignment with the same theme as the upcoming session. The aim with the home assignments was to facilitate implementation and integration of lifestyle changes in their everyday life. A further aim was to inspire and support the children and parents in making lifestyle changes based on their own individual situation (66). The home assignments were built on six steps/questions that would help the children and parents in their lifestyle changes:

1. Describe the current situation.
2. Based on the current situation, what can be improved?
3. Select one or several goals.
4. What steps can be made to reach the goal?
5. Are there any obstacles that could prevent the goal/goals to be reached?
6. What can the parents do to make it easier for the child to reach the goal/goals?

The goals regarding the dietary part of the intervention were based on the current national nutrition recommendations (1) as well as guidelines for healthy food habits from the National Food Administration (71). Thus, the intervention had both nutritionally and food-based goals. To reach the nutritional recommendations the following nutritional goals were set:
• Eat no more than 10 E% (proportion energy of total EI) from refined sugar, e.g. sucrose, glucose, fructose and starch hydrolysates (1).
• Eat no more than 10 E% from saturated fat and trans fatty acids (1).
• Eat 2-3 g fiber per MJ of EI (1).

To reach the nutritional recommendations and guidelines the following food-based goals were communicated to the children:

• Choose “keyhole” labeled foods when possible. The “keyhole” is created by the Swedish Food Administration and is a guide for consumers in finding food items that contain more dietary fiber and less salt, sugar and SFA compared to similar food items (72).
• Use “the plate model” (shows how a healthy meal can be composed by visualizing proportions of different food groups) as a guide to get a well-balanced meal (73).
• Distribute your meals during the day (breakfast, lunch, dinner and 1-3 snacks) (1).
• Eat at least 500 g fruit, berries, vegetables and root vegetables each day (1).
• Eat no more than 10 E% from energy dense foods (71).

Below is a description of the sessions concerning diet during the first year of the intervention.

Session 3. “Tasting of healthy breakfast foods and snacks”
During this session children and parents were divided into two groups which both tasted healthy alternatives to foods commonly consumed as breakfast and snacks. The foods that the children tasted were; breads, spreads as well as yoghurt and sour milk (“fil”). All foods were key-hole labeled. In this food tasting the children and parents were introduced to the SAPERE-method, which aims at helping children increase preferences for new foods by describing them with the help of the five senses (74). Before the session the children were instructed to describe their breakfast habits and to reflect up on if anything could be improved. The parents received a home assignment were they were going to reflect on their child’s breakfast habits and write down what could be improved and how they could contribute to this improvement.

Session 5. “What are healthy food habits?”
Children and parents first had a joint session where they discussed how the body works, why and what we need to eat to be healthy, advantages of eating regularly, the plate model, portion sizes, fruit, berries, vegetables, root vegetables and energy dense foods and the keyhole label. The children and
parents were then divided into two groups. The children received five problems that they were supposed to solve with the help of what they had learned from the joint session. The parents had a deeper discussion about energy balance, eating regularly, the plate model, the key hole label, fruit, berries, vegetables, root vegetables and energy dense foods. The home assignment before this session was for the children to reflect on their food habits in general and choose one thing they thought was important in particular to improve.

Session 6. “Hunger and craving”
The session started with children and parents in separate groups, discussing the difference between hunger and craving. The children discussed and shared their experiences on what could be done when craving something that is not necessary to eat. Both groups discussed how to handle situations when people around the child offer foods that they want to limit the intake of for example, energy dense foods. At the end parents and children together discussed who has the responsibility for what at home when it comes to for example, making sure that vegetables are served at supper, decide what to eat for supper etc. Before the session the children had made a simple food record (without estimating portion sizes) during 1 day and registered if they were hungry or craving before they ate.

Session 8. “Tasting of fruit and vegetables (children)” and “Healthy cooking (parents)”
The children tasted different fruits, vegetables, root vegetables as well as legumes using the SAPERE-method. They visited four different stations where the first station included four different fruits which the children tasted with their eyes blinded. They were then supposed to describe the fruit with all senses except sight. At the second station they first tasted legumes in their natural shape and then got to taste them when they had been baked in bread and used in a dip (hummus). At the third station, carrots and white cabbage that was prepared in different ways (e.g. cooked, diced, mixed with vinaigrette) was tested. At the fourth station the children tested different vegetables and root vegetable with a dip made of avocado. One goal with this session was for the children to find out what they liked and disliked (e.g. a special consistency) instead of, for example, saying that they do not like vegetables in general. The home assignment before this session was for the child to reflect upon their vegetable intake and set up a goal on how the vegetable intake could be improved.

Before the session the parents were asked to e-mail recipes that were commonly cooked in their home. The two most common recipes sent in were modified by the research team to become healthier by, for example, using
keyhole labeled products or adding vegetables or legumes. During the session the parents were divided into six groups who each received a task. Three groups cooked food based on the recipes that the parents had sent, one group cooked food based on legumes, another one cooked food on fish and the last group prepared different kinds of salads that could fulfil the vegetable part of “the plate model” (Figure 3).

![Parents doing healthy cooking in session 8.](image)

**Figure 3** Parents doing healthy cooking in session 8.

**Session 11. “Exhibition of sugar rich foods”**

The aim of the session was to show how much the sugar content can be decreased with small changes. The children and parents went through five stations where the first station focused on sugar rich drinks and healthier alternatives to sugar rich drinks (Figure 4). The sugar content in each drink was visualized by sugar cubes (“sockerbitar”). The second station included sugar rich breakfast foods and snacks, e.g. cereals and yoghurt as well as less sugar rich alternatives. After these stations parents and children were split up. At the third station parents discussed light products with the focus on diet beverages and were informed about how to read nutritional labels on different foods. The third station for the children included a game about the keyhole label with the aim to learn about what it stands for. Parents and children were reunited for the fourth station where a demonstration of two different breakfasts was visualized. One breakfast was prepared with keyhole labeled products and one with sugar rich products. The sugar content was then visualized with sugar cubes. The fifth station concerned energy dense food and the participants were shown how much energy dense foods that according to the guideline may be consumed during a week by a 10 year old child followed by a discussion. Before this session the children were
supposed to register what they drink to all meals during a day and set up a
goal concerning what can be improved regarding what they drink.

Figure 4 Exhibition of sugar-rich foods in session 11.

Year 2
During the second year of the intervention the communication with the
children was solely through the web platform. This part of the intervention
was considered to be a stage where the families worked on maintaining
lifestyle changes that had been done during the first year of the intervention
but also on making new lifestyle changes. The second year was based on 12
assignments that the children, and sometimes parents, were supposed to do
in their home setting and then report to the leaders and/or the other
participants through the web platform (Table 2). Five of the assignments
focused on food habits while the others focused on physical activity and
behavioural change. One example on an assignment was planning meals for
a week and to go shopping and keep the “keyhole label” and the “plate
model” in mind during the whole process. Another assignment was for the
children and parents to share their best tip to the other participants on how
to include fruit and vegetables with each meal.

Pilot study
Before the study started a majority of the sessions and measurements were
tested on children in the same age group as the study population. Four of the
food related sessions were tested in a grade 4 school class in Umeå and one
session was tested on a group of overweight and obese children in
Östersund, Sweden. The session “Cooking” was tested on a group of
voluntary parents and was performed at the Department of Food and
Nutrition at Umeå University. All measurements regarding dietary intake
were tested on children 8-10 years old before the study started to ensure that they were suitable for the age group. The diet history interview was tested on three children and the food record was tested on two children.

The pilot study resulted in changes concerning adapting information and practical tasks to get more child-friendly as well as to shorten down and exclude some exercises that were too time consuming. Mainly the instructions were made clearer regarding the food record to minimize misunderstandings.

**Actions for preventing drop outs**
Since it is known that intervention studies are associated with a high proportion of dropouts (58), actions were taken throughout the whole study to minimize and prevent this as well as to motivate both children and parents to participate in all measurements. At baseline, 1-year measurement and endpoint the children received a breakfast after leaving fasting blood samples as well as a small gift e.g. a CD, book or ticket to an indoor water park. The parents also received one-time tickets to a local fitness club.

Two times during the first and second year of the study cinema tickets were raffled among the children who had completed the 2-day food records. Also, at the end of the study all children who had completed all 2-day food records were included in a raffle of a digital camera. Among the parents poles for Nordic walking were raffled after the third physical activity measurement.

