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Eating habits among adolescents and their mothers

The Stockholm Weight Development study (SWEDES)

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”Jag har en mamma som vet vad man ska äta
för att bli stor och stark, och en pappa som
kan laga bilar.
Det är allt man behöver.”

Matilda Vågstrand, 7 år

ABSTRACT

The aims of this thesis were threefold. Firstly, to explore the possibility to improve the quality of dietary data and to identify under- and overreporters of energy intake. Secondly, to investigate the eating habits of adolescents and the association with overweight. Thirdly, to study the associations between maternal and child eating habits.

SWEDES is a cross-sectional study from Stockholm of 481 children and their mothers. Their diet was assessed by an extensive dietary questionnaire from the SOS (Swedish Obese Subjects) study. Questionnaires regarding meal patterns and eating behaviours (TFEQ) were also used. Energy expenditure was assessed by adding estimated PA from validated questionnaires to calculated BMR. Body measurements included both BMI and fat mass measured by BodPod. Salivary cariogenic bacteria counts were used as an objective estimate for sugar intake.

To improve dietary data an energy quotient was used (EI:EE) as a variable controlling for energy misreporting. In doing that, we found associations for body fatness with total energy intake, as well as to a high relative intake of sugar (when measured as bacteria counts) and a low relative intake of milk. The adolescents had in general reasonably aacceptable eating habits compared to nutritional recommendations, even though there was a relatively high intake of low-nutritious foods (25 E%). Subjects with poor breakfast habits and/or high soft drink consumption had a less healthy eating pattern than other subjects. High fruit juice, as well as soft drink, consumption was associated with a lower intake of nutritious foods such as milk and cooked meals. Relationships between mother and child were found in eating habits, in BMI and in the tendency to underreport. Overall, the eating pattern of daughters had a stronger relationship with the mothers' than the sons had. Foods which strongly and positively correlated to the intake of the mothers were cakes/cookies/buns, fruit juice and salty snacks in both girls and boys. Milk and soft drinks had no relationship at all between the generations. To overreport the total energy intake was as common among the adolescents as to underreport the energy intake. The overreporters had specific characteristics, somewhat inverted of those of underreporters, with for example lower family income and a lower BMI.

As expected, a high total energy intake seems to be the most important dietary predictor for overweight. However, more specifically our results suggest that attempts to reduce the consumption of sweet beverages and to encourage eating breakfast could be useful prevention strategies against weight gain in adolescents. When aiming at decreasing the intake of for example cakes/cookies/buns and salty snacks in adolescents, the mothers could be targeted, whereas other ways have to be used when aiming at reducing soft drink intake. The quality of dietary surveys will be improved if misreporters are identified and adjusted for in the statistical analyses. However by excluding under- and/or overreporters important information from different sub-groups are lost.

LIST OF PAPERS

I. Karin Vågstrand, Britta Barkeling, Heléne Bertéus Forslund, Kristina Elfhag, Yvonne Linné, Stephan Rössner, Anna Karin Lindroos.
Eating habits in relation to body fatness and gender in adolescents - results from the 'SWEDES' study.
Eur J Clin Nutr 2007;61:517-525

II. Karin Vågstrand, Anna Karin Lindroos, Dowen Birkhed, Yvonne Linné.
Associations between salivary bacteria and reported sugar intake and their relationship with body mass index in women and thier adolescent children.
Publ Health Nutr 2007; electronic publication ahead of print.

III. Karin Vågstrand, Anna Karin Lindroos, Yvonne Linné.
Characteristics of high and low energy reporting teenagers and their relationship to low energy reporting mothers.
Submitted for publication

IV. Karin Vågstrand, Yvonne Linné, Kristina Elfhag, Jan Karlsson, Anna Karin Lindroos.
Correlates of soft drink and fruit juice consumption among Swedish adolescents.
Submitted for publication

ABBREVIATIONS

AR/AER	Adequate energy reporters
BF%	Body fat percentage
BMI	Body mass index (kg/m^2)
BMR	Basic metabolic rate
CI	Confidence interval
CFU	Colony forming units
CV	Coefficient of variation
DLW	Doubly-labelled water
E%	Energy percentage
EE	Energy expenditure
EI	Energy intake
FFM	Fat free mass
FFQ	Food frequency questionnaire
HER	High energy reporters
LER	Low energy reporters
LB	Lactobacilli
MET	Metabolic energy turnover
MJ	Megajoule (equals 240 kcal)
MS	Mutans streptococci
OR	Overreporters of energy intake (Paper I)
OR	Odds ratio (Paper III)
PA	Physical activity
PAL	Physical activity level (EE:BMR)
SD	Standard deviation
SOS	Swedish Obese Subjects
SPWDS	Stockholm Pregnancy and Weight Development Study
SPAWN	Stockholm Pregnancy and Women's Nutrition Study
SWEDES	Stockholm Weight Development Study
TEE	Total energy expenditure
UR	Underreporters of energy intake

CONTENTS

1. BACKGROUND

1.1 Introduction

One of the greatest threats to public health today is overweight and obesity and of special concern is the development of overweight in children and adolescents. The prevalence of overweight and obesity has increased in the last few decades in Sweden as well as in most other countries.[1] Figure 1 shows the increase of prevalence among Swedish conscripts up to 1995, and the overweight prevalence has increased continuously since then, in both boys and girls.[2]

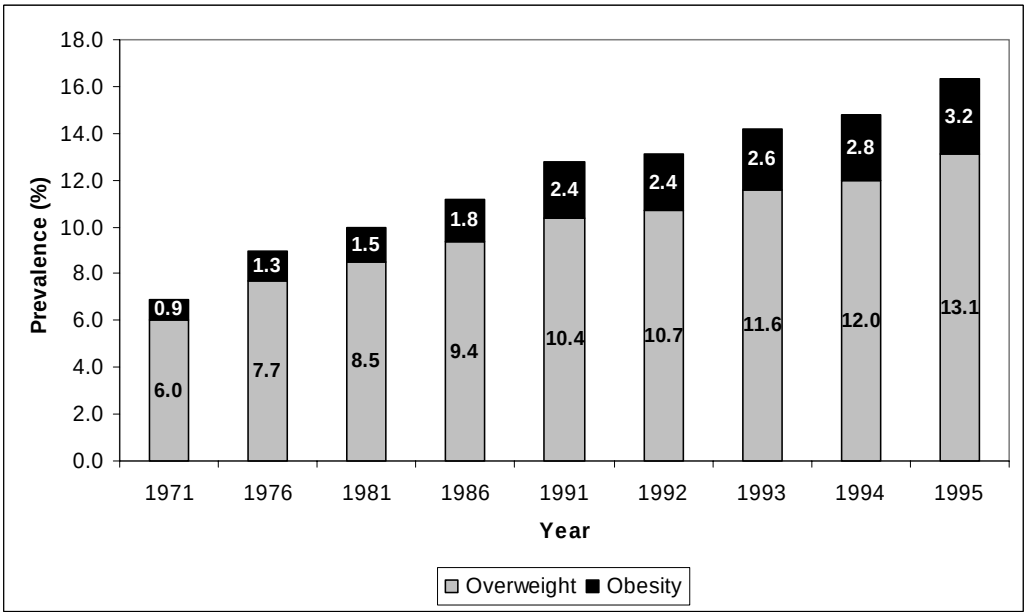

Figure 1. Prevalence of overweight (BMI>25 kg/m^2) and obesity (BMI>30 kg/m^2) in 18y Swedish males 1971-1995. Reprinted from Rasmussen et al.[3]

The explanation of why someone becomes overweight is very simple - a too large energy intake in relation to the energy expenditure. Instead, the more important question is *why* someone becomes overweight and obese, *in spite* of this basic knowledge of energy balance known to most people. Why does it seem a majority of people in our part of the world eat a little bit too much every day, just enough to experience an ongoing weight increase throughout their lives? Moreover, why do more and more people overeat? We do not know the answers to those questions today, but we know that the aetiology of obesity is very complex, involving many genetic as well as environmental factors, such as psychological behaviour, learned habits, stress, economics, values and norms, medical conditions, education etc.[4]

Even if the human body has refined control mechanisms to regulate energy balance, it seems to lack the possibility to adjust for very small shifts towards a too large intake. All overeating, even extremely small, is enough in the long term to cause overweight. Interestingly enough, there are individuals that keep the same low weight throughout their whole adulthood in spite of the obesogenic environment of our society. Recently a gene was discovered in 8% of

Scandinavians that seems to protect against obesity,[5] but even though genes can reduce the risk, no one is completely protected against the impact of the environment.

Consumer statistics from the last decades show that the increase in overweight prevalence is accompanied with a rise in the average energy consumption.[6] A corresponding decrease in energy expenditure seems also to have occurred at the same time, even though the evidence is limited due to lack of longitudinal data as well as difficulties to assess physical activity.[7]

Today there is a consensus among most experts that more resources have to be allocated for overweight prevention, and that focus should be on children and adolescents. Many physical consequences are associated with adult overweight and obesity, for example diabetes type II, cardio-vascular diseases, joint problems and cancer.[1] The health complications are less profound in children but many of the adult problems are seen in children as well.[8] However, the most important reason for targeting childhood overweight is the strong association with adult obesity. Between 26% and 41% of obese preschool children become obese as adults.[9] Even stronger associations are seen as the children get older; around 70% of obese adolescents become obese as adults.[10] It is obvious that what young people do today might reflect what the adult population weighs tomorrow. Because of that, it is crucial to understand the behaviour of young people in able to judge where and when prevention strategies for reducing obesity prevalence in the future would be most effective.

We, as a society, need more research to understand how eating habits are related to obesity and weight gain. We need to combine different obesity-related research areas, such as physical activity, behavioural sciences and genetics, with dietary factors into complex studies.

1.2 Eating habits of Swedish adolescents

According to the Nordic dietary recommendations (NNR),[11] 50-60% of the total energy intake is recommended to be eaten as carbohydrates, whereof a maximum of 10 E% from added sugar. The intake of dietary fibres is recommended to be 3g/MJ, the fat intake between 25 and 35 E% and protein 10-20 E%. These recommendations, valid for both adults and children from the age of two, are guidelines for a diet which provide basis for good health, as well as prevent overweight.

Of these recommendations, the recommendations for dietary fibres and sugar seem to be the most difficult to meet for Swedish adolescents. The fibre intake in boys have been reported to be from 1.7 to 2.6 g/MJ in various studies whereas girls reported an intake between 1.9 and 2.9 g/MJ.[12-14] The intake of added sugar has been reported to be between 12 and 13 E% in girls, whereas in boys to be close to the maximum intake of 10 E%.[12-15]

Except for fibres and sugar is the recommended distribution of macronutrients met by the average Swedish adolescents, which means that young people in Sweden have better food habits than other countries. A review has concluded that Swedish and Norwegian children and adolescents have the lowest fat intake in Europe (30-33 E%), whereas Spain, Greece and UK have the highest (>40 E%).[16] This review also reported that Swedish and Norwegian adolescents had the lowest intake of alcohol, whereas UK, Netherlands and Germany had the highest.

In NNR there are guidelines regarding meal patterns as well. It is suggested that 20-25% of the energy during a day should be taken at breakfast. This seems to be met by Swedish adolescents, at least in one study of 14-15 year old teenagers where the average intake from breakfast was 20-21 E%.[15] However, some individuals tend to skip breakfast completely and that is a worry. Eating breakfast is associated with a higher quality of the diet during the day and better cognitive function as well as lower body weight,[17-19] although evidence for a direct causality is still lacking. In a study of 15-21 years old subjects 4-5% had breakfast two times per week or less.[20] Another study showed that 12-17% of 14-15 years old boys and girls had breakfast once a week or less, and more importantly, that children of low educated parents had breakfast less often than those of high educated parents (8% vs. 22% once a week or less).[21] No other meals were as associated with education level in this study as breakfast was. In other countries, though, skipping breakfast seems to be more common than in Sweden. In USA for example 25-37% of children and young adults[22, 23] do not eat breakfast at all.