Both children and parents participating in the first information meeting as well as the participants in the intervention attending the last group session were served a fruit salad. For the intervention children juggle balls were raffled in connection to session 8 for those who had completed the home assignment and at the end of year 1 each intervention group was invited to a family activity which involved playing Laserdome. The Laserdome activity was done to support team building before the second year of the study started and contact was held through the web platform.

When a family decided to leave the study a voluntary questionnaire was sent to the family with a few questions about the reason for leaving the study.

**Data collection**

**Diet history interview**
DHI assessing dietary intake two weeks retrospectively were performed at baseline and at the end of the intervention study. The first groups did their DHI in October 2006 and the following three groups did their interviews in
January, March and May/June 2007. DHI was repeated two years after
baseline (between October 2008 and June 2009). All interviews, except two,
were conducted at the Department of Food and Nutrition and lasted 1-2
hours. One child together with at least one parent was invited. At baseline 73
children were accompanied by a mother, 16 by a father and 3 were
accompanied by both parents. At the 2-year follow-up 32 children had their
mother with them, 13 had their father, and 3 had both parents with them.
Questions were directed directly to the child, however, parents contributed
with information when they felt it was needed.

The interview started with questions about the children’s general meal
pattern on weekdays and weekend days. The interview then proceeded with
detailed questions about what foods and meals the children had consumed
the past two weeks. Since Swedish school children are offered free school
lunch, a list of the meals that had been served in each child’s school the
previous two weeks was shown to help the child to remember. Portion sizes
of each food item and dish eaten by the child were described with the help of
food-portion photographs (10), household measurements, standard weights
of food items or bags of rice in different volumes. At baseline a majority of
the interviews were performed by MW and 19 interviews were performed by
a trained nutritionist. At endpoint 12 interviews were done by MW, 17 by a
trained nutritionist and 19 by two trained dieticians.

**Food record method**

The children were instructed to do a total of six separate 2-day food records
during the study, three during the first year and three during the second
year. At the 1-year measurement the children also were instructed to perform
a 4-day food record. At the end of the study 16 days of food record were
aimed for to be collected for each child. The measurements were planned so
that they would include the same proportions of weekdays and weekend days
as a regular week. The food records were done on consecutive days and all
seasons, including holidays, were included in the measurement days.

The children were provided with a digital camera to photograph everything
eaten during the recording days. They were instructed to bring the camera if
they left home so that everything eaten away from home, e.g. at school,
would be covered. Before taking a picture the children were instructed to lay
a measuring tape beside the plate or food item to make it easier for
interpretation of size. At the end of each day the child, together with a
parent, was instructed to sit down and look at the pictures taken and write
everything down in the food diary. If the children had forgotten to
photograph anything, they were also instructed to write this. Portion sizes
were assessed by looking at the photographs and then comparing them with
food-portion photographs (10), household measures or standard weights of food items. Data of the food records were nutritionally calculated and pictures were compared with the amount that had been recorded in the diary. If a child’s assessment seemed unrealistic, a new judgement based on the picture taken was made regarding portion size or amounts.

**Calculation of energy, nutrients and food groups**
The reported dietary intake was entered into the dietary analysis program Dietist XP version 3.0 (Kost och Näringsdata AB) to calculate the EI and nutrient intake of each child. Dietist XP was based on the Swedish Food composition database version 2008-03-06. Food items and dishes that did not exist in the database were replaced with a similar food item or dish existing in the data base. If no similar food item or dish existed, information about the energy and nutrient content of the specific food or dish was manually entered in to the database. Sucrose was the only refined sugar that could be calculated in the nutritional calculation program and was used to evaluate intake of refined sugar. The data entry into Dietist XP was done by MW a trained nutritionist and three trained dieticians.

The nutritional calculation program used was not able to create food groups and therefore a program that was able to provide this information was developed in Excel (Microsoft, 2010). The program was designed so that the food groups as well as the individual foods included in each food group could be decided by the user. The program provided information about individual intake in grams of each food group as well as energy and nutrients contributed from the food groups. In the Swedish Food composition data base (version 2008-03-06) 107 food groups were defined by the Swedish Food Administration. These 107 food groups were compressed by the Excel program developed for the present study, into 51 food groups of which the food groups that best suited the aim of the present study were selected to be included in the analyses. The food group called keyhole labeled foods (e.g. bread, cereals, spreads, dairy products etc.) was defined according to criterions that the Swedish Food Administration had defined (75).

**Doubly labeled water method**
To validate the ability of the DHI method to assess EI of overweight and obese children, TEE was measured with the DLW method in 22 randomly selected children (11 girls and 10 boys), 9 from the intervention group and 12 from the control group. Each child collected three baseline urine samples the days before the administration of an oral dose of DLW corresponding to 0.12 g 2H and 0.25 g 18O per kg estimated body water (15, 76). The dose bottle was rinsed with tap water, which also was ingested by the child. During the following two weeks five urine samples were collected at: 12 hours, 24 hours
and 8, 13 and 14 days after dose administration. The body weight of each child, to the nearest 0.1 kg in light clothing, was measured with a body scale (AJ Medical, Sweden) before the oral dose was ingested and after the last urine sample had been collected 14 days later. All children stayed healthy during the measurement period and were instructed not to drink water from any place other than their home community.

Urine samples were stored at –18 °C until analysed by isotope ratio mass spectrometry (Aqua Sira, VG, UK) (77). The TEE was calculated using the equation of Schoeller et al (15) and the respiratory quotient was set to 0.85 (78). DHI was performed the day after the last urine sample was collected to cover the same 14 days that TEE was measured using the DLW method. Estimated EI from the DHI was compared with the mean daily TEE measured by the DLW method.

**SenseWear Armband**

At baseline 22 randomly selected children (the same that participated in DLW measurements) were instructed to wear the armband during the same 14 days that the DHI covered. The rest of the group (n=71) was instructed to wear the armband over four days. These four days included two weekdays and two weekend days.

During the following years of participation the children were instructed to wear the armband during the same days as the 2-day and 4-day food records. Furthermore, during the DHI at the 2-year follow-up the children were instructed to wear the armband during four consecutive days.

At each measuring occasion the children were instructed to start wearing the armband the night before the first measuring day and to take it off the morning after the last measuring day. The armband was worn on the back of the right upper arm and each child was instructed to wear it at all time except when in contact with water, e.g. showering, swimming or when participating in other water activities. The software program Interview Professional (version 5.1) together with information about age, sex, weight, height and handedness of each child was used to calculate the TEE from the armband's registrations. Estimated EI from the DHI and food records was then compared against the mean daily estimate of TEE from SWA.

Physical activity level (PAL), which is TEE divided by basal metabolic rate (BMR), was used to express the child’s degree of activity in relation to the BMR (79). PAL can be used to estimate the accuracy of reported TEE. In the same way, the quotient of EI:BMR can be used to estimate the accuracy of reported EI. PAL and EI:BMR should be equal if the person is weight stable.
during the measurement period. BMR was calculated according to Schofield for normal weigh children (1) and Dietz et al. for overweight and obese children (80).

**Anthropometric measurements and metabolic parameters**

Two paediatric research nurses performed all anthropometric measurements (Figure 5). Children’s weights and heights were measured in light clothing and without shoes. Weight was measured with an electronic scale (AJ Medical, Sweden) to the nearest 0.1 kg and height with a wall stadiometer (Hyssna Measuring Equipment AB, Sweden) to the nearest 0.1 cm. Waist circumference was measured to the nearest 0.1 cm with a non-elastic flexible tape halfway between the tenth rib and the iliac crest in a standing position. Hip circumference was measured at the widest point between hip and buttocks.

Body composition was assessed by dual-energy x-ray absorptiometry (Lunar prodigy whole-body scanner GE Medical Systems, Madison, WI, USA) with the child in a supine position. Body-fat was expressed in kilograms (fat mass kg) and as percent fat (fat mass %) in soft tissue. Fat content in soft tissue in the trunk was expressed as percent fat (truncal fat %).

Overweight and obesity were defined according to the IOTF’s age and sex specific BMI cut-offs (19). An age and sex specific BMI corresponding to adult BMI of 25-29.9 kg/m² was considered as overweight while an age and sex specific BMI corresponding to adult BMI ≥ 30 kg/m² was considered as obese. Further, BMI was converted to BMI z-scores by using both US reference data (81) and a Swedish reference population (82). A z-score above + 2 SDS was considered as overweight and obese.

Waist-to-hip ratio was calculated as waist circumference / hip circumference. Sagittal abdominal diameter was measured using a ruler to the nearest 0.1 cm from bed to the top of the abdomen with the child in a supine position.

The children were classified as having the metabolic syndrome using the definitions of the International diabetes federation (83); waist circumference ≥ 90 percentile and the presence of two or more other clinical features (i.e., elevated TC, low HDL-C, high blood pressure or increased glucose). Reference data collected in a cohort of 10-year old children from Umeå was used when defining the 90th percentile of waist circumference (65).
Figure 5 Anthropometric measurements of a child performed by one of the research nurses.

**Biochemical measurements and blood pressure**
Venous blood samples were collected after 24 hours fasting by one of the two paediatric research nurses. The blood samples were analyzed for plasma glucose and serum lipids Total Cholesterol (TC), High-Density Lipoprotein-Cholesterol (HDL-C), Low-Density Lipoprotein-Cholesterol (LDL-C), Triglycerides (TG), apo lipoprotein A1 (apo A1) and apo lipoprotein B (apo B), insulin and HbA1c. Homeostatic Model Assessment (HOMA)-index was calculated according to the equation \((S_{\text{insulin}} \times P_{\text{glucose}} / 22.5)\) (84). The blood samples were analysed according to standard methods at the Department of Clinical Chemistry, Umeå University Hospital, Umeå, Sweden.

Blood pressure was measured after five minutes of rest, in a supine position on the right arm. An electronic blood pressure device (Welch Allyn Spot Vital Signs, Welch Allyn AB, Sweden) was used and a variety of cuff sizes were used to get a good fit around the arm.

**Puberty stage**
Each child’s puberty stage was assessed by one of the two paediatric nurses according to Tanner (85, 86). Puberty was defined according to the following two groups: pre-pubertal (Tanner stage 1) and pubertal (Tanner stage 2-4).
Ethical approval and considerations

Written, informed consent was obtained from all parents and verbal consent was ascertained from each child through their parents. All children were individually coded and the data were analysed anonymously. The study was approved by the Regional Research Ethics Review Board, the Faculty of Medicine, Umeå University, Umeå, Sweden (ref nr. 05-088M). The study is registered in Clinical trials (reg. Nr: NCT01012206).

At the beginning of the study all parents were informed that they would be contacted if any of the measuring variables were abnormal in any way. This concerned both physiological and psychological parameters that were checked after each measurement. In case of abnormal values parents were contacted by either the study child psychologist or one of the paediatricians in the research team and were offered help.

Children who had decided to leave the study before endpoint were asked to participate in the last measurements. The dropouts were all contacted by mail and did not have to take any contact with the researchers if they did not want to participate. This request may be considered ethically questionable since the participants had made a decision to leave the study. The research group did, however, decide to do this to be able to increase the study power.

Including a control group, which is praxis in RCT, raised some ethical considerations since overweight and obese children are a group that need support and treatment to be able to improve health. In the community where the present study was performed no organized support or treatment is available which meant that being in the control group made no difference from not being a part of the study. The families were allowed to accept support or treatment outside the study if offered but they then had to leave the study. We were not informed about this happening in any of the participants. The control group was invited to a seminar after the final measurements where they received a summary of the information given during the intervention.

Statistical methods

All statistical analyses were performed using SPSS for Windows version 15.0-18.0 (SPSS Inc. Chicago) and a p-value <0.05 was considered statistical significant (Table 3). All variables were assessed for normality and non-normal distributed variables were analysed with non-parametric tests.

In all analyses the intention to treat (ITT) approach was used to keep participants in the groups that they were randomized to at inclusion. Drop outs were taken care of by using the “last observation carried forward
principle” where approximated values for dietary data were used from the 2 and 4-day food records conducted during the first and second year of the study. For metabolic markers baseline measures were used as approximated values for the missing 1-year measurement. All analyses were also done per protocol (data not shown) with no different results.

**Table 3** Overview of the statistical methods used in the included papers.

<table>
<thead>
<tr>
<th>Method</th>
<th>Paper 1</th>
<th>Paper 2</th>
<th>Paper 3</th>
<th>Paper 4</th>
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<tr>
<td><strong>Parametric tests</strong></td>
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<td>X</td>
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<td>Paired t test</td>
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<td>X</td>
<td>X</td>
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<tr>
<td>One-way analysis of covariance</td>
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<td>X</td>
<td>X</td>
<td>X</td>
</tr>
<tr>
<td>Bland Altman method</td>
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<td></td>
<td></td>
<td>X</td>
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<tr>
<td>Pearson’s product moment</td>
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<td></td>
<td>X</td>
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<td>correlation</td>
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<tr>
<td>Wilcoxon signed rank test</td>
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<tr>
<td>Chi Square test</td>
<td>X</td>
<td>X</td>
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</tbody>
</table>
Results

Validity of a diet history interview
Of the 92 children who participated in the DHI at baseline, 85 were included in the validation against TEE measured by SWA. Four children were excluded because they had worn the armband <19 h/d each measuring day which was considered too short. Three more children were excluded because their weight had become normal between the time of inclusion and baseline measurements. One of these normal weight children was also excluded from the group of 22 children who had been instructed to wear the armband during 14 days as well as to measure TEE with DLW. Of the 85 who were included in the validation of EI against SWA, 48% were girls. Among the 21 children included in the validation of EI against DLW, 11 were girls.

The EI assessed by DHI was underestimated by 14% which corresponds to 1.73 ± 2.63 MJ/d, when validating reported EI against measured TEE among the 85 children who had complete SWA measurements (p=<0.001) (paper 1, figure 1). When comparing EI against TEE measured with the DLW method (n=21) the same proportion of underestimation was noticed, i.e. 14%, which corresponded to 1.66 ± 1.76 MJ/d (p=<0.001) (paper 1, figure 2). Regardless of what reference method was used for validation there were no differences between intervention and control groups or gender. For both validations a trend was noticed where underestimation increased with increased BMI (r=-0.38; p=<0.001) as well as increased age (r=-0.21; p=0.05). Furthermore, the EI of children with obesity was underestimated twice as much as the EI of children with overweight (22% vs. 11%) (p=0.005) when comparing against TEE measured with SWA.

Intervention study

Participants and participation rate
In total, 93 children participated in baseline measurements (Figure 2). Of the 93 children who participated in baseline measurements the mean age was 10.5±1.09 years old and 51% were girls. There were no differences between intervention and control groups in age (p=0.914) or distribution of gender (p=0.215). At baseline 34% of the children in the intervention group and 22% of the children in the control group had reached puberty (Tanner stage 2-4). At 1-year measurement the corresponding proportions were 40% and 36% in intervention and control group respectively. No child had reached Tanner stage 5 (post-pubertal) at the 1-year measurement.
From baseline to 1-year measurements 38% (n=35) dropped out, (20/48 (42%) from the intervention group and 15/45 (33%) from the control group), leaving 58 children to participate in the 1-year measurement. Between 1-year measurement and endpoint 7 more children (12%) (three children in the intervention group and four children in the control group) dropped out which means that the total dropout rate throughout the whole study was 45% (n=42) (23/48 (48%) in the intervention group and 19/47 (40%) in the control group). However, before endpoint all dropouts were invited through a letter to participate in the last measurements (with the possibility to choose what measurements they wanted to participate in) and five families (two from the intervention group and three from the control group) were interested in participating. This resulted in 56 children that were included at endpoint measurements. There were no statistically significant differences in dropout rates between the groups throughout the study.

Intervention families participating during the whole first year of the study had a mean participating rate of 7 sessions (range: 1-14). Four children participated in all 14 sessions and 7 children participated in all sessions regarding food habits. All children attended at least one session regarding food habits. The mean attendance rate of the 5 sessions regarding food habits among intervention children who participated during the first year (n=28) was 3.8 (range: 2-5), 3.4 (range: 2-5), 3.4 (range: 3-5) and 3.1 (range: 1-5) in groups 1-4, respectively.

Among those families that participated in the study during the second year the average visiting frequency on the website was 37 times (range: 3-109). For the five assignments concerning food habits the following average number of families read the assignment; “Healthy snacks (children)”: 9 families, “Healthy snacks (parents)”: 5 families, “Meal planning”: 7 families, “Food advertisement”: 6 families, “Five a day (children)”: 3 families, “Five a day (parents)”: 3 families and “Unhealthy snacking”: 3 families.

Dietary intake

Data included in analyses
In total 92 of the 93 children participated in the DHI at baseline and of these 83 fulfilled the inclusion criteria of having at least a 0.6 EI:TEE quotient and were included in the analysis (paper 2, figure 1). The 0.6 EI:TEE quotient was set to exclude participants with obvious incomplete dietary intake data.