There are no clear guidelines regarding how large the intake from snack meals should be due to the lack of evidence regarding optimal meal patterns. Nevertheless, it is noticeable that in a study of 15-16 year old teenagers more than one third on average of all energy during a day was taken between main meals.[15] The COMPASS study (14-15 year old subjects) showed that those that had breakfast regularly ate unhealthy snacks less frequently (1.2 compared with 1.6 times a day).[21] 7% of the total sample in that study reported eating sweets every day, and 45-50% three days per week or more. 7% of the girls and 14% of the boys drank soft drinks daily. A larger proportion of children of low educated mothers had a high intake of "unhealthy" foods (46-52%; girls-boys) compared with children of high educated mothers (24-26%).

In summary, Swedish adolescents generally have better food habits than young people in other countries, but there are concerns for some individuals, especially children of low educated parents, with too large intakes of unhealthy snack foods and not eating breakfast.

1.2.1 Eating habits that lead to overweight

Overweight is always caused by too much energy eaten compared with the energy consumed. Hence, the most likely results from dietary surveys should be that overweight people have on average a higher energy intake than leaner individuals. However, this is rarely found in observational studies. Cross-sectional and longitudinal studies in children and adolescents have shown a variety of results; positive, negative and non-significant relationships between energy intake and fatness.[24] This lack of association have earlier perplexed the researchers, but since the development of the doubly-labelled water (DLW) technique[25] as an objective measurement of total energy expenditure, that has changed. DLW studies have shown, as expected, that overweight and obese individuals have a higher energy demand, and consequently a higher energy intake, than normal weight individuals.[26, 27]

To find conclusive evidence of relationships between the composition of the diet and weight development is equally difficult. Newby et al have concluded in a literature review[28] that there is some evidence, although inconclusive, suggesting a positive association between fat intake and obesity, but that there are too few studies on protein, carbohydrate and fibre intakes to make any statement about them. However, when the energy density of the diet is studied instead of specific macronutrient, it has been shown that high energy density diets promote

weight gain in both adults[29, 30] and children.[31] Energy dense foods are usually high in fat, but most importantly, low in dietary fibre and water.

Since energy intake and diet composition are burdened by reporting bias, studies of meal patterns and eating behaviours may be a better way of finding valid associations. The behavioural aspect with most conclusive results is breakfast habits. A high BMI has been shown to be inversely associated with frequent breakfast habits among adolescents in various studies.[15, 19, 32-34] There are indications that snack frequency[35], portion sizes[30] and fast food consumption[34, 36] might be related to overweight as well, but more research is needed before any conclusions can be drawn.

1.2.2 The problem of liquid calories

As stated above it is difficult to find a single food group or macronutrient responsible for the increased obesity prevalence. However, there is some convincing evidence regarding soft drink consumption and weight gain. Two recent reviews[37, 38] and one meta-analysis[39] have concluded both that more research is needed, but also that there are enough evidence today to recommend prevention strategies targeting a reduction of soft drink consumption. Even though soft drinks have been the target in most studies, other caloric beverages could have the same problematic effect on weight. For example has fruit juice consumption been shown to be related to a higher body weight.[36, 40, 41]

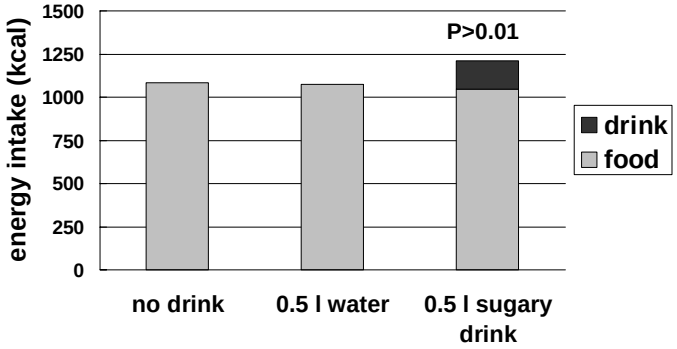

Figure 2. The difference in total energy intake during a meal when either no drinks, only water or sugar-containing fruit drinks were served with a meal. Data from a of Rolls et al.[42]

The reason for high beverage consumption as a risk for overweight is not entirely understood. One possible explanation is shown in figure 2 where the total energy intake of a meal increased when a caloric beverage was served.[42] There was no compensatory decrease in food intake as a response to the intake of liquid calories in this study, probably due to lack of satiety sensation from the liquid.[42, 43] However, the evidence regarding the satiety effect of beverages taken between meals and the compensatory behaviour at following meals is inconclusive.

The intake of sweet beverages, mainly soft drinks, have increased in the last few decades (see figure 3), and there are reasons to believe that young people have a large proportion of this consumption. Studies have shown that the older the child[44, 45] and the younger the adult[46, 47] the higher is the soft drink consumption. The average soft drink consumption among Swedish

adolescent girls have been reported in an observational study from 1995 to be 180 g/day[15] In a more recent Swedish survey, even though in a younger age group (11 years), the intake of soft drinks was 128 g/day.[48]

In parallel with the increased soft drink consumption milk consumption has decreased, something that is problematic in many ways. Milk is an important calcium source and a low intake of calcium during adolescence is critical because it jeopardizes the accrual of maximal peak bone mass.[49] To replace a nutritious alternative as milk with empty calories such as soft drinks is not a beneficial development.

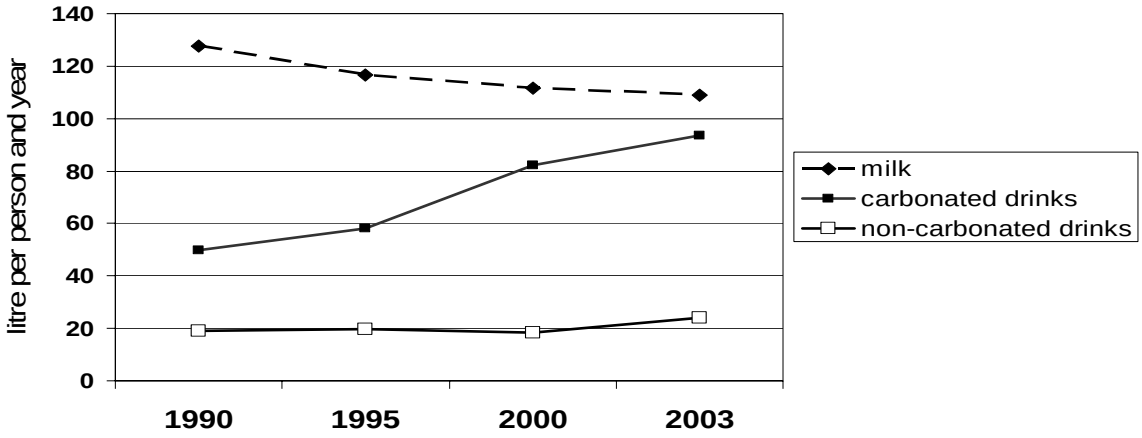

Figure 3. Trends in consumer statistics of different beverages in the Swedish population.[6]

1.3 Mother and child interaction

It is well known that obesity and overweight runs in the family.[50-52] The weight status of the biological parents is therefore considered as a good predictor of overweight and obesity in children. Garn *et al*[50] have stated that the probability of a child becoming obese is 7% if none of the parents are obese, 40% if one parent is obese and 80% if both parents are obese.

It is obvious that parents and children share some eating habits as they live together and share meals. There are today consistent evidence of a relationship between parental intake and the children's intake of especially fat, fruit and vegetables.[53, 54] Mothers can act as roll-models for their children when it comes to good eating habits. It has been shown that mothers consuming a lot of fruits and vegetables have daughters consuming more fruits and vegetables than daughters of other mothers.[53] It has also been shown that sharing meals with the family seems to protect against overweight.[55, 56] The foods chosen by the teenager or child itself seem to be less healthy and more energy-dense than the usual family dinner.[57]

Mothers can obviously also act as bad examples. Children of obese mothers have been shown to have a higher intake of dietary fat than other children.[52, 58] Problematic eating behaviour such as bulimic behaviour, emotional eating, dietary restraint and weight concern has also been shown to have mother-daughter as well as father-son associations.[59, 60]

Even though it is important to have control over the child's eating habits,[61] it can be counterproductive to be too restricted. Several studies have shown that parental feeding restrictions have a negative effect in young children.[62] Children, aged 5-7 years, with parents restricting palatable foods were more likely to over-eat those items when available and to gain weight, than children of non-restricted parents were. The level of restriction that could cause these negative effects is unknown and may depend on parent or child characteristics, including familial predisposition to obesity.[62] Hence, it seems to be more effective as a parent to be a good example rather than teaching the child how to eat.

This thesis has studied the associations between mother and child. However, fathers have most certainly a great influence on child behaviour too, even though varied in different cultural contexts. Nevertheless, there are results suggesting that mothers have a greater impact on eating habits of the children than fathers have.[58-60]

1.4 Dietary assessment methods

Dietary assessment is very difficult, and there is no doubt that one of the major problems in nutritional research is to assess the diet accurately. There are different assessment methods for free-living subjects available as shown in table 1. Different methods are associated with different types of problems.[63] The method considered the most accurate is weighed diet records, but it has problems both with compliance and with the risk of changing eating behaviour during the recording period. The 24 h recall-method on the other hand, can suffer from the participants' limited memory, and the quality of the outcome is depended on the skill of the interviewer. Diet history methods are labour intensive, but the outcome data is usually with high quality. The most convenient method, especially in large populations, is food frequency questionnaires (FFQ), but because of its standardized design, the flexibility regarding unusual food intake is limited. In addition, groupings of food items could cause classification problems.

Besides these methods, it is possible to measure the diet exact and objectively, for example by keeping the study subjects in a confined area and register all their intakes. However, these unnatural circumstances affect eating the habits and the outcome is something else than a habitual intake.

When reading and evaluating any result based on dietary assessments, it is always important to scrutinize how the assessment was done. It is equally important to be aware of that it takes more than one high quality dietary study to make any statements or dietary recommendations.

1.5 Reporting bias

It is not possible to measure dietary intake without error. If errors occur randomly, they cancel out each other and the average values would still be valid. However, large random errors require larger study populations to find significant associations. A much larger problem is systematic errors, also called bias, which can seriously distort the results. Bias is defined as 'any process at any stage of inference which tends to produce results or conclusions that differ systematically from the truth'.[64] Biases can occur in all kind of research at any stage, from planning a study to publishing the results.

Table 1. Summary of traditional dietary assessment methods with comments on the amount of labour and financial resources involved. Reproduced from the thesis of AK Lindroos.[65]

Method	Description	"Burden"	
		Investigator	Participant
Diet records	Record of all food eaten over a defined period, usually between one and seven days. Days can be consecutive or non-consecutive. -Usually open-ended format. -Foods weighed or estimated with house-hold measures. -Act of recording can affect diet.	High	High
Single 24 h recall	Recalls the types and amounts of foods consumed. -Usually open-ended interview. -Can be telephone based. -Intake the previous 24 hours. -Possible interviewer bias.	Medium/ High	Low
Dietary history	Original research diet history: 1) Detailed interview 2) Cross-check food frequency list 3) 3 day food record -Usual food intake patterns. -Period may be last month, last 6 months or last year. -Possible interviewer bias.	High	High
	Modifications: Usually combination of 1) and 2). -No standardised protocol.	High	Low
Food frequency questionnaires	Questionnaires on how frequently certain foods are eaten. -Foods usually aggregated into groups. -Closed-ended questions. Subjects generalises to usual food intake. -Measured period; last month, last 6 months or last year. -Can be administered by mail thereby eliminates interviewer bias.	Low	Low

In the study of diets, one of the most challenging tasks is to deal with reporting bias. There are three common sources of reporting bias according to Margetts and Nelson;[66] social desirability bias, recall bias and interviewer bias. Social desirability is when the individual wishes to convey a desirable image and to keep within social norms and therefore changes the answers accordingly. It might be embarrassing to admit for example eating one bag of potato chips per day or never eating vegetables. Recall bias has to do with bad memory and unawareness of ones diet. Most people do not have a clear picture of what they ate yesterday,

yet alone what they ate a week ago. Interviewer bias occurs when the interviewer in some way influences the answers made by the respondent. All errors made can be unintentional, intentional or a combination of both.