At the 1-year measurement 52 of the 58 children still participating in the study conducted the 4-day food records (paper 2, figure 1). However, eight were regarded as incomplete (EI:TEE quotient <0.6) and were replaced
according to the last observation carried forward principle with approximate values from previous 2-day food records. The same procedure was done with 14 drop outs between baseline and the 1-year measurement. On average the replaced measurements came 6.5 months (range: 3-9) before the 1-year measurement. Remaining were 66 children to be included in the analysis of dietary data at the 1-year measurement.

Of the 56 children who still participated in the study at endpoint measurements, 48 participated in the DHI but only 45 children fulfilled the 0.6 EI:TEE quotient (paper 4, figure 1). All three incomplete measurements as well as measurements of the 24 children who had dropped out were replaced according to the principle of carrying the last observation forward. The incomplete measures and drop outs were replaced with 2-day food records or 4-day food records done on average 16 (range: 2-22) months before the endpoint measurements. In total 72 children were included in the analyses for dietary intake at endpoint. When evaluating EI against TEE measured with SWA at endpoint 38 children were included in the analysis since they were the only ones who had participated in both the DHI and SWA measurement.

**Energy intake**

There were no differences in EI:TEE between intervention and control groups either at baseline, after 1 year or at endpoint (Table 4). At endpoint EI in the whole group was 25% lower than measured TEE which corresponds to 2.84 ± 2.08 MJ/d (p=<0.001). In the intervention group EI was 28% lower than TEE (p=<0.001) and in the control group EI was 21% lower (p=<0.001). No difference was found between intervention and control groups or between genders. There was a strong negative correlation between the degree of difference between EI and TEE and BMI (r=-0.50, p=<0.001). However, no statistically significant correlation was found between the difference in EI and TEE and age (r=0.28, P=0.088). At endpoint, the intervention group had 13% lower EI:BMR quotient than the control group (p=0.040) (Table 4).
Table 4 Differences between intervention and control groups at baseline, 1-year measurement and endpoint, regarding energy expenditure, energy and macronutrient intake among overweight and obese 8-12 year old children.

<table>
<thead>
<tr>
<th></th>
<th>Baseline</th>
<th>1-year measurement</th>
<th>Endpoint</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Intervention (n=81)</td>
<td>Control (n=64)</td>
<td>p&lt;sup&gt;1&lt;/sup&gt;</td>
</tr>
<tr>
<td>BMR&lt;sup&gt;2&lt;/sup&gt;, MJ</td>
<td>6.49±0.83</td>
<td>6.45±0.84</td>
<td>0.816</td>
</tr>
<tr>
<td>TEE&lt;sub&gt;i,j&lt;/sub&gt;, MJ/d</td>
<td>10.5±1.78</td>
<td>10.9±1.76</td>
<td>0.311</td>
</tr>
<tr>
<td>EI, MJ/d</td>
<td>9.29±1.77</td>
<td>9.45±1.50</td>
<td>0.693</td>
</tr>
<tr>
<td>TEE&lt;sub&gt;i,j&lt;/sub&gt;/BMR</td>
<td>1.60±0.21</td>
<td>1.71±0.29</td>
<td>0.145</td>
</tr>
<tr>
<td>EI/BMR</td>
<td>1.44±0.26</td>
<td>1.48±0.30</td>
<td>0.509</td>
</tr>
<tr>
<td>EI/TEE&lt;sub&gt;i,j&lt;/sub&gt;</td>
<td>0.89±0.18</td>
<td>0.87±0.18</td>
<td>0.622</td>
</tr>
</tbody>
</table>

1. Difference between groups were calculated with independent sample t-test at baseline and one-way ANCOVA at 1-year measurement and endpoint.
2. Basal metabolic rate was calculated according to Schofield for normal weigh children (1) and Dietz et al. for overweight and obese children (80).
3. Total energy expenditure measured with SenseWear armband covering 4 days.
4. Reported energy intake by a diet history interview covering 14 days at baseline and endpoint and a 4-day food record at 1-year measurement.
5. Percentage of total EI.
Macronutrient intake

There were no differences in macronutrient intake between the groups at baseline (Table 4). Children in both groups met the recommendations for all macronutrients with the exception that both groups had a higher intake than recommended of energy from SFA (recommendation ≤ 10 E%) and a lower intake than recommended of energy from polyunsaturated fatty acids (PUFA) (recommendation 5-10 E%). The intervention group also had a lower intake than recommended of dietary fiber (2-3 g/MJ) at baseline.

At the 1-year measurement the intervention group consumed 7 g less total fat (p=0.028) and 2.2 g less monounsaturated fatty acids (MUFA) (p=0.041) per day compared to the control group (Table 4). The intake of E% from fat (30.8 E% vs. 33.6 E% in intervention and control groups respectively) (p=0.023) and PUFA (4.09 E% vs. 5.04 E%) (p=0.012) was also lower in the intervention group compared to the control group. Furthermore, compared with the intervention group, the control group had a greater increase in proportion of fat intake (E%) from baseline to the 1-year measurement (paper 2, table 2). Other differences included a decrease in absolute intake of PUFA (g) in the intervention group but an increase in the control group (p=0.034). PUFA expressed as E% increased in both groups, but the increase was greater in the control group (p=0.012). At the 1-year measurement there was no difference in the proportion of children reaching the nutritional intervention goals of SFA (recommendation ≤ 10 E%) and dietary fiber (recommendation 2-3 g/MJ) between intervention and control groups (paper 2, table 3). However, a statistically significant larger proportion of children in the intervention group had an intake of refined sugar below the maximum recommended intake (≤ 10 E%) compared to the control group (p=0.019). Regarding meeting the recommendations at the 1-year measurement, children in both groups had a higher intake than recommended of SFA (≤ 10 E%). The control group had a 2.4% higher intake than the maximum recommended intake of refined sugar (≤ 10 E%) whereas the intervention group just about exceeded the maximum recommended intake by 0.6%. Both groups were below the recommended intake of dietary fiber (2-3 g/MJ).

At endpoint the intervention group had a 10.6 g lower intake of total fat (p=0.022), a 3.7 g lower intake of MUFA (p=0.048) and a 53 mg lower intake of cholesterol (p=0.035) compared to the control group (Table 4). There was no difference in proportion of children meeting the nutritional goals of the intervention regarding SFA, refined sugar and dietary fiber between the intervention and control groups at endpoint (Figure 6). Both intervention and control children consumed more than the maximum
recommendation of SFA (≤10 E%) and ate less than the recommended amount of PUFA (5-10 E%) (1). The control group exceeded the maximum recommendation of refined sugar (≤10 E%) at endpoint while the intervention group did not. Only the intervention group met the recommendations of dietary fiber (2-3 g/MJ).

Figure 6 Proportion of children in intervention (n=37) and control groups (n=35) consuming recommended intake of food groups and macronutrients at endpoint. There were no differences between the groups when using Chi Square test.

Food intake
At baseline the intervention group had a 74% higher median intake of sugar sweetened beverages (soft drinks and non-natural sweetened fruit juices) than the control group (p=0.014) (Paper 4, table 3). Both groups consumed about 50% of the recommended intake of fruit, berries, vegetables, root vegetables (excluding potatoes) (recommendation ≥500 g/d). Consumption of energy dense foods was 4% and 5% above the recommendation (≤10 E%) in intervention and control groups respectively.

There was no difference in proportion of children in the intervention and control group who reached recommendations regarding fruit and vegetables and energy dense foods at endpoint (Figure 6). Both groups reached about half (46% and 51%) of the recommended intake regarding fruit, berries, vegetables, root vegetables (excluding potatoes) (≥ 500 g/d) at endpoint (Paper 4, table 3). Regarding consumption of energy dense foods, both groups exceeded the recommendation (≤ 10 E%) by 4%. At endpoint the intervention group consumed 89% less sugar sweetened beverages than the control group (p=0.015) (Paper 4, table 3). The lower intake of sugar
sweetened beverages in the intervention group also resulted in that energy
dense foods was 53% lower among the intervention children compared to
control children (p=0.014) (Figure 7). The intervention group consumed
3.0 times more keyhole labeled foods (p=0.031), especially keyhole labeled
dairy products where the intervention group ate 3.5 times more than the
control group (p=0.032). There was no difference in consumption of breads
(> 6% fiber) between intervention and control groups at endpoint. However,
when bread was divided into hard and soft breads, the intervention group
consumed a median of 3 grams of hard breads per day in comparison to the
control group’s median of 0 grams consumption at endpoint (p=0.028).