1.5.1 To identify misreporters of energy intake

The method most commonly used for identifying energy underreporters is to look at the EI:BMR quotient. Those with an EI:BMR below a certain level, usually 1.2 but other cut-offs are used as well,[67] are classified as underreporters. To be able to identify possible overreporters, an upper cut-off limit has to be defined. Most previous research has failed to do that, either because information of physical activity is lacking or because overreporting is considered a minor problem.

When using the same cut-offs for the whole sample no consideration is taken to physical activity. The only underreporters that would be identified are those with a sedentary lifestyle and identified overreporters would probably all have a high level of PA. Physical activity can vary immensely between individuals, with habitual PAL values ranging from 1.2 (extremely sedentary) to 2.2 (extremely active).[68] To improve the classification of misreporters, the individual activity level should be considered when deciding on which specific cut-off value to use.[69]

1.5.2 Underreporting of energy intake

Underreporting of total energy is commonly described,[70-72] but varies depending on which method used. In a review by Black et al.[73], 88% of the diet recalls, 64% of the diet records and 25% of the diet histories presented EI below what is needed for maintaining a sedentary lifestyle.

It is well known that underreporting is very closely related to overweight,[74, 75] and the probability for underreporting increases as BMI increases,[76-78] but also other properties are related to underreporting. There is substantial support today for following factors to be predictors of energy underreporting[72]:

- Overweight
- Gender (women more than men)
- Older age
- Lower education
- Higher dietary restraint
- Higher social desirability

1.5.3 Overreporting of energy intake

The occurrence of energy overreporting has been estimated to only a few percent among adults; for example 3% (diet history, Sweden),[79] 5-7% (FFQ, Sweden),[76] 3-7% (24h recall, Iran),[80] but also as high as 16-24% in a Jamaican study (FFQ).[81] In studies of children and adolescents overreporting prevalence of 16-17% have been seen both when using 24 h recall in USA[82] and diet history in Sweden.[83]

There are numerous studies published describing the characteristics of energy underreporters, but little, if anything, is known about overreporters.

1.5.4 Selective misreporting

When someone's total energy is under-reported, it is likely that some types of foods are more underreported than others. That is what we call selective misreporting. Even if selective underreporting might be more common, selective overreporting exists too. Food considered by the respondent to be unhealthy, such as sugar- and fat-containing food items, has been shown to be selectively underreported (or under-eaten during the study period).[71, 84-86] Study subjects predicting how accurately they would report their food intake if they were interviewed stated that cakes, pastries, confectionary and fatty foods were the main food groups they would under-report. Fruits and vegetables were the food groups they most likely would over-report.[87]

Selective misreporting is a problem when the focus is certain nutrients or foods, for example following a hypothesis of snack food intakes as a cause for weight development in children.

1.6 Evidence for a link between bacteria and sugar intake

There is a need for validating different dietary assessment tools. This can be done in several ways, for example by comparing the outcome from two different assessment methods. Another way is to use objective measurements and biomarkers. Total energy intake can for example be measured precisely and objectively by using DLW technique. However, this method is expensive and time-consuming and is not realistic to use in large study populations.

There are also biomarkers available for validating different parts of the diet, for example urinary nitrogen as a measurement for total protein intake. Until recently, no method existed for assessing parts of the diet particularly suspected to be under-reported, like fat and sugar. Urinary sucrose and fructose has been suggested as a new biomarker for sugar intake.[88] The results are promising but the method is complicated and involves twelve 24-hour collections of urine.

Other possible candidates for objective markers of sugar intake are salivary counts of bacteria lactobacilli (LB) and mutans streptococci (MS), two groups of cariogenic bacteria. This is a very simple and non-expensive method that easily could be performed on a large number of subjects. However, the evidential body for a link between sugar intake and the amount of these bacteria has to be evaluated before we know if this is a practicable way.

We have recently published a literature review with the aim to establish the level of evidence for the association between sugar intake on one side and LB and MS on the other side.[89] Another objective of the review was to establish whether the bacteria link is applicable within a normal population and within normal sugar consumption. Below is a summary of that review.

It is well known that a frequent intake of sugar causes caries.[90] Of all fermentable carbohydrates, sucrose is believed to be the most cariogenic.[90-92] The amount of acid-producing and acid-resistant bacteria, such as LB and MS, in the saliva is associated with caries aetiology and is thereby a link between sugar and caries. An association between LB and sugar intake was presented as early as the 1940s and 50s[93, 94] and has been regarded as evident since then. But even though these early works showed convincing data, there were no

statistical analyses performed and the diets used in these experimental studies were very extreme (e.g. no carbohydrates at all). Hence, the evidence value is minor.

In recent years, MS have become the most interesting bacteria. They are now considered more cariogenic than LB[91] and many recent papers have focused on MS rather than LB. Most of these papers refer to an early publication, where the link between MS and sugar intake was first experimentally tested.[95] However, this study, even though presenting very clear and convincing results, had only six study subjects and is hardly ideal for giving evidence for a hypothesis alone. Since then, numerous other papers have been published. In total, 27 papers were considered relevant for this review, whereof 15 intervention trials and 12 cross-sectional trials. The included studies were evaluated with study design as the strongest quality parameter. Emphases were placed, regardless of study design, on dietary assessment methods and the awareness of reporting bias and dietary compliance.

The highest quality study by Wennerholm et al[96] found positive associations between sugar intake and both MS and LB counts. This was the only study where statistical comparisons were made between test and control group. The only intervention trial[95] and seven out of eight cross-sectional trials[97-103] studying MS only, did find a MS-sugar link. Of the four intervention studies investigating LB only, three found a positive association with sugar intake.[104-106]

Of the studies, besides Wennerholm et al, looking at both bacteria three out of nine intervention trials[107-109] and two out of three observational trials[110, 111] found a relationship between both bacteria and sugar intake. Some studies found an association with LB, but not with MS,[101, 112-114] whereas others found associations with MS, but not with LB.[115, 116]

Only two intervention studies[117, 118] and two observational studies did not find any relationships with sugar at all.[119, 120]

There are different standards for estimating the strength of evidence. Table 2 presents definitions commonly used by SBU (Swedish Council on Technology Assessments in Health Care). Using these definitions, the strength of evidence for the association between sugar intake and both LB and MS was between 2 (moderately strong basis for scientific evidence) and 3 (limited basis for scientific evidence).

Table 2. Rating the strength of evidence.

1.	Strong scientific basis	At least two studies with high evidence value[†] or a good systematic review.
2.	Moderately strong scientific basis	One study with high evidence value plus at least two studies with medium high evidence value.
3.	Limited scientific basis	At least two studies with medium high evidence value.
4.	Insufficient scientific basis	Other

[†]A study with high evidence value is a randomized controlled study meeting high quality standards regarding size, duration, drop out analyses, inclusion criteria etc.

The fact that the study with the highest evidence value[96] did show associations between sugar intake and both LB and MS is important for providing a substantial support for the hypothesis. But since it did not meet all quality standards of strict RCT definitions,[121] this study is not sufficient for giving evidence strength 2. However, the large number of studies with homogenous results, even though with low individual evidential value, strengthens the evidence for a link between sugar and bacteria.

It has to be remembered that there are many explaining factors for LB and MS counts, other than sugar intake. For example, detention surfaces (fillings, dentures, etc), oral hygiene and salivary flow rate may be of great importance.[91] In children, the parental bacteria counts are an important determent as well.[102, 122] Thus, there are large inter-individual variations in salivary bacterial counts and they can never be used as a precise measurement of sugar intake.

In conclusion, there is a limited to a moderately strong scientific basis in the existing literature for the association between sugar intake and the counts of oral lactobacilli (LB) and mutans streptococci (MS). However, there are many confounding factors. There is a need for high quality randomized controlled studies to strengthen the evidential value of this method.

1.7 Historical background to SWEDES and drop-out analyses

SWEDES forms part of a cohort that started in 1984 with the Stockholm Pregnancy and Weight Development Study[123-125], see figure 4. The participants in SPWDS were recruited through maternity care units in the southern part of the Stockholm area. Midwives performed the data collection at normal scheduled visits without any extra effort for the participants. This resulted in a high participation rate of 2342 women. The sample represented a socially mixed, but ethnically homogenous, urban population from both the inner city area and various suburbs.

The next study, SPAWN[110, 126-128], included 556 mothers and had the objective of studying weight development fifteen years after delivery. SWEDES was initiated in 2001 with the objective to study mother-child interaction, and consequently, both mothers and the 16-17 years old children were invited to participate.

1.7.1 Drop-out analyses

Drop-out analyses between SWEDES participants and non-participants based on data from 1984-1985 are presented in table 3.

Lifestyle and social variables such as smoking habits, working situation, breastfeeding duration and nationality showed significant differences between the two groups, indicating that SWEDES is not a representative sample of the original study and, consequently, probably not a cross-sectional sample of the Stockholm population. Unfortunately, no data is available on educational level, but the proportion of highly educated women in SWEDES is very high, 60%, compared to 27% for average women of this age in Stockholm.[129] When participation in a study involves taking time off work and filling out extensive questionnaires, it is expected that educated people with an interest in research and health-related issues are over-represented. This situation is difficult to avoid in this kind of study.

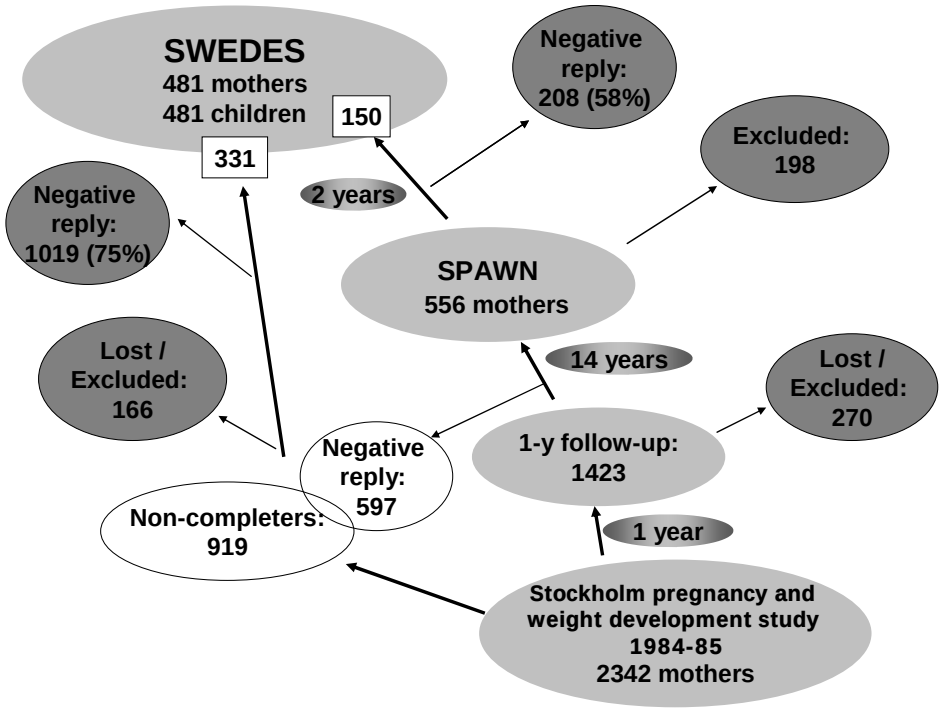

Figure 4. Recruitment and drop-out rate in the SWEDES cohort 1984 to 2002.

Habitual food habits were not the focus in 1984. Therefore, the only dietary data available for drop-out analyses are meal patterns, which showed no significant differences between the groups. There is no statistically significant difference between participants and non-participants in BMI, even though the participants were both slightly taller and heavier. Drop-out analyses for pregnancy parameters have been tested before, but without any significant differences.[130]

Previous large studies of Swedish adolescents including a registry study have found similar mean BMI[21, 131], waist circumference[21] and body fat%[21] as in the SWEDES study. The prevalence of overweight among boys in SWEDES was also similar to what has been reported before for military conscripts[3] The prevalence of obesity among the mothers was very close to the prevalence of middle-aged women in Stockholm as reported by the National Bureau of Statistics.[129]

In summary, there were no differences in BMI, pregnancy parameters and meal habits between the participant and non-participants of SWEDES. In addition, BMI was close to the expected in these age groups. Nevertheless, we have a biased population in regard to education and other social parameters.