Figure 7 Difference between intervention (n=43 at baseline, and n=37 at endpoint) and control
groups (n=40 at baseline, and n=35 at endpoint) in median consumption of different food
groups (g) at baseline and endpoint among overweight and obese children. Statistically
significant differences between groups are calculated with Mann Whitney U test and are marked
with *.

There were no differences in proportion of energy contribution from fruit,
berries, vegetables and root vegetables (excluding potatoes), energy dense
foods or keyhole labeled foods between the intervention group and control
group, neither at baseline nor at endpoint (Figure 8). However, the
intervention group consumed close to significant (p=0.052) less energy from
energy dense foods.
Figure 8 Difference between intervention (n=43 at baseline, and n=37 at endpoint) and control groups (n=40 at baseline, and n=35 at endpoint) in median energy contribution of food groups expressed as proportion of total energy intake at baseline and endpoint among overweight and obese children. There were no differences between the groups when using Mann Whitney U test either at baseline or endpoint.

**Anthropometric and metabolic parameters**

**Data included in analyses**

All 93 children participated in the measurements of anthropometrics and blood pressure at baseline. One child refused to leave blood samples and consequently 92 children were included in the analysis of biochemical values at baseline. For the 35 children who dropped out between baseline and the 1-year measurement, measurements of anthropometrics, metabolic parameters and blood pressure from baseline were used as a proxy for the 1-year measurement. This resulted in 93 children who were included in the 1-year measurement for anthropometrics and blood pressure and 92 children for biochemical analyses.

**Metabolic syndrome**

At baseline there were no differences between the groups besides a 2.2% higher fat mass in the intervention group (p=0.044) (Table 5). Three children met the criteria’s for metabolic syndrome at baseline, one in the intervention group and two in the control group.

At the 1-year measurement there was no difference in BMI (Table 5) or proportion of children classified as overweight or obese according to Cole et al.’s definition (19) between intervention and control groups (paper 3, table 2). After 1 year 4 children in the intervention group had changed from being classified as obese to being overweight and 2 children from being overweight
to normal weight (Figure 9). In the control group 2 children had changed from being classified as obese to being overweight and 6 children from being overweight to normal weight. Both groups had decreased BMI z-scores independent of which reference population used. Regardless of reference population the proportion of children above 2 SDS in both groups did not change significantly from baseline to the 1-year measurement.

![Bar chart showing number of participants classified as normal weight, overweight, and obese at baseline and 1 year measurement in the intervention and control groups.](image)

**Figure 9** Number of participants classified as normal weight, overweight, and obese at baseline and 1 year measurement in intervention (n=93 at baseline and 1 year measurement) and control group (n=93 at baseline and 1 year measurement). There were no differences between the groups when using Chi Square test.

The intervention group had a 1.2 cm higher waist circumference (p=0.043) and the waist/hip ratio was significantly different between the groups (p=0.029) at the 1-year measurement (Table 5) as a result of a 0.02 increase in the control group compared to a 0.01 increase in the intervention group. Regarding metabolic markers, the only difference between the groups at the 1-year measurement was a 0.05 lower apoB/A1 ratio in the intervention group (p=0.041). The prevalence of metabolic syndrome had increased non-statistically significant from one to three participants in the intervention group but remained the same in the control group.
Table 5 Differences between intervention and control groups at baseline and 1-year measurement in anthropometric and metabolic parameters of overweight and obese 8-12 year old children.

<table>
<thead>
<tr>
<th></th>
<th>Baseline (n=48)</th>
<th>1-year measurement (n=45 or 44a)</th>
<th>P²</th>
<th>Baseline (n=48)</th>
<th>1-year measurement (n=45 or 44a)</th>
<th>P²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Weight, kg</td>
<td>52.1 (9.95)</td>
<td>50.4 (9.99)</td>
<td>0.402</td>
<td>54.9 (10.4)</td>
<td>54.0 (11.7)</td>
<td>0.509</td>
</tr>
<tr>
<td>Height, cm</td>
<td>149 (7.86)</td>
<td>149 (8.64)</td>
<td>0.951</td>
<td>152 (8.38)</td>
<td>153 (9.33)</td>
<td>0.324</td>
</tr>
<tr>
<td>BMI, kg/m²</td>
<td>23.4 (2.79)</td>
<td>22.6 (2.39)</td>
<td>0.148</td>
<td>23.5 (2.70)</td>
<td>22.8 (2.86)</td>
<td>0.704</td>
</tr>
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<td>BMI z-score</td>
<td>2.03 (0.88)</td>
<td>1.77 (0.71)</td>
<td>0.130</td>
<td>1.81 (0.82)</td>
<td>1.55 (0.82)</td>
<td>0.844</td>
</tr>
<tr>
<td>BMI z-score</td>
<td>3.23 (1.34)</td>
<td>2.75 (1.04)</td>
<td>0.057</td>
<td>2.94 (1.22)</td>
<td>2.57 (1.21)</td>
<td>0.536</td>
</tr>
<tr>
<td>Waist circumference, cm</td>
<td>78.0 (10.1)</td>
<td>74.7 (8.80)</td>
<td>0.094</td>
<td>79.3 (9.99)</td>
<td>78.1 (9.14)</td>
<td>0.043</td>
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<tr>
<td>Hip circumference, cm</td>
<td>89.4 (7.53)</td>
<td>87.1 (7.57)</td>
<td>0.145</td>
<td>90.4 (7.65)</td>
<td>89.0 (8.29)</td>
<td>0.932</td>
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<tr>
<td>Waist/hip ratio</td>
<td>0.87 (0.07)</td>
<td>0.86 (0.07)</td>
<td>0.352</td>
<td>0.88 (0.07)</td>
<td>0.88 (0.06)</td>
<td>0.029</td>
</tr>
<tr>
<td>Sagittal abdominal diameter, cm</td>
<td>17.6 (2.53)</td>
<td>17.0 (1.82)</td>
<td>0.153</td>
<td>17.9 (2.22)</td>
<td>17.5 (2.29)</td>
<td>0.590</td>
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<tr>
<td>Fat mass, kg</td>
<td>19.8 (4.10)</td>
<td>17.0 (4.07)</td>
<td>0.171</td>
<td>20.6 (5.11)</td>
<td>19.3 (5.7)</td>
<td>0.483</td>
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<tr>
<td>Fat mass, %</td>
<td>39.2 (6.17)</td>
<td>37.0 (4.33)</td>
<td>0.044</td>
<td>39.0 (6.11)</td>
<td>36.9 (5.82)</td>
<td>0.965</td>
</tr>
<tr>
<td>Trunkal fat mass, %</td>
<td>38.4 (7.46)</td>
<td>36.2 (5.42)</td>
<td>0.115</td>
<td>38.0 (7.47)</td>
<td>35.9 (7.46)</td>
<td>0.830</td>
</tr>
<tr>
<td>Diastolic blood pressure, mm Hg</td>
<td>66.6 (5.60)</td>
<td>66.7 (6.14)</td>
<td>0.959</td>
<td>66.7 (5.44)</td>
<td>66.6 (6.00)</td>
<td>0.272</td>
</tr>
<tr>
<td>Systolic blood pressure, mm Hg</td>
<td>112 (8.92)</td>
<td>113 (8.80)</td>
<td>0.739</td>
<td>111 (8.58)</td>
<td>114 (9.28)</td>
<td>0.758</td>
</tr>
<tr>
<td>Total cholesterol, mmol/L</td>
<td>4.44 (0.91)</td>
<td>4.51 (0.82)</td>
<td>0.711</td>
<td>4.32 (0.91)</td>
<td>4.33 (0.82)</td>
<td>0.520</td>
</tr>
<tr>
<td>LDL-cholesterol, mmol/L</td>
<td>2.58 (0.78)</td>
<td>2.71 (0.74)</td>
<td>0.415</td>
<td>2.54 (0.78)</td>
<td>2.64 (0.75)</td>
<td>0.828</td>
</tr>
<tr>
<td>HDL-cholesterol, mmol/L</td>
<td>1.46 (0.32)</td>
<td>1.35 (0.28)</td>
<td>0.104</td>
<td>1.39 (0.35)</td>
<td>1.28 (0.29)</td>
<td>0.983</td>
</tr>
<tr>
<td>S-triglycerides, mmol/L</td>
<td>0.88 (0.53)</td>
<td>0.95 (0.39)</td>
<td>0.498</td>
<td>0.87 (0.63)</td>
<td>0.89 (0.40)</td>
<td>0.286</td>
</tr>
<tr>
<td>Apolipoprotein B, mg/L</td>
<td>745 (173)</td>
<td>782 (174)</td>
<td>0.316</td>
<td>733 (172)</td>
<td>755 (162)</td>
<td>0.860</td>
</tr>
<tr>
<td>Apolipoprotein A1, mg/L</td>
<td>1350 (182)</td>
<td>1330 (169)</td>
<td>0.708</td>
<td>1290 (195)</td>
<td>1230 (149)</td>
<td>0.060</td>
</tr>
<tr>
<td>Apolipoprotein B/A1 ratio</td>
<td>0.56 (0.14)</td>
<td>0.59 (0.14)</td>
<td>0.280</td>
<td>0.57 (0.13)</td>
<td>0.62 (0.13)</td>
<td>0.041</td>
</tr>
<tr>
<td>F-glucose, mmol/L</td>
<td>4.52 (0.43)</td>
<td>4.65 (0.42)</td>
<td>0.157</td>
<td>4.58 (0.42)</td>
<td>4.62 (0.41)</td>
<td>0.565</td>
</tr>
<tr>
<td>S-insulin, mU/L</td>
<td>10.3 (6.77)</td>
<td>10.2 (6.82)</td>
<td>0.976</td>
<td>11.2 (5.76)</td>
<td>10.4 (5.71)</td>
<td>0.699</td>
</tr>
<tr>
<td>HOMA-index</td>
<td>2.06 (1.37)</td>
<td>2.18 (1.65)</td>
<td>0.722</td>
<td>2.28 (1.19)</td>
<td>2.20 (1.34)</td>
<td>0.827</td>
</tr>
<tr>
<td>Hb A1c, %</td>
<td>4.03 (0.24)</td>
<td>3.98 (0.27)</td>
<td>0.337</td>
<td>4.11 (0.23)</td>
<td>4.03 (0.27)</td>
<td>0.612</td>
</tr>
</tbody>
</table>

1 One child refused to give a blood sample.
2 P-values for difference between groups calculated with independent samples t-tests at baseline and and one-way ANCOVA at 1-year follow-up.
3 Reference population from CDC in the USA (81).
4 Reference population from a Swedish population-based study (82).
Discussion

Main findings
The main findings in the present study were that children in the intervention group improved food habits in regards of a lower intake of sugar sweetened beverages and a higher intake of keyhole labeled foods after 2 years of intervention compared with the children in the control group. Furthermore, the intervention group improved their macronutrient intake in comparison to the control group, regarding a lower intake of fat at both the 1-year measurement and endpoint, and a lower intake of cholesterol at endpoint. Despite the positive effects on food habits in the intervention group, the intervention did not affect BMI solely in the intervention group. Both groups’ BMI remained stable from baseline to the 1-year measurement and BMI z-score decreased in both groups.

Dietary intake
There are few studies that have shown a difference in food habits between overweight children and their normal weight peers (20, 87). There are several factors that contribute to the difficulties in detecting differences between normal, overweight and obese children regarding dietary intake. One thing is difficulties in measuring dietary intake with errors like under- and over estimation of EI as well as selective underreporting of foods that are known as unhealthy and over reporting of foods that are known to be healthy (88). One study reported that a difference of 250 kcal between EI and TEE is enough to explain the difference between being normal weight or overweight (89), and a small difference like that may be too small for a dietary assessment method to detect. A second factor that makes it difficult to evaluate EI is that participants may eat less or healthier during the period that EI is assessed. This can give an incorrect picture of a participant’s dietary intake i.e. that EI is estimated lower than it normally is. However, if TEE is known and data on body weight or BMI during a longer period of time are available it is easier to draw correct conclusions on how valid reported EI is.

Energy and macronutrient intake
The 14% underestimation of EI at baseline was relatively low considering that it was a group of children with overweight and obesity which are known to underreport more than children with normal weight (11, 90). Other studies on obese children have reported underreporting as high as 41% (90). An underestimation of reported EI can, for example, be a consequence of underreporting, memory lapses or short comings of nutritional calculation programs (91).
At endpoint EI was evaluated against measured TEE. This cannot strictly be called a validation since validation of EI assumes that a person is weight stable and thereby in energy balance. In the present study where weight loss cannot be excluded in the intervention group, the assumption of energy balance could not be made. This concerns mainly the intervention group but it is not possible to exclude the possibility that the control group was also affected by the study since they were engaged in measurements of food and physical activity habits (92). Looking at the period EI and TEE was measured as well as during the whole study period we can conclude that weight, length and BMI has increased because of growth during the 2-years. Since the children were growing a natural increase in BMI is expected but the decreased BMI z-score from baseline to endpoint (data not shown) indicates that the increase in BMI was lower that ought to be expected and it is possible that the children have had a negative energy balance. The difference in EI and TEE is most likely explained by a combination of both under eating and underestimation of EI.

The fat intake as a proportion of total energy in the present study was close to the population goal (30 E%) (1) in the intervention group at all three measurements while the intake was somewhat above this in the control group at 1-year measurement and endpoint. SFA intake as proportion of total energy was above the maximum recommended intake (≤10 E%) at baseline, at the 1-year measurement and at endpoint but was similar to what other studies including overweight and obese children have reported. One study showed an intake of 15.4 E% among 9-year old Swedish children and another study showed an intake of 11.6 E% among American Indian school children (93, 94).

Carbohydrate intake was lower than the recommended population goal (55 E%) in both groups on all three measurements but was similar to what other studies have reported among normal weight (3, 95, 96) and overweight children (93, 94). The intake varied between 52-53 E% among normal weight children (3, 95) and 51-56 E% among overweight children (93, 94). The role of macronutrient proportions is a subject that is frequently discussed among researchers as well as in media when it comes to preventing overweight and obesity. So far there are limited amount of studies that have evaluated different types of macronutrient composition in the treatment of overweight and obesity among children and no consensus can be drawn of their effectiveness (97, 98).

Sucrose intake was close to the maximum recommended intake (≤10 E%) in both groups but was lower than the sucrose intake in a national sample of
the Swedish child population (12 E%). The children in the present study had a somewhat higher intake of dietary fiber than reported in other studies, e.g. intakes of 1.6 g/MJ in overweight children and 1.7 g/MJ in normal weight children (93).

**Food intake**

Only one study has been identified which evaluated the dietary part of an intervention in a similar way as we have done (99). Burrows et al. evaluated three different intervention programs on overweight and obese 8 year old children; one parent-centered nutrition lifestyle program, one child-centered physical activity skill development program and one where both programs were combined. After 1-year all three groups had improved their dietary intake similarly by decreasing EI as well as decreasing percent energy from sugar sweetened drinks, fruit juice, packaged snacks and confectionary. Further, the children increased the amount of energy from low-fat dairy products.

The intake of fruit, berries, vegetables and root vegetables in the present study was lower than recommendations and did not increase during the 2-year study period in either of the groups. Low intakes of fruits and vegetables in comparison to recommendations among children have been observed in several previous studies (3, 100, 101). The latest national survey on Swedish children’s food habits showed an intake of 193 g/day (61% less than the recommendation) among 11 year olds (3) and the fruit intake among 11 year olds in European countries vary between 149-265 g/day (100). Studies have also shown a tendency that fruit and vegetable intake decrease with increased age (3, 101). This was not the case in the present study, which implies that participating in a study where food is in focus may have had a maintaining effect on the fruit and vegetable intake. Another possible explanation is that the intervention program failed in reaching out to the children regarding the intake of fruit, berries, vegetables and root vegetables. In accordance with the present study, the Special Turku Coronary Risk Factor Intervention Project showed little result after trying to improve fruit and vegetable intake among Finish children (101). In contrast, intervention studies performed in school settings with the aim to improve fruit and vegetable intake have showed more promising results (102).

At baseline the intervention group had a statistically significant higher intake of sugar sweetened beverages than the control group. However, this reversed during the study period and at endpoint the intervention had a lower intake than the control group. This was explained by the control group who increase their consumption of sugar sweetened beverages statistically significant while the intervention group had a non-significant decrease from
204 to 119 g/day from baseline to endpoint. This change in sugar sweetened beverage consumption between the groups also resulted in a lower consumption of energy dense foods in the intervention group at endpoint. However, the lower intake of energy dense foods did not have the effect that more children in the intervention group compared with control group met the recommendation (\( \leq 10 \% \)) of energy dense foods at endpoint. It is possible that a larger decrease in other categories of energy dense foods would have been needed to impact on the proportion of children eating \( \leq 10 \% \) of energy dense foods. The role of sugar sweetened beverages has been discussed in many publications and it has been suggested that sugar containing drinks play an important role in the development of overweight and obesity (103, 104). However, more recent reviews have described the evidence as not conclusive (105).