Table 3. Dropout analyses. Comparing participants and non-participants of SWEDES in pre-pregnancy variables in 1984/1985.
Mean ± SD in continuous variables, n (%) in categorical variables.

	Non-participants (n=1858)	Participants (n=481)	p-value †
Body measurements			
Height (cm)	166 ± 5.8	167 ± 5.9	0.02
Weight (kg)	59.4 ± 8.4	60.6 ± 8.9	0.01
BMI (kg/m^2)	21.5 ± 2.8	21.7 ± 2.8	0.10
Lifestyle / social parameters			
Smoking			
Yes	593 (34)	110 (24)	<0.001
No	1161 (66)	347 (76)	
Nationality			
Swedish	1767 (95)	468 (97)	0.04
Other	90 (5)	13 (3)	
Work			
Full-time employed	1138 (62)	309 (65)	0.005
Part-time employed	493 (27)	136 (29)	
Not employed	211 (12)	30 (6)	
Marital status			
With partner	1665 (91)	446 (94)	0.08
Single	90 (5)	18 (4)	
Other	83 (4)	12 (2)	
Physical activity, leisure time			
Inactive	266 (18)	57 (14)	
4-6 hours/week	737 (51)	189 (48)	0.03
Regular exercising	384 (27)	132 (33)	
Regular hard exercising	50 (4)	17 (4)	
Physical activity, work			
Light	457 (30)	148 (35)	
Medium	346 (23)	87 (21)	0.26
Hard	583 (39)	158 (38)	
Very hard	29 (2)	5 (1)	
Not working	99 (6)	22 (5)	
Meal pattern			
Number of breakfasts / week			
Never	52 (3)	8 (2)	
1-4 times	87 (6)	21 (5)	0.28
5-6 times	64 (4)	14 (3)	
Every day	1339 (87)	384 (90)	
Between-meal snacks / day			
0-2 times	1242 (81)	350 (82)	0.60
3-5 times	271 (18)	73 (17)	
6 times or more	16 (1)	2 (1)	
Regular meals			
Yes	1219 (80)	349 (82)	0.34
No	303(20)	75 (18)	
Child			
Birth weight of child (g)	3453 ± 563	3465 ± 504	0.66
Sex of child ‡			
Girls	922 (49)	277 (58)	0.002
Boys	956 (51)	204 (42)	
Breastfeeding at 6 months			
Exclusive	292 (19)	107 (25)	<0.001
Partial	655 (42)	201 (47)	
Not breastfeeding	605 (39)	120 (28)	

† t-tests or chi2-tests, depending on type of variable. ‡ More children than mothers due to some twin births.

2. AIMS OF THE THESIS

Methodological aspects of dietary assessment

- To examine the quality of the collected dietary data and investigate how it can be improved (paper I).
- To describe the characteristics of those who under-, over- and adequately report their total energy intake (Paper III).
- To explore the possibilities of using salivary bacteria as an objective measurement of sugar intake (Paper II).

Eating habits of adolescents and the association with body fatness / body size

- To describe the eating habits of Swedish teenager, focusing on gender differences (Paper I).
- To investigate the correlations between dietary habits and body fatness in adolescents (Paper I).
- To investigate if there are associations between sugar intake and BMI in adolescents and middle-aged women (Paper II).
- To analyse the correlates of sweet beverage consumption in adolescents (Paper IV).

The relationship between adolescents and their mothers

- To explore similarities between adolescents and their mothers in different dietary aspects (Paper II, III and IV).

3. METHODS

3.1 Study design

The participants in SWEDES were recruited in two steps. Firstly, we invited the 556 women from the SPAWN-study to participate. Secondly, we tried to find the remaining 1786 of the original SPWDS study population. After excluding all women who had moved away from Stockholm and those not found or deceased, an additional 1516 women were invited to participate, see figure 4 (p.12). The final study population consisted of 279 girls, 202 boys and 481 mothers. In total 962 individuals came to the Obesity Unit at Huddinge hospital between May 2001 and June 2002. Informed consent was obtained from each mother and child. For subject characteristics, see table 4.

Table 4. Description of the SWEDES participants. Mean ± SD.

	Mothers (n=481)	*Daughters* (n=279)	*Sons* (n=202)
Age, year	46.9 ± 4.6	16.8 ± 0.4	16.9 ±0.4
Weight, kg	68.4 ± 12.2	59.7 ± 9.2	68.7 ± 12.0
Height, cm	167 ± 6	167 ± 6	180 ± 6
BMI, kg/m^2	24.5 ± 4.2	21.5 ± 3.0	21.1 ± 3.3
Waist, cm	82 ± 11	71 ± 7	75 ± 9
Body fat %	34.5 ± 8.4	29.4 ± 6.5	16.3 ± 7.4
Prevalence of overweight, incl. obesity, BMI>25 †	34.3%	10.4%	14.9%
Prevalence of obesity, BMI>30 †	8.9%	2.9%	3.0%

† Age- and sex-dependent isoBMI was used for classification of the children as recommended by the International Obesity Task Force.[132]

SWEDES has a wide data set including many research fields. Besides dietary and physical activity data, questionnaires regarding eating behaviour, eating disorders, personality and body image were used, blood samples for metabolic parameters and DNA were drawn and height, weight, waist circumference and body fat were measured. All variables were collected equally from child and mother.

The dietary and physical activity data from the earlier studies (SPWDS, and SPAWN) was very limited and is not comparable with the SWEDES data. Therefore, all results of this thesis, except the drop-out analyses, are based on cross-sectional data from 2001-2002.

The data collection phase of SWEDES was funded by the European Commission, Quality of Life and Management of Living Resources, Key action 1 “Food, nutrition and health”

programme as part of the project entitled "Dietary and genetic influences on susceptibility or resistance to weight gain on a high fat diet" (QLK1-2000-00515).

3.2 Measurements

The data collection was administered and performed by research nurses and nutritionists. The dietary questionnaire was sent out in advance to the participants to be filled out at home, while all other questionnaires were completed on arrival at the clinic. Only those measurements used in the analyses in this thesis are presented below.

3.2.1 Body measurements

Body composition was estimated by densitometry via air-displacement plethysmography measurement using the BodPod© Body Composition System.[133, 134] The BodPod was used in an enclosed room without windows, where a constant environment could be kept. Two measurements were performed on each subject wearing tight-fitting underwear and swim cap, see figure 5. If the two measurements differed by more than 150 ml a third measurement was performed. The calculation of body volume was done with pre-programmed equations and using predicted lung volume. Data on body density were converted to fat mass and fat free mass using the equation of Siri.[135]

Body weight was measured to the nearest 0.1 kg on the scales of the BodPod. Standing height was measured to the nearest cm against a wall-mounted stadiometer. Waist circumference was measured at the minimum circumference between the iliac crest and the rib cage. Hip circumference was measured at the maximum circumference over the buttocks. Both measurements were rounded to the nearest 0.5 cm.

Figure 5. Photos of a BodPod© examination in SWEDES

3.2.2 The SOS dietary questionnaire

A dietary questionnaire originally developed for the Swedish Obese Subjects (SOS) Study was used in a slightly modified form to assess dietary intake.[136] In a validation study, mean energy intake from the questionnaire did not differ significantly from estimated energy expenditure in neither normal weight nor obese adults.[136] The questionnaire has also been validated in 18 (9 boys / 9 girls) 15 year old adolescents using doubly labelled water.[137] In both girls and boys, the reported mean energy intake did not differ significantly from measured energy expenditure.

The questionnaire is based on a simplified dietary history and covers dietary intake during the past three months. Emphasis is placed on cooked meals and sandwiches and the questionnaire includes coloured photographs to assist subjects in describing portion sizes of cooked meals. For intake of beverages, milk products, sweets and snacks, a semi-quantitative approach was used with pre-defined portion sizes. For candies, chocolates and crisps/cheese doodles, sizes of pre-confectioned packages sold in Sweden were used to quantify amounts. The amounts of all reported foods were converted into energy and nutrient intake per day, using food tables from the Swedish National Food Administration.[138]

The dietary intake was collapsed into the following 14 food groups: cooked meals (meat/fish with potatoes/pasta/rice and/or vegetables), light meals (soup, salad, omelette, toasted sandwich etc), fast food (pizza, hamburger and hot dog), milk (milk, yoghurt etc), breakfast cereals (including porridge and gruel), fruit, non-alcoholic beverages, alcoholic beverages, sandwiches, 'godis' (candies/sweets/chocolate), 'kaffebröd' (cakes/cookies/biscuits/pastries), desserts, salty snacks (crisps, cheese doodles, popcorn, nuts etc) and miscellaneous (sandwich toppings without bread and egg). These food groups have later been adjusted depending on the objective of particular analyses. In paper II and IV 'godis', 'kaffebröd' and desserts were combined into a new food group called sweet food items (II) or sugary foods (IV). In paper IV fruit juice and soft drinks, which form part of the non-alcoholic beverages food group, were analysed separately.

3.2.3 Meal pattern questionnaire

A specific meal pattern questionnaire[139] was used to describe meal frequency. The subjects were asked to describe how they usually eat during a day, specifying time for meal and type of meal. Four different meal types were defined: main meal, light meal/breakfast, snack meal and drink meal. There was no absolute definition of each meal but examples were given in the questionnaire. Examples of a main meal: cooked dish, soup with bread, salad with bread, pizza. Examples of a light meal/breakfast: porridge, breakfast cereals, sandwiches, soup, salad, omelette. Examples of a snack meal: sandwich, cracker, cookie, cake, bun, fruit, candy, chocolate, ice cream. Examples of a drink meal: coffee, tea, soft drink, juice, milk, beer, wine. Breakfast was classified here as a light meal in order to differentiate it from main meals and snack meals. Note that light meal here has a different definition from light meal in the SOS dietary questionnaire.

3.2.4 IPAQ and SAPAQ - Physical activity questionnaires

A self-administered questionnaire, IPAQ (International Physical Activity Questionnaire),[140] was completed by the mothers for assessing their physical activity. For the children, an adjusted version of IPAQ, called SAPAQ (Swedish Adolescent Physical Activity Questionnaire) was used.[141] These questionnaires are designed to collect information on

frequency, duration, and intensity of physical activity (PA) in three different domains (school /work, self-powered transportation and leisure time) during the last seven days. Energy expenditure from physical activity was calculated by EE_{PA} = (MET-$min_{questionnaire}$/60) x body weight.[142]

3.2.5 Other questionnaires

TFEQ-R18 (Three Factor Eating Questionnaire – Revised 18 items)[143] was used to assess eating behaviour. It is a revised short-form version of the original TFEQ, a frequently used instrument for describing eating behavior.[144] The TFEQ-R18 covers three eating behaviour domains: the *cognitive restraint* scale (conscious control over food intake in order to influence body weight and body shape); the *emotional eating* scale (tendency to overeat in relation to negative mood states); and the *uncontrolled eating* scale (propensity to lose control over eating when feeling hungry or when exposed to external stimuli).

The subjects were also asked in an appendix to the dietary questionnaire how many times per week they normally eat breakfast, choosing from never, 1-4 times per week, 5-6 times/week or daily. These categories were then collapsed into two alternatives; 0-4 times or 5-7 times per week.

In addition, questions regarding demography and life-style parameters, such as education, income, country of origin, number of children, smoking habits etc., were asked in a separate questionnaire.

3.2.6 Accelerometers

Physical activity was also measured by means of the Manufacturing Technology Incorporated (MTI, Fort Walton Beach, FL, USA) activity monitor in a randomized selected subgroup of 61 mother-child pairs during seven days. However, complete data was retrieved from only 47 children and 50 mothers due to either problems with the device (6 mothers, 6 children) or failure of the participant (5 mothers, 8 children). There were no statistically significant differences between the group with complete accelerometer results and the rest in terms of BMI, BF%, reported EE or reported EI.

Equations for calculating counts/min from accelerometer into total energy expenditure:

- Children: TEE_{acc} = (0.173 * FFM) + (0.00447 * counts/min) + (0.656 * sex) + 0.74 [145]
- Mothers: TEE_{acc} = (174.4 * FFM) + (4.72 * counts/min) + 1051.4.

The equation for the mothers is derived from a doubly labelled water study on 50 adults (24 women) with mean age of 34.7 years; stand. error of est. =1548 MJ/d, R^2=0.65 (Ekelund *et al*, unpublished data).