The intervention in the present study seemed to have had a maintaining effect on the intervention children’s intake of keyhole labeled foods since the intake remained stable during the 2-year study. The intake in the control group on the other hand decreased significantly from baseline to endpoint resulting in a significant difference in intake between the groups at endpoint. So far there are no studies published on the effect of keyhole labeled foods in treatment and prevention of overweight and obesity.

**Anthropometric and metabolic parameters**

At 1-year measurement there was no difference between intervention and control groups in BMI. However, the statistically non-significant increase in BMI from baseline to the 1-year measurement was notably small (2% or 0.52 kg/m\(^2\)) when comparing to the increase in BMI among the Swedish reference children where the boy’s BMI increased 7% (1.8 kg/m\(^2\)) and the girls 8% (1.2 kg/m\(^2\)) between 10-12 years of age (82). Thus, both study groups decreased their BMI z-score between baseline and the 1-year measurement when comparing to both reference populations (U.S. (81) and Swedish (82)). The lack of difference between intervention and control groups as well as the relatively small increase in BMI indicates that both groups were affected in a similar way during the study period. One reason for this could be that merely participating in a study with focus on food and physical activity brings awareness to the child’s food and physical activity habits. Another reason could be the effect of influencing factors in the society and community, e.g. on-going discussions in the media during the past years about overweight and obesity that may have brought awareness to families and the society in general (28).

Ford et al concluded that a BMI z-score decrease of \( \geq 0.25 \) is needed for minor improvement of metabolic markers like blood pressure, S-
triglycerides, S-LDL-cholesterol and insulin sensitivity among adolescents (106). Other studies have shown that a BMI z-score reduction of at least 0.5 is needed for major improvement of metabolic health in children (107, 108). The children in the intervention group had an average reduction in BMI z-score of 0.29 when comparing to the U.S reference population. The only positive effect of the intervention on metabolic markers was seen in a lower apo B/A1 ratio in the intervention group compared to the control group at 1 year measurement. There are several possible explanations for not seeing more effect of the intervention on metabolic markers. The children’s metabolic variables were within normal range when included in the study, why improved values should not be expected. Another contributing factor to the limited effect could have been that the metabolic parameters are influenced by several lifestyle factors, e.g. both dietary intake and physical activity. The fact that the children in the intervention group showed some improvements regarding energy and macronutrient intake at the 1-year measurement and that the physical activity of the children decreased between baseline and the 1-year measurement (64) may have counterbalanced any positive effect of reduced BMI.

When comparing the content of our intervention program against other RCT programs with the same aim, these programs usually contain the same components as ours, i.e. diet, physical activity and behavioural treatment. However, what differs is how the interventions were performed e.g. number of sessions, how the study messages was delivered, if the focus was on the child or parents, the length of the program, etc. One thing that stands out in our study is the inclusion of both overweight and obese children. Most studies, not performed in schools, include only obese children (109-112). When looking at other similar studies compared to ours, the ones with longer follow-ups (>1.5 years) often fail in maintaining or decreasing BMI in the intervention group (110, 112, 113). In general few studies have longer follow-ups than 1 year. One study on 7-9 year old obese children in Finland showed no intervention effect on BMI two and three years after baseline when having participated in a family based treatment (110). Williamson et al. showed no intervention effect on BMI after a 2-year web-based intervention among 11-15 year old overweight and obese African-American girls (113). Similar results were seen among 8-12 year old extremely obese children after 1.5 years (112). However, one study from the U.S.A on 8-16 year old obese children showed a 2.8 kg/m² lower BMI in the intervention group compared to control group after 2 years (109). Two of the above described studies (69, 113) without effects at endpoint did however, show statistically significant differences in BMI after 6 months. It may be that families are more motivated in the beginning when participating in a study and therefore positive results on short term follow-ups may occur. However, keeping up
the motivation and improved lifestyle may be more difficult during longer periods of time.

A recently review concluded that there is convincing evidence that school-based interventions are effective in reducing prevalence of childhood obesity (60) while many studies at an individual level show more limited results (20). Positive aspects of focusing on schools are that more children can be targeted, that the children are more or less forced to take part in the intervention and that a side-effect can be that the intervention influence lifestyle also in the home setting. A recent school-based (grades 1-4) intervention study performed in Sweden showed that the prevalence of overweight and obesity decreased by 3.2% in intervention schools compared to a 2% increase in control schools (114). Intervention children also reported healthier eating habits at home, i.e. decrease in high-fat dairy products, sweetened cereals and sweet products.

As the cause of overweight and obesity is multifactorial it is likely that a more holistic approach is needed in combination with prevention at the individual level. A large contribution to the increase in overweight and obesity is attributed to social and environmental forces that an individual, and certainly not a child, can control. Examples on negative social trends that could be affected from a broader perspective are more structured and organized actions aimed at improving food served at daycares and schools, education about good food habits to pregnant women and safer ways to get to school by walking or biking. Thus, to tackle the overweight and obesity epidemic, interventions from a broader public health perspective are needed. A few years ago the Swedish government launched a national program to improve dietary and physical habits on several levels in society but no major campaign on the national level was ever carried out (28). The present study further emphasizes the importance of primarily focusing on primary prevention (21). A logical setting to aim primary prevention is schools and the focus should be on promoting healthy food habits and to decrease sedentary activities to maintain a healthy body weight (115).

Methodological considerations

Study design
A major strength in both the validation study and the intervention study is the RCT study design. RCTs are often described as the design that provides the highest degree of evidence in health care research (116). The intervention study had an efficacy approach which means that the outcomes of the study were assessed in a controlled setting and that the researcher who usually has developed the program is highly involved in every step of the intervention
Showing that an intervention program has efficacy under ideal conditions is considered as the first step before it is tested in a real setting (117). There are, however, some aspects of the RCT that needs to be taken into consideration, e.g. difficulties in keeping participants and researchers blinded and contamination between intervention and control groups (21). In the present study blindness was not possible neither for the participants nor the researchers. However, the research nurses who performed the anthropometric and biochemical measures were not informed about group allocation.

Another strength of the present study is the use of ITT which is considered the golden standard when determining which participants to be included in the analyses of results (118). ITT is a strategy where intervention and control groups are compared in the groups that they originally were allocated regardless of if they deviated from the intervention protocol (119-121). The biggest advantage of using ITT is that confounders and risk factors among the participants that may affect outcomes are balanced between the groups (121). Consequently, any differences between the groups can be seen as a result of the intervention and not because of differences in the groups. A disadvantage of using ITT is that the treatment effect generally is limited because of dilution due to non-compliers (118).

Between recruitment and baseline measurements three children (two from the intervention group and one from the control group) went from being overweight to normal weight. These children had just passed the overweight limit when they were included and a small change in weight or height or an error in the measurement of weight and height could have made this happen. However, we decided to keep these children in the study in accordance to the ITT principle (119). Two of the subjects left the study during the first year but one child stayed the whole study. Inclusion of children not fulfilling inclusion criteria could have been avoided if the randomization of children was done after baseline measurements as recommended in the CONSORT statement (116).

Until now there is no adequate strategy on how to handle missing values in RCT (122). In the present study we used the “last observation carried forward” principle with approximated values to replace missed measurements because of dropouts or to replace measurements that were not considered complete. This method of handling missed values have been described as one of the most commonly used strategies for dealing with missing data (119). However, dealing with missing observations in this way can introduce biases like limitation of within patient variation (121). To ensure that potential biases were not introduced because of the last
observation carried forward principle, all analyses were also done per protocol. The per protocol analyses did not show different results and therefore the last observation carried forward principle was chosen to be presented. An alternative method that could have been used is the statistical method Mixed model which has become a more widely used method during the past few years. Important strengths with the Mixed model analysis method are that imputations are not necessary and that each participant contributes with the measurements they have done during the study (122).

The relatively long study of two years is another advantage of the present study. In a recent review of studies with the aim of treating overweight and obesity only 4 of the 63 included studies had a follow-up of at least two years (58). When aiming at changing lifestyle it is important that the time of follow-up corresponds to the time frame of lifestyle changes. Even though we had a relatively long study in comparison to other RCTs (58) it may not have been long enough to see the full effect of the study. A negative consequence of studies going on for a longer period of time is difficulties in keeping participants throughout the whole study.

**Generalization, dropout rate and recruitment**

The study population was mainly families representing those living in the town of Umeå, which is a town with a high educational level (123). A smaller proportion came from villages surrounding Umeå. We did not succeed in reaching out to families with other ethnical backgrounds and it is most likely that families that agree to participate in a study like the present one are likely to be more motivated than those who decline participation. This may be limiting factors when it comes to the generalization of the results from the present study.

When interpreting the results of the study the high dropout rate (45% during the whole study) should be taken into consideration. A recent review reported dropout rates between 12 and 52% in other intervention studies aiming at preventing overweight and obesity after 12 months of follow-up (58). No statistical analysis could be done based on the questionnaire sent to dropouts because of the low response rate (14 of 42 families returned the questionnaire). However, when looking at the questionnaires that were filled out reasons like lack of time, the child did not want to participate, and that they already knew what was discussed during the sessions were quite common. Other factors that could have contributed to the high dropout rate are the repeated measurements and the relatively large work load passed on to the families during the study. Many different measurements were done at many occasions which may have had a tiring effect on the children even though it was not expressed as a reason for dropout. The high dropout rate
resulted in a lower power of the study and might have caused difficulties in seeing statistically significant differences between the groups.

We had difficulties in reaching a high enough statistical power already at baseline even though we contacted all families with children in the age group of interest and had ambitious recruitment procedures. We aimed to recruit 120 children to reach an 80% study power and to cover up for a 30% dropout. However, we only managed to recruit 105 families of which 93 started the study. One possibility for the difficulties in recruiting could be that many parents do not recognise their child as being overweight or obese even though they are (124). Another reason could be that food intake for some people is sensitive to bring up, especially at young age, and our understanding was that there was sometimes a larger fear of eating disorders among the parents as a study side effect than fear of health consequences of being overweight or obese as a child. There is no evidence that children who have participated in intervention programs aiming at preventing overweight and obesity have had negative effects on self-image or caused eating disorders like anorexia nervosa (125).

A shortcoming of the present study is that potentially gender differences could not be evaluated because of the low study power. Little research has been done evaluating differences in intervention response with respect to gender. However, two studies have shown that boys seem to respond better to obesity prevention programs than girls (126, 127).

**Dietary assessment**

Evaluating dietary habits in general and changes in dietary habits in particular include many challenges (14). The ambitious evaluation of dietary habits is a strength of the present study. We used two different methods to assess the dietary intake (DHI, 2 and 4-day food records). To capture a person’s natural variation and possible changes in dietary habits, the 4-day food record at the 1-year measurement may have been too short to capture a natural variation in dietary intake (9). However, a 14 day period, as included in the DHI at baseline and endpoint, have a greater chance of capturing changes in foods that are consumed regularly.

We used two different objective methods to validate estimated EI from the DHI against TEE. DLW was one of the methods and is known as the “golden standard” when measuring TEE in free living conditions (14). The drawback of the method is that it is expensive and demands special laboratory equipment. SenseWear Armband Pro (version 5.1) was the other method used and it was validated against DLW on the actual study population and showed good agreement with DLW measurements on group level (16). A
EI:TEE quotient of at least 0.6 was used to exclude the incomplete reports of EI from the analysis. The quotient was set quite low since some children may have been in a negative energy balance to stabilize or decrease BMI and we did not want to exclude these children.

The decrease in sugar sweetened beverages did not seem to affect sucrose intake at endpoint. Of note here is the inability to correctly evaluate the intake of refined sugar due to shortcomings in the database provided by the National Food Administration in Sweden. The maximum recommended intake of $\leq 10 \text{ E}\%$ from refined sugars such as sucrose, glucose, fructose, starch hydrolysates and other carbohydrates that do not include essential nutrients is set to ensure adequate nutrient density. However, the database does not distinguish mono- and disaccharides that origins from natural sources like fruit, from foods like sweets or soda where sugar has been added. In the present study, sucrose was used to evaluate if the goal concerning refined sugar had been reached since sucrose is a commonly used sweetener in Europe (128), but also because one of the intervention goals was to increase fruit intake which has a relative high glucose and fructose content. However, it is important to remember that the intake of refined sugar may be underestimated when using sucrose as a proxy since glucose is excluded. On the other hand when comparing sucrose with the recommendation, sucrose from natural sources like fruit may have been included. An estimation of refined sugars including both monosaccharides and sucrose would on the other hand result in overestimation.

There are also some methodological difficulties that should be considered when evaluating the food groups in the present study. We based our food groups on already created groups from the National Food Administration and adapted them to suit the aim of the present study. This adaptation was necessary to answer the objective of paper 4 but it makes it difficult to compare some food groups (e.g. keyhole labeled foods) with food groups in other studies.

**Anthropometry**

When using BMI z-score one needs to keep in mind that if the reference population includes many heavy children then the children in the study group need a higher BMI to be classified as overweight or obese compared to if a thinner reference population is used. Other methodological considerations to take into account are that the BMI measure does not separate fat mass from muscle mass or reveal anything about fat distribution.
Intervention program

The present intervention program was first developed for children with overweight to prevent further increase of BMI. However, because of recruitment difficulties children with obesity were also included. If it was known that the intervention program would include obese children during the planning stage, the program should have been stricter in some aspects, e.g. more focus on limiting EI and increasing TEE. There are intervention programs that specify how much in negative energy balance an overweight or obese child should be in (20), and it is possible that the present intervention program would have been more effective if more focus had been on decreasing EI. However, it is not unusual that intervention programs do not focus on kilocalories (69) and national guidelines, e.g. the UK recommends behavioural strategies where the actual calorie intake is not specified for treatment of overweight and obesity.

The low attendance rate on sessions may be a result of too many sessions, that the sessions were not appealing enough or that the families did not prioritize to participate. The number of sessions varies widely in different intervention studies aiming at preventing or treating overweight and obesity and it is difficult to draw conclusions on what is most effective. However, Nowicka et al. has showed that an attendance of 3.4 sessions during one year can be enough to affect BMI z-score in obese children (111).

During the second year of the study when the web platform only was used to communicate with the participants our understanding was that many parents were not comfortable with using a computer in general, and many children were not familiar with using the computer in a commutative way. Many actions were undertaken to activate and engage the families in the web platform throughout the whole study. For example, a recipe as well as a joke was posted every week and if a family had not logged on to the web platform for longer than a month, they were reminded through a phone call by the researchers. Despite the many actions undertaken a low visit frequency rate by many of the families was seen and consequently many children did not receive the intervention as it was planned during the second year of the study. This may have been one of many other reasons to why the intervention had a limited effect. Williamson et al. described the same problem with a lower visiting rate on the intervention web platform the longer the intervention preceded (113). Two reports from the Swedish Media Council that were published in 2010 reported that 83% of all 5-9 year old children and 95% of all 9-12 year old children use a computer in their spare time (129). In the age group 5-9 years it was very rare that children used social networks. However, somewhere around 9 years of age seemed to be a break point where more and more children start to communicate through
social networks (129). Another factor that may have added to the low activity on the web is the way the platform was designed. The used web platform is designed to be suited for university studies and may not have been appealing enough to use for the children. Unfortunately, the platform had limited abilities to adapt the functions and apparel.

**Implication for further research**
Due to difficulties in measuring dietary intake there is little known about the role of diet in prevention and treatment of childhood overweight and obesity. Future research should focus on well designed and well powered studies that use appropriate validated dietary assessment methods to evaluate the effect of dietary intake in prevention and treatment of overweight and obesity. Future research should also focus on a more holistic approach since there are many aspects of the environment that the individual cannot control, especially not children. To tackle the obesity epidemic a combination of broader public health interventions reaching out to the population and interventions aimed at the individuals will be needed. This study further supports the view that future efforts should be aimed primarily at primary prevention of overweight and obesity.
Conclusions

The EI of overweight and obese children was well captured by a DHI compared with objectively measured TEE. After two years of intervention the children in the intervention group had a lower intake of sugar sweetened beverages and a higher intake of keyhole labeled foods compared to control group. Further, the intervention children had a lower intake of fat (g), MUFA (g) and cholesterol compared to the control group. Only limited effects on anthropometric and metabolic parameters were seen after one year of intervention. BMI remained stable in both the intervention and the control groups and both groups decreased their BMI z-score.

The intervention improved the children’s food habits but the limited effect on body composition and metabolic markers indicate the importance of focusing on primary prevention regarding childhood overweight and obesity.
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