3.2.7 Saliva sampling and bacteria cultivation

Fasting, paraffin-stimulated whole saliva was collected in the morning. One millilitre of the saliva was transferred to 4.2 ml of VMG transport medium.[146] The sample was sent by mail to the Department of Cariology in Göteborg and was processed within 24 hours. It was dispersed on a Whirlmixer for 20 seconds, serially diluted in 0.05 M phosphate buffer and plated on MSB agar [147] to estimate the number of MS, and on Rogosa SL agar to estimate the number of LB. The MSB agar plates were incubated in 95% N_2 and 5% CO_2 at 37°C for 2 days and the SL agar plates aerobically at 37°C for 3 days. The number of colony-forming

units (CFU) of MS on MSB agar were counted and identified by their characteristic colony morphology. All CFU in SL agar were regarded as LB.

3.3 Classification of misreporters of energy intake

All study subjects were divided into different EE groups (low, medium and high), based on their estimated EE (EE_{PA} + BMR). The cut-offs were chosen to create three equally large groups (tertiles) among girls, three groups among boys and three among mothers. Within each EE group the confidence interval (CI) for EI divided by BMR were calculated using the Goldberg equation (see below). BMR was calculated using the Schofields equation.[148]

The PAL-values, calculated from total TEE_{acc} divided by BMR in the accelerometer sub-group, were also divided into tertiles before used in the equation. The mean PAL values in these groups, 1.45, 1.60 and 1.77 for girls, 1.57, 1.75 and 1.87 for boys and 1.42, 1.58 and 1.70 for mothers, were considered valid for the whole sample.

The Goldberg equation[69]

$$EI / BMR < PAL \times \exp\left[\sqrt{(CV_{BMR}^2 + CV_{EE}^2)} \times SD_{max}\right]$$

$$EI / BMR > PAL \times \exp\left[\sqrt{(CV_{BMR}^2 + CV_{EE}^2)} \times SD_{min}\right]$$

CV_{BMR} = 8.5% and CV_{EE} = 15% (as suggested by Black[69])
$SD_{min\ /\ max} = \pm 2$ (95% CI)

This resulted in three different confidence interval (CI) for boys (1.11-2.22, 1.24-2.47, 1.32-2.64), three for girls (1.03-2.05, 1.13-2.26, 1.25-2.50) and three for mothers (1.00-2.00, 1.12-2.22, 1.21-2.41) - which CI to use depending on EE group. Individuals with an EI/BMR below their confidence interval were classified as underreporters (UR), those above as overreporters (OR), and the rest as adequate reporters (AR). In paper III, UR, OR and AR were renamed LER (low energy reporters), HER (high energy reporters) and AER (adequate energy reporters).

3.4. Statistical methods

The parametric methods used in this thesis are independent t-tests, univariate ANOVA with Bonferroni post-hoc tests, univariate and bivariate Pearson's correlations and linear and binary regression analyses. In some places, non-parametric analyses, such as Mann-Whitney U-test, Chi-2-test and Spearman's correlation, were used.

Many variables, including most dietary variables, had skewed distribution. To handle this, all variables with a skewness >2 or kurtosis >7[149] were ln- or root-transformed before used in any parametric analyses. Variables containing zero values had a constant added to all observations before ln-transformation.

The analyses were performed in SPSS, version 11.5, 12.0 and 14.0, and statistical significance was defined as p-values <0 05.

3.4.1 Under- and overreporting of energy intake

The problem of under- and overreporting of the energy intake was handled differently in different papers. In paper I and III, all results were presented as either AR only or as the whole sample. In paper II an energy quotient was used for adjusting for misreporting (see section 4.1.1.). We tested to include the energy quotient in the regression models in paper IV as well, but since it did not affect the result, we decided that energy adjusting, as described below, was enough to control for energy misreporting.

3.4.2 Adjusting for total energy intake

In paper I, E% was used instead of the absolute measurements to make the intakes more unrelated to EI. However, even though E% is a relative measurement, it does not automatically make the food group/nutrient unrelated to total EI. Instead, unwanted variation could occur, particularly when the food group/nutrient has a weak correlation with total energy intake or has a low variability. E% then become highly related to the factor whose effect we wanted to remove, that is, energy intake.[150]

In paper IV, we chose instead to use "the residual method" as suggested by Willett[150] to adjust for total energy intake. The residuals from separate linear regressions were calculated with total energy intake as the independent variable and absolute intake of a food group as the dependent variable. The residuals by definition provide a measure of the food group intake uncorrelated with total energy intake.

4. RESULTS AND DISCUSSION

The presentation of results follows the structure of the aims of the thesis (see p.14). The specific aim has its own heading, where all results related to that topic is presented together with a brief discussion. For more details, please refer to the full text papers at the end of the thesis.

4.1 Methodological aspects of dietary assessment

4.1.1 To examine the quality of the collected dietary data and investigate how it can be improved (paper I).

We classified the participants into underreporters (UR), overreporters (OR) and adequate reporters (AR) of energy intake using the equations defined under Methods (p.19). As seen in figure 6, boys and girls had similar patterns with almost as many OR as UR (Boys: 16% UR, 17% OR. Girls: 13% UR, 19% OR) whereas mothers had a large proportion of UR (39%) but very few OR (n=5).

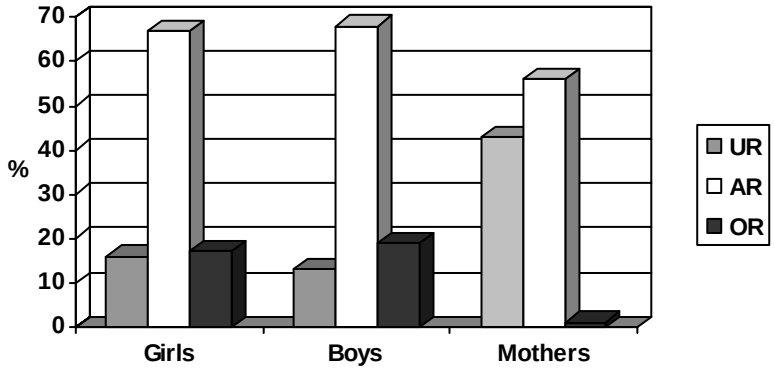

Figure 6. Proportions of under-, over- and adequate reporters of energy intake among girls, boys and mothers.

Underreporting is a well-known phenomenon more or less common in all dietary surveys.[72] The most common method used for identifying underreporters is to use a lower cut-off, for example EI:BMR=1.2, and classify everyone beneath that as underreporters. Few have speculated on an upper limit, and not many studies have presented the number of overreporters. In this study, we have used confidence intervals for classifying misreporters, which have opened up the possibility to identify both under- and overreporters.

Different assessing methods are more or less likely to be affected by under- and overreporting. The questionnaire used in this study has been shown to have a tendency to give an overall higher energy intake than other methods.[136]

In this study, we found a high prevalence of overreporting among the adolescents, but not among the mothers. Other studies assessing the diet of children and adolescents have found

similar prevalence of overreporting as we did.[82, 83] Overreporting prevalence among adults has previously been reported to be between 3 and 7% in various populations and methods.[76, 79, 80] Hence, it is possible that overreporting is generally more prevalent among young subjects than in adult populations.

Table 5 shows the differences in correlation coefficients between the whole sample and AR only in the association between EI and body measurements. The expectation is that body weight and EI should be positively correlated to each other, assuming that the heavier person (either fat and/or muscle mass), the higher energy demand. These results suggest that the group of AR reported more accurately than the whole group, and that the classification into AR, UR and OR was meaningful and increased the quality of the dietary data.

Table 5. The correlation (Spearman's correlation coefficient) between energy intake and different anthropometric measurements in the whole sample and in the group of AR (adequate reporters) only.

	All			**AR only**		
	BF%	BMI	Weight	BF%	BMI	Weight
Girls	-0,21**	-0,18**	-0,15*	0,01	0,16*	0,23**
Boys	-0,22**	0,00	-0,04	-0,02	0,38***	0,36***
Mothers	-0.01	0.03	0.10*	0.22**	0.28***	0.36***

* P<0.05, ** P<0.01, *** P<0.001

We have also used an energy quotient (reported EI divided by estimated EE) as a controlling variable in the correlation between body weight and EI. This adjusted correlation analysis resulted in even higher correlation coefficients among the children than in the group of AR only above (daughters: r=0.66, sons: r=0.68, mothers: r=0.31, p<0.001). This shows that the use of the energy quotient as a controlling variable in multivariate tests with the purpose of enhancing the quality of dietary data is meaningful.

Even though we have established that under- and overreporting of total energy intake exists in this population, we have no method, except oral bacteria (see below), to explore whether selective misreporting occurred or not. However, the discrepancies in the results between the AR sub-group and the whole sample, as reported in paper I, were very few, suggesting a modest selective misreporting. Nevertheless, the few places of significant discrepancies between the two sets of results, might give us some indication of which foods most affected by misreporting; namely sugar intake among girls and cooked meals among boys.

4.1.2 To describe the characteristics of those who under-, over- and adequately report their total energy intake (Paper III)

In paper III, underreporters were named low energy reporters (LER) and overreporters high energy reporters (HER).

We saw a trend from LER to HER in some characteristics among the children. Those variables were BMI (p for trend <0.001), BF% (p for trend <0.001), family income (p for trend=0.008), number of working hours of mother (p for trend=0.01) and number of children in the family (p for trend=0.02 in boys, NS in girls, NS for boys-girls interaction), as seen in figure 7. There were no statistically significant differences between the groups in occupation or marital status of mother, smoking status or parental education.

In mothers, no differences were found between LER and AER, except in BMI (LER: 25.3±4.7 kg/m^2, AER: 24.2±4.0 kg/m^2, p=0.01) and in BF% (LER: 36.0±8.7, AER: 33.5±7.8, p=0.002). Trend analyses among mothers were meaningless since only five individuals were classified as HER.

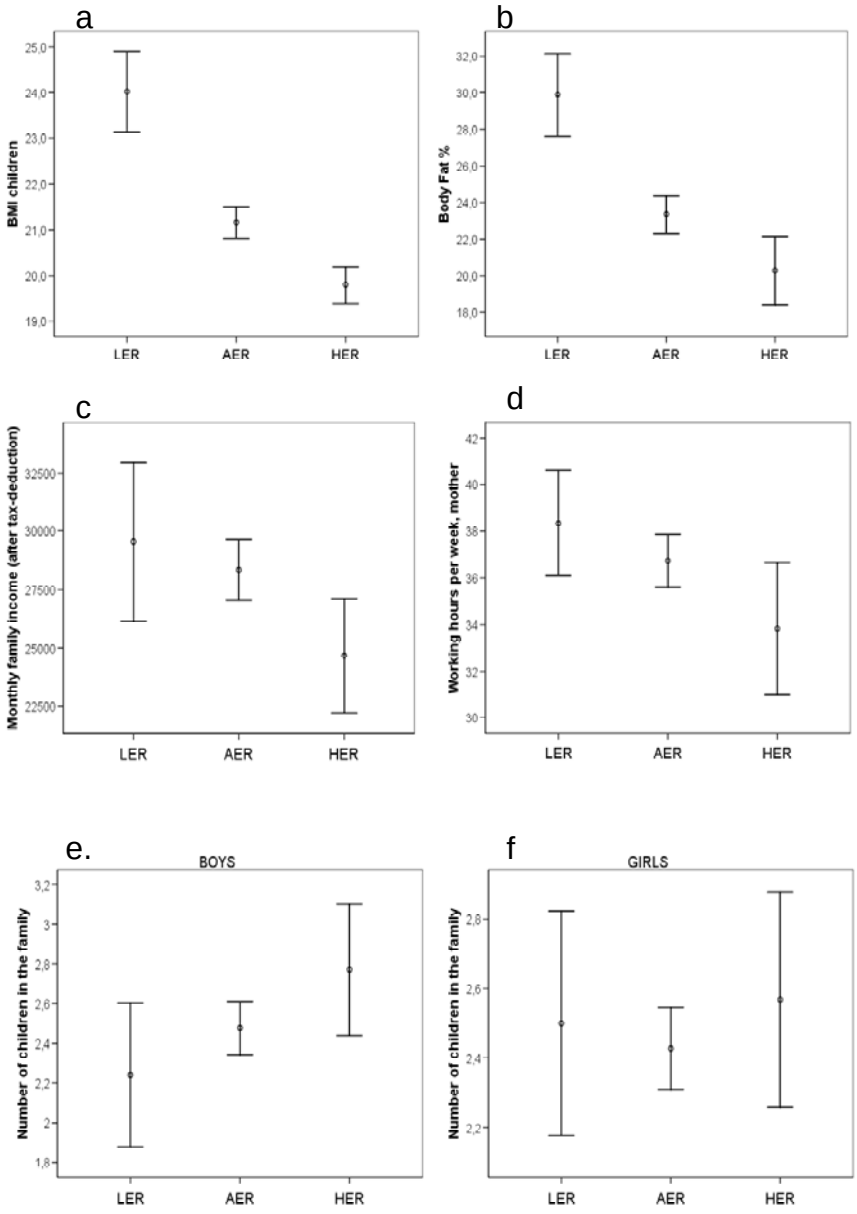

Figure 7. Differences between low energy (LER), adequate (AER) and high energy reporters (HER) with 95% confidence intervals in *a)* BMI, *b)* BF%, *c)* family income, *d)* number of working hours of mother, *e-f)* number of children in the family (*e.* boys, *f.* girls).

4.1.3 To explore the possibilities to use salivary bacteria as an objective measurement of sugar intake (Paper II)

Reported total sugar intake was significantly associated with lactobacilli (LB) in mothers (p=0.001), but not in daughters and sons (p=0.03 for mother-son interaction). When excluding lactose from the total sugar intake, the association with LB was significant also in daughters (p=0.03). Mutans streptococci (MS) were associated to total sugar intake (lactose excluded) in daughters only (p=0.005).

The explained variance for the variation in MS counts, when including all sugar-containing food groups and other variables that might influence bacteria counts, was 7.4% in girls, 8.4% in boys and 5.3% in mothers. In sons, the maternal bacteria counts were the only significant variable predicting MS counts, whereas beverages, candies/chocolates and fruit predicted MS counts in girls. In mothers, BMI and sugar intake from milk were the only variables that independently predicted MS counts.

In the LB regression model, a high BMI and a low energy intake from cooked meals and fast food were significant predictors in mothers. The model explained 7.6 % of the variance in LB counts. In the children, the explained variance was low, 3.4 % for daughters and 2.3 % for sons.

In summary, both bacteria counts were associated with reported intake of sugar-containing products, especially in mothers and daughters, but the associations were overall weak and difficult to interpret.

Whether the salivary levels of these bacteria are a good marker for sugar intake or not is difficult to say based on the results of this study. Nevertheless, this study combined with all previous studies[89] shows that a link exist. To find substantial evidence, experimental studies of high quality are required. For example could salivary bacteria levels be compared with urinary levels of sucrose and fructose, as described by Tasevska et al.[88] There is also a need for exploring the relationship to different types of sugar and to different eating patterns, before the use of bacteria as a sugar marker could be used fully. Until then, salivary bacteria might be used on a population level as done below (section 4.2.3) as a complementary measurement to self-reported sugar intake, as long as the limitations are pointed out.

4.2 Eating habits of adolescents and the association with body fatness

4.2.1 To describe the eating habits of Swedish teenager, focusing on gender differences (Paper I).

Boys reported a larger intake of most food items and had a mean total EI of 3200±620 kcal/day compared to the girls' 2300±450 kcal. In relative numbers (E%), girls had a higher intake of carbohydrates and dietary fibre than boys. Girls had also a relatively higher intake of light meals and fruit and boys had a relatively higher intake of fat and milk. The intake of sweet food items and the intake of non-alcoholic beverages contributed to around 10 % each to the total energy intake. Adding energy from salty snacks to that number makes a total mean intake from low-nutritious food of about 25 E%.

Boys reported more meals per day than girls did (4.9 *vs.* 4.6 / day, p=0.02). The meal categories with gender differences were main meals (2.0 *vs.* 1.9, p=0.005) and light meals/breakfasts (1.3 *vs.* 1.1, p=0.004). The frequency of snack and drink occasions were similar in girls and boys (1.6 times and 0.7 times/day, respectively).

We found also differences between girls and boys in the temporal distribution of meals. Boys had similar number of meals as girls from 10 am to 10 pm, but had significantly more meals late at night and early in the morning, see figure 8.

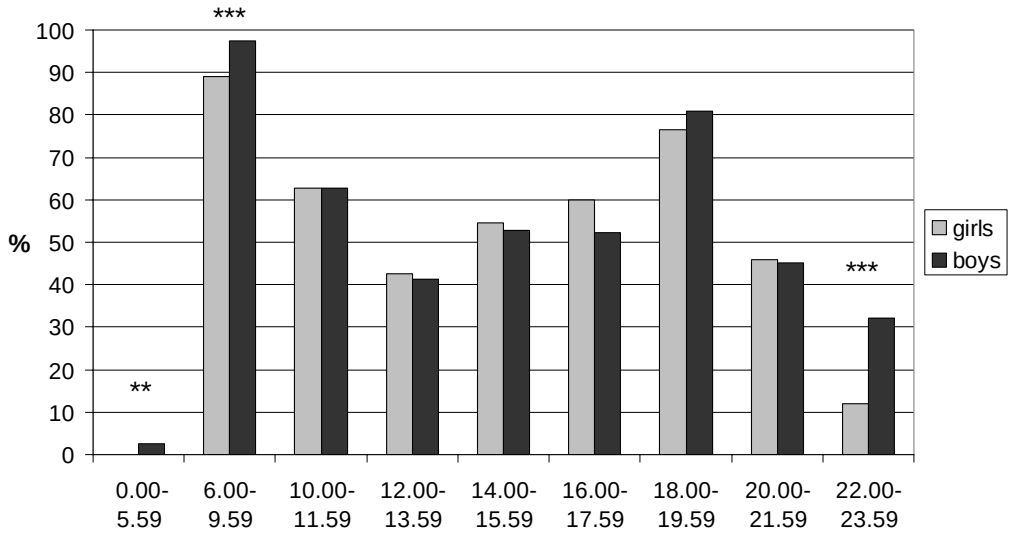

Figure 8. The percentage of girls and boys having at least one meal in different time intervals. A meal here is defined as an eating occasion; either a main meal, a light meal/breakfast or a snack meal. Drink occasions were not included. ***p*-value <0.01, ****p*-value <0.001 (Mann-Whitney *U*-test.)

The associations between breakfast frequency and other dietary habits were also explored. Girls who had breakfast 5-7 times/week reported a lower intake of sweet food items, salty snacks and non-alcoholic beverages compared to those who had breakfast 0-4 times/week. The relationship between breakfast habits and other habits was less obvious in boys. Even though the higher intake of energy-dense foods among breakfast-skippers, we found no difference in total energy intake between the two breakfast groups.

Many other studies have noticed that good breakfast habits seem to protect against weight gain, as well as being beneficial for other aspects like academic performance.[15, 19, 32, 33] We could not see a relationship between frequent breakfast-eating and a higher BF%, but the amount of energy-dense foods eaten could lead to an excess energy intake and weight problem in the future.

The intake of total energy as well as macronutrients and food groups found in this study are reasonably concordant with other studies of Swedish adolescents,[12-15, 18] except for a few differences. Firstly, we found a higher relative intake of protein and fat than previous studies. Secondly, the gender differences in our study seemed to be larger than shown before.

The different patterns of boys and girls in the temporal distribution have not, to our knowledge, been described before. Boys have a higher energy demand than girls, which could be met by larger meals, but apparently by more meal occasions as well, as shown here. It is interesting that those extra meals were not taken during the day but late at night and in the morning.

4.2.2 To investigate the correlations between dietary habits and body fatness in adolescents (Paper I)

The results below are all based on the group of adequate reporters only. For the results of the whole sample, please refer to paper I.

The only dietary variable found that correlated significantly to BF% in both girls and boys was the relative intake of milk. BF% was, in girls only, also related to a high relative intake of fibre and alcohol and a low relative intake of sugar, and to a low relative intake of breakfast cereals in boys only (all these results; $r_s = \pm 0.2$).

In boys, but not girls, a high BF% correlated with fewer eating occasions ($r_s = -0.2$, $p=0.006$), but none of the other meal variables (breakfast frequency, number of main meals, time of the day etc.) were significantly related to BF%.

Table 5 (p.22) shows that no significant positive correlation were found between EI and BF% or between EI and BMI when including all study participants in the three groups. It is obvious that those with a high BF% have (or used to have) a too large intake *in relation* to their energy expenditure, but that does not automatically imply that they have a higher EI than those with a low BF%. A tall lean person could have a higher energy demand, and consequently a larger EI, than a short, chubby person. This could be due both to larger muscular mass, and to higher physical activity level, both factors known to the increase the energy demand.[151, 152]

To explore the associations between EI and overweight measurements linear regression models were constructed and adjusted for fat free mass (FFM), physical activity (PA) and misreporting (energy quotient, see p.22). The results now showed significant associations between EI and BF% in all groups (girls: stand.$\beta=0.6$, $p=0.002$, $R^2=0.1$; boys: stand.$\beta=0.8$, $p<0.001$ $R^2=0.2$; mothers: stand.$\beta=0.9$, $p<0.001$, $R^2=0.2$). Corresponding figures for the association between EI and BMI were: stand.$\beta=0.3$, $p=0.05$, $R^2=0.3$ (girls); stand.$\beta=0.6$, $p<0.001$, $R^2=0.5$ (boys); stand.$\beta=0.7$, $P<0.001$, $R^2=0.3$ (mothers).

In conclusion, when adjusting for individual energy demand, energy intake had a clear positive relationship with fatness. EI was here stronger associated with BF% than with BMI, probably due to BF% being a better measurement for obesity than BMI.

When using a questionnaire as an assessment tool as we do here, the amount of random errors are usually more than if using, for example, diet records. These errors lead to overall weaker results and problems with reaching significant levels. The choice of method is always a balance between practicability (use of low-burden methods in large populations) and accuracy (minimizing random errors) of the method. If we had used another, more accurate, method, the results regarding eating habits and overweight might have been more conclusive.

4.2.3 *To investigate if there are associations between sugar intake and BMI in adolescents and middle-aged women (Paper II)*

The word "sugar" here includes all mono- and disaccharides combined.

The mean reported total sugar intake in mothers was 92 ± 39 g/day (median 84g/day), daughters 143 ± 83 g/day (median 129g/day) and sons 185 ± 90 g/day (median 166g/day). In figure 9, the proportions of the sugar intake from different food groups are presented. The single most important contributor in children was beverages, 33% of the total sugar intake in girls and 36% in boys. In mothers, sugar from beverages and fruit each contributed to about 22%.

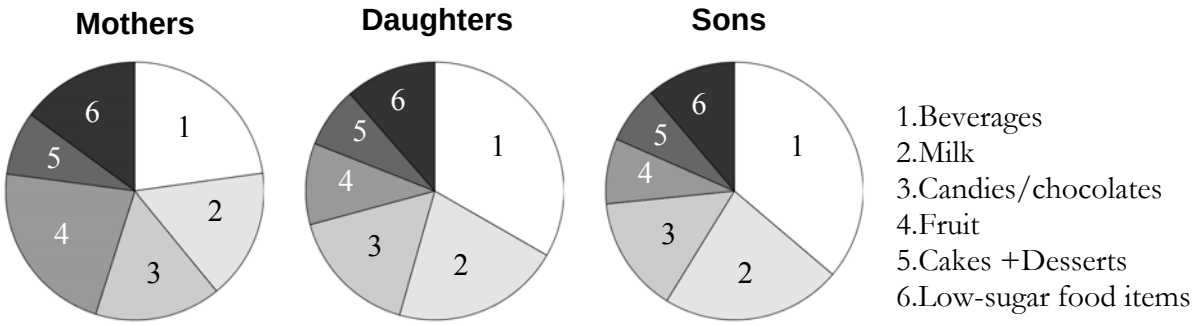

Figure 9. Dietary sources of sugar among mothers, daughters and sons. Low-sugar food items were defined as food items containing <20 E% mono-/disaccharides.

In this paper, we used two different measurements for sugar intake, self-reported sugar intake and levels of MS and LB counts in the saliva. The results are presented in table 6. There was a statistically significant correlation between both bacteria counts and BMI in mothers. The correlation between MS counts and BMI was significant in the children too, if boys and girls were combined (r=0.14, P=0.008). The self-reported sugar intake, however, was not related to BMI.

Given the assumption that salivary bacteria counts is a good measurement for sugar intake (see discussion in 4.1.3), this result suggests that overweight and obese individuals have a higher relative intake of sugar than leaner subjects, although not detected when using self-reported dietary data. Many previous cross-sectional studies have found negative associations between sugar intake and BMI.[153, 154] These relationships might be a result of selective underreporting rather than a true negative relationship. If so, an objective measurement of sugar intake would be more reliable than self-reported data, even salivary bacteria with all its limitations.

Table 6. Correlation coefficients for BMI vs. bacteria counts and reported sugar intake.

	BMI					
	Mothers		Boys		Girls	
	Crude r	Adj. r †	Crude r	Adj. r †	Crude r	Adj. r †
MS counts	0.18***	0.17***	0.11	0.14	0.05	0.05
LB counts	0.14**	0.11*	0.05	0.02	0.05	0.06
Reported sugar intake	0.02	0.01	-0.13	-0.10	-0.15*	-0.01

† adjusted for total energy intake and energy under-/overreporting (energy quotient)
* $p<0.05$, ** $p<0.01$, *** $p<0.001$

4.2.4 To analyse the correlates of sweet beverage consumption in adolescents (Paper IV)

The beverages analysed in paper IV were *soft drinks*, including non-carbonated drinks such as cordial ('saft'), and *fruit juice*. However, an average diet also consists of other caloric beverages, such as alcoholic drinks, coffee, tea and milk. Table 9 (p.30) shows an overview of all caloric beverages, except for milk, in the diet of the study subjects. In the median SWEDES adolescent, the reported total intake of these beverages contributed with 11% to the total energy intake, compared to 9% in the mothers.

To explore the correlates for soft drink and fruit juice consumption, variables covering three main areas, life style, eating habits and maternal impact, were combined in multivariate regression models. Table 7 and 8 show the correlates with significant impact on reported intake of soft drinks and fruit juice, respectively.

There was an interaction found between girls and boys in the relationship between the two beverages; boys with a higher intake of fruit juice reported a *lower* intake of soft drinks, whereas girls with a large intake of juice consumed *large* amounts of soft drinks.

The associations between eating behaviour scores and reported intake differed for fruit juice and soft drinks. High fruit juice consumption was associated with *higher* cognitive restraint, whereas soft drink consumption was associated with *lower* cognitive restraint. This result was not unexpected as previous studies have shown that restrained eaters tend to choose more healthy foods.[155] Although fruit juice might be considered a healthy food choice, it is interesting to note that it was consumed on the expense of more nutritious foods, such as milk and cooked meals, in a similar pattern to soft drinks.

Table 7. Correlates of SOFT DRINK consumption†

	Standardized beta	*P*
GIRLS		
Breakfast (0=seldom, 1=often)	-0.23	<0.001
Intake of cooked meals †	-0.17	0.006
Intake of milk †	-0.13	0.03
Cognitive restraint	-0.12	0.04
Adjusted R^2	***0.09***	
BOYS		
Intake of cooked meals †	-0.23	0.001
Intake of milk †	-0.20	0.006
Intake of fruit juice †	-0.18	0.01
Breakfast (0=seldom, 1=often)	-0.15	0.02
Intake of salty snacks †	0.14	0.05
Adjusted R^2	***0.14***	

† measured as the residuals from the correlation between total energy intake and the actual food group

Table 8. Correlates of FRUIT JUICE consumption†

	Standardized beta	*P*
GIRLS		
Intake of fruit juice, mother †	0.32	<0.001
Cognitive restraint	0.16	0.01
Intake of milk †	-0.14	0.02
Emotional eating	-0.13	0.03
Smoking, mother	0.12	0.03
Smoking, child	0.11	0.05
Adjusted R^2	***0.14***	
BOYS		
Intake of fruit juice, mother †	0.29	<0.001
Intake of milk †	-0.28	<0.001
Intake of cooked meals †	-0.22	0.001
Intake of soft drinks †	-0.21	0.002
Adjusted R^2	***0.19***	

† measured as the residuals from the correlation between total energy intake and the actual food group

Table 9. The reported energy intake from beverages.

		Girls			Boys			Mothers		
		Mean	SD	Median	Mean	SD	Median	Mean	SD	Median
Fruit juice	kcal †	90	102	55	118	120	96	53	79	27
	E%	3.7	4.3	**2.5**	3.5	3.4	**2.3**	2.7	3.7	**1.6**
Soft drinks¶	kcal ‡	72	81	57	143	155	80	20	50	0
	E%	2.8	2.9	**2.0**	4.0	3.9	**2.5**	0.9	2.0	**0**
Alcoholic beverages										
	kcal	22	52	0	30	61	0	87	68	78
	E%	0.8	1.7	**0**	0.9	1.9	**0**	4.6	3.7	**3.8**
Other §	kcal	128	214	65	141	197	69	38	62	23
	E%	4.6	5.3	**3.0**	4.0	5.0	**2.2**	1.9	2.7	**1.2**
Total beverages										
	kcal	311	291	261	432	315	345	197	141	170
	E%	12.0	7.2	**10.7**	12.4	7.1	**11.1**	10.0	6.2	**9.2**

† Based on an average energy content of 48 kcal /100g.
‡ Based on an average energy content of 40 kcal /100g.
¶ Soft drinks include both carbonated and non-carbonated drinks ('saft').
§ Chocolate drinks and coffee/tea with milk/cream/sugar.

4.3 The relationship between adolescents and their mothers

4.3.1 To explore similarities between adolescents and their mothers in different dietary aspects (Paper II, III and IV).

Figure 10 presents results, not published before, of the correlations between food choices of the mother and food choices of the child. An overall gender difference was clear; mothers and girls had generally more similar eating patterns than mothers-boys had. The strongest correlations found, in both girls and boys, were for the intakes of fruit juice and sweet bakery goods ('kaffebröd'). Milk intake was the food group with the lowest correlation coefficient.

When using energy-adjusted variables (energy residuals),[150] the inter-generational pattern looked basically the same as when using absolute values. Fruit juice (r=0.3) and 'kaffebröd' (r=0.3) was in the top and milk (r=0) at the bottom. The only differences between the two sets of results were found in girls, where the energy-adjusted analyses showed stronger correlations for fast food (r=0.23) and cooked meal (r=0.18) intake and weaker correlations for fruit (r=0.12) and salty snacks (r=0.13), compared to the results in figure 10.

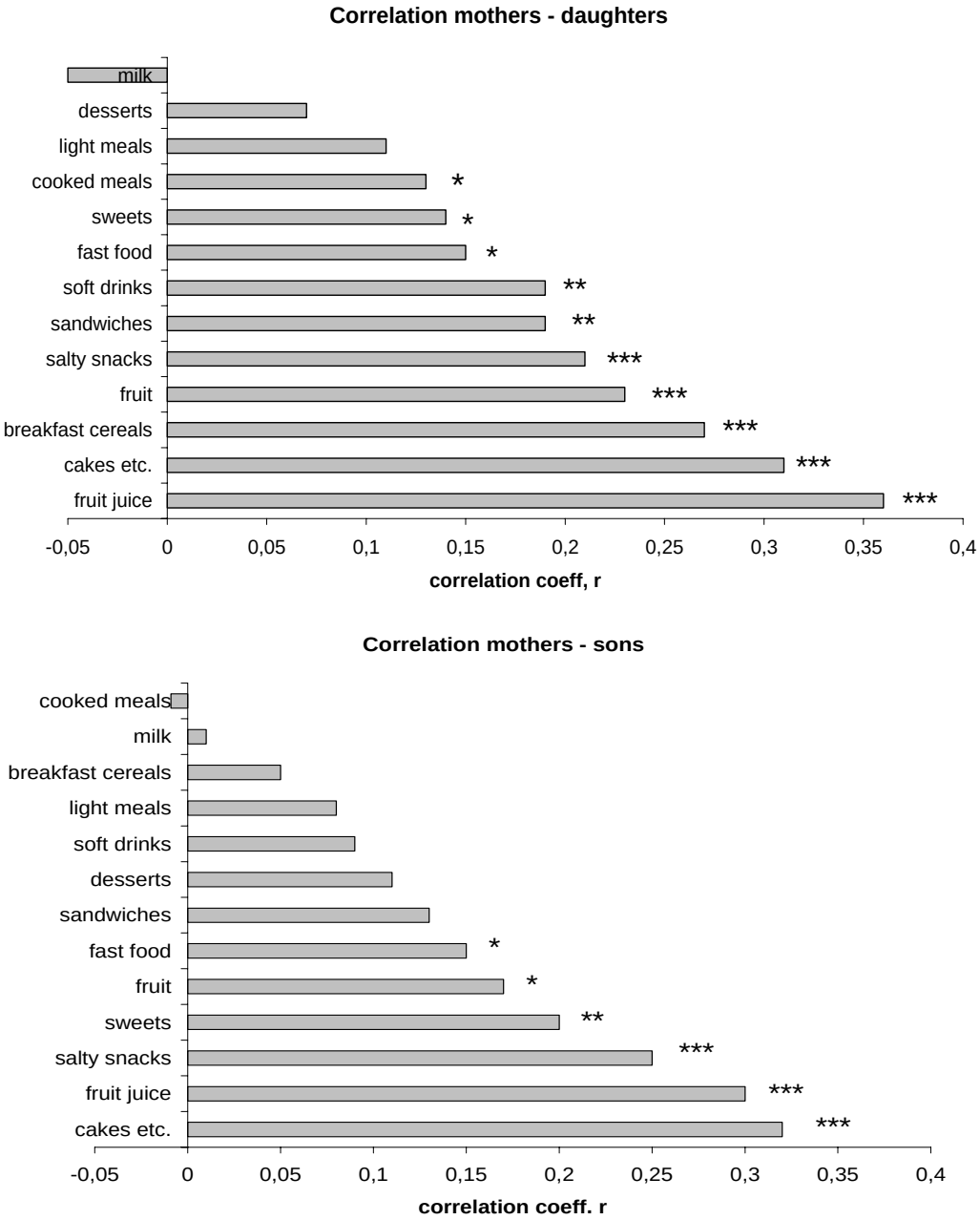

Figure 10 a-b. Correlation coefficients between the energy intake of different food groups between ***a)*** mother and daughter and ***b)*** mother and son. *** $p<0.001$, ** $p<0.01$, * $p<0.05$

Another example of mother-daughter similarities, from paper III, is the higher risk of daughters who underreport their energy intake having an underreporting mother (Odds Ratio=3.3, p=0.002), whereas no associations were found in reporting capacity between mothers and sons.

It is no surprise that girls show more similar habits with their mothers than boys do. Adult men and women have generally different eating habits. Women often report for example higher intakes of fruit and vegetables and lower intakes of fat and they are also more health

conscious than men.[156] These sex differences in food choices have also been seen among teenagers.[14, 157, 158]

On the other hand, we did find one association between sons and mothers not found in daughters-mothers; salivary bacteria levels (paper II). The correlation coefficient between MS counts of mothers and sons was 0.23 (p=0.004), whereas 0.12 (NS) in daughters. A weak correlation was also found in LB counts (r=0.18, p=0.04) in boys but not in girls. The bacteria counts were used as markers for sugar intake and this result consequently suggests that there might be a closer relationship in sugar intake between mothers-sons than between mothers-daughters. However, these results are not verified by any other findings in this study, nor in any previous study, and the explanation is perhaps found elsewhere. Oral bacteria colonisations are transmitted from mother to child in early childhood,[108, 159] and it is possible, for any unknown reason, that boys are more susceptible for that transmission than girls. There could also be other explanations connected to the properties of these bacteria, not known to us.

Previous studies have shown that there is a relationship between parental and child intake of fat, fruit and vegetables.[54] In this study, we have shown that also the habit of eating 'kaffebröd', fruit juice and salty snacks is "inherited" from the mother. Some of these mother-child results might give us an idea how different foods are consumed. Some items, such as fruit juice and 'kaffebröd', are probably consumed at home in a similar pattern as the rest of the family, while the consumption of other foods, such as soft drinks, is much more controlled by the teenager him-/herself, bought and consumed away from home.

The intake of milk, however, seems to be an exception to these arguments. It is very likely that milk is consumed at home, but still no mother-child associations were found. Instead, milk might be considered as a different kind of food item in children than in adults. Children and adolescents are probably more likely to consider milk as a thirst quencher, a beverage among other, whereas adult women probably rather see milk as part of their breakfast or used in cooking or in coffee/tea.

A high BMI of the mother is a risk factor for the child to become overweight and obese.[50-52] It seems that overweight mothers tend to overfeed their children more than other mothers, and/or to pass on their own bad habits to their children. It has been shown, for example, that children of obese mothers have a higher intake of dietary fat than other children.[52, 58] In our study, we found an interesting mother-child association, presented in figure 11, suggesting an association between how often the child eats breakfast and the body size of the mother. Interestingly enough, there was no significant relationship in any of the other possible combination; breakfasts of *child* and body size of *child* (see paper I), breakfasts of *mother* and body size of *mother* or breakfasts of *mother* and body size of *child*.

It is plausible that a child of a large or obese mother would have other eating behaviours than other children. Besides the risk of mirrored habits, growing up in a family with a heavy mother (or father), might create more weight conscious children. The child could both have "inherited" the mother's own weight consciousness, but also being deterred by the size of the mother, deciding never to become like her. It has been noticed before that weight conscious and dieting individuals tend to skip meals in a belief that that would help them to lose weight,[160, 161] and that could explain our results.

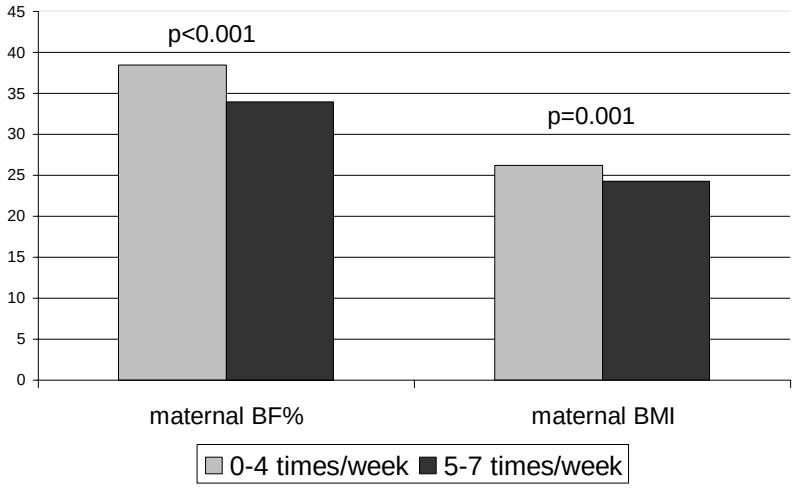

Figure 11. Associations between body size of mother and breakfast frequency of child.

5. GENERAL DISCUSSION AND FUTURE PERSPECTIVE

When summarizing all results of the thesis, using the experience and knowledge derived from the work, there are general conclusions to be drawn. Below is a comprehensive discussion of these general issues, as well as future perspectives.

Eating habits and obesity

There is no doubt that the population of the industrialized world has become fatter in the last few decades. The reason is most likely a change in both diet and physical activity. Consumer statistics show that since 1970 the average consumption of energy in Sweden has increased by 10%, whereof almost 8% the last ten years.[6] When looking at different food groups, the consumption of some food groups has increased, *e.g.* vegetables and sweets, whereas other, *e.g.* potatoes and butter, has decreased. Nevertheless, putting all information together, the obvious pattern seen over the last decades is an overall increased consumption of most foods.

A longitudinal study comparing objective consumption data from various countries with body mass index from the multi-centred MONICA study, came to the conclusion that the rise in overweight and obesity prevalence is explained to 69% by an increased energy intake, while fat or sugar intake has no significant association with the increase of obesity prevalence at all.[162] Hence, the conclusion is that some people get fat from to much fat, some from too much sugar, but as a population we get fatter because we simply eat too much.

This is supported by the positive relationship for both body fatness and BMI to total energy intake, and the inconsistent results for some food groups and behaviours, found in this study. A lot of effort is put into finding components of the diet and eating behaviour that causes overweight, both in scientific work and in the speculations of laymen. Sometimes that search overshadows the most important fact: eating too much causes obesity. It is important to be aware that a single food item or behaviour cannot solve the complicated jigsaw puzzle. It would be very convenient if we by taking away a certain food group or illegalizing a certain habit, would solve the problem of obesity. Instead, everyone is an individual with different habits and preferences and the only true general cause of overweight is an excess energy intake

There is, nevertheless, a constant need for analyzing food groups and macronutrients, finding specific risk behaviours for obesity in different sub-groups. Everything that could lead to relevant prevention strategies and treatment programs for the fattening population of today is important research.

Assessing the diet of adolescents

When assessing the diet of adolescents there are some age-dependent factors to consider. I strongly recommend that data on energy expenditure are used for identifying, not only underreporters, but also overreporters of energy intake. We have shown that overreporting could be prevalent among younger subjects. Another complication of young age we noticed was the low level of awareness among the adolescents of what foods they actually eat. Therefore, it was a good idea to have a parent involved. The mothers acted as good information sources of foods eaten at home. The involvement of parents seemed also to secure a higher participation rate, since many of the young participants had low motivation and came

only due to the persistence of their mothers. However, it is important to realize that the involvement of a parent could be a source of misreporting if a child wants to hide intakes of certain foods, for example alcohol, from the parent.

In addition, it is always important to separate boys and girls. In every analysis of this thesis, I found different associations in boys than in girls. Combining them into one group would have generated false results. Most studies divide the sexes, but surprisingly few test the gender differences and interactions statistically. This gender approach is probably as important in all age groups.

Addressing the problem of reporting bias

We would not have found the association between body size and total energy intake if we had not addressed the problem of under- and overreporting. To use the quotient EI/EE as an adjusting variable in multivariate analyses seems to be a good way to control for misreporting. The advantage is that we have a continuing variable useful in tests such as correlations and regression analyses.

A more comprehensible approach for dealing with misreporters could be to present the results of adequate reporters separately. However, those results give limited information. We have shown that under- and overreporters of energy intake are different from adequate reporters in many aspects. If misreporters are left out, we leave out many overweight individuals and as well as individuals with problematic eating. Therefore, the results of adequate reporters should be presented next to the results of the whole sample. Comparisons of the two sets of results can reveal interesting information on the phenomenon of energy misreporting. Another drawback by analysing adequate reporters separately is of course the problem of decreased power.

I cannot give a recommendation on how the problem of misreporting should be addressed, except that it should and must be addressed. Both methods used in this thesis give meaningful results and are useful in different contexts.

Strengths and limitations of the SWEDES study

The SWEDES study is unique in many ways. Firstly, we have collected the same data from mothers as from the teenagers. The combination mother-teenager is not that commonly seen as a research approach. Most mother-child studies are performed on smaller children, whereas adolescence studies often target the teenager itself. Secondly, we have collected information from many different areas (metabolic parameters, genetics, psychology, eating habits, physical activity etc.) making very complex analyses possible, even though we have limited the focus in this thesis to eating habits. Thirdly, we have information on the entire diet with details regarding frequency, quantity, meal patterns as well as psychological eating behaviour.

All dietary questionnaires have weaknesses. A weakness with the SOS dietary questionnaire is the low precision, as shown earlier by the low correlation between reported energy intake and measured energy expenditure with the doubly labelled water method.[137] On the other hand, the frequency approach combined with portion sizes and detailed information on snack foods of this questionnaire, have been proven earlier to be successful.[65] The relative intake of most variables was more or less the same after excluding suspected misreporters, suggesting that quantity rather than quality of the diet was affected by misreporting. Since overreporting

was as common as underreporting in our adolescent population, the mean values of total energy intake was very plausible and more or less equal to the results of a study using DLW technique in 16-20 year old Swedish subjects.[12]

When we made the classifications into under- and overreporters, we compared EI with estimated energy expenditure (EE). In an ideal situation, we would have objective precise measurements of EE. At the time of this study, the size of the study population made it impossible to use accelerometers in all subjects. Instead, we had to rely on PA questionnaires. However, the larger part of EE in most people is used for basic metabolism (BMR) and not for physical activity. We calculated individual BMR by using equations (Schofield)[148] proven to be the most accurate for adolescents.[163-165]

The likely selection bias in SWEDES towards higher education is a problem shared with all similar studies. A selected study population could be a problem if making conclusions about habits of the typical Stockholm inhabitant, but probably not when studying relationships between diet and obesity. There is nothing suggesting that these relationships are different among SWEDES participants than they are among those choosing not to participate. Overweight and obesity is equally problematic in high-educated as in low-educated persons.

Future perspectives

There are many approaches available for targeting eating habits in an overweight perspective in future research. Especially, there is a need to further explore the relationships between parental and child eating habits. There are hardly any studies targeting the attitudes of children toward their parents' weight, in contrast to the many studies targeting the attitudes of the parents. I want to see more studies investigating which habits are inherited from the parents, and why other habits are not. In addition, to investigate at what age children are most susceptible to parental influence and to what kind of influence. If we have more knowledge of these processes, we can target parents in intervention studies in a more effective way.

Other research targets, such as the effect of portion sizes on satiety, possible compensatory behaviour at subsequent meals after intake of energy-dense foods and liquid calories, the effect on eating behaviour of the child by the presence of a parent, and many others areas, could be tested experimentally. The possible outcome in these trials would be even more interesting if overweight and normal weight children are studied separately and compared.

There is a need for more large longitudinal studies measuring dietary behaviours, physical activity and weight. This is of course costly and time consuming, but is the only way to address causality and to get evidence for the aetiology of obesity. It would be very interesting to follow these adolescents into adulthood, and to measure the results of their adolescent habits in terms of adult body size and metabolic parameters.

6. CONCLUSIONS

- Low-nutritious foods contributed to 25% of the total energy intake in the SWEDES adolescents. A high proportion of these adolescents had meals at usual meal times, the milk intake was generally high and cooked meals (as defined under Methods) were eaten in much larger amounts than fast food was. It is possible, however, that these habits are exclusive for our selected population, even though similar to results from previous studies.

- Both BMI and BF%, had clear positive associations with total energy intake, suggesting that a high total energy intake is the most important predictor for overweight.

- A high intake of both soft drinks and fruit juice were associated with a low intake of more nutritious food sources such as milk and cooked meals. This suggests that even though fruit juice is considered a healthy food choice, the health implications of high fruit juice consumption, although contributing to some nutrients, could be similar as for high soft drink consumption.

- Given the assumption that salivary bacteria counts is a good measurement for sugar intake, overweight and obese individuals have a higher relative intake of sugar than leaner subjects, although not detected when using self-reported dietary data.

- The higher tendency of adolescent daughters to share eating habits and behaviours with their mothers compared to sons are consistent with previous results. We found that some food groups were consumed independently of the mother, like milk and soft drinks, whereas others, like 'kaffebröd' and fruit juice were closer related to the mother's intake in both girls and boys. This opens up possibilities for targeting mothers with effective messages in intervention strategies for preventing childhood obesity.

- The body size of the mother has an impact on the eating habits of the child, something that need more future research attention.

- The gender differences found in this study high-lighten the importance of always analyse boys and girls separately, and to test for gender interactions.

- This study has shown that the phenomenon of energy overreporting should not be ignored, since overreporting of energy intake had the same occurrence as underreporting among the adolescents in this study. Overreporters seem to be a distinct group, somewhat inverted of typical underreporters. If excluding under- and/or overreporters from analyses, important information from different sub-groups are lost and the possibility of making generalized conclusions are reduced.

- The quality of the self-reported dietary data can be improved by either adjusting for the degree of misreporting by using an energy quotient (EI:EE) in parametric multivariate analyses, or, in descriptive analyses, by excluding misreporters of energy intake.

- The association found between bacteria counts and sugar intake in this study further strengthens the evidence regarding a bacteria-sugar-link. However, there is not enough evidence today for using the bacteria as a quantifying tool of sugar intake.

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