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Dietary Intakes of Swedish Children and Adolescents: the European Heart Study

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DIETARY INTAKES OF SWEDISH CHILDREN AND ADOLESCENTS – THE EUROPEAN YOUTH HEART STUDY

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ABSTRACT

What children eat is important both for their health now and for their risk of chronic non-communicable diseases, such as cardiovascular disease, in the future. The diets of 1,121 children (aged 9 y, *n* = 552) and adolescents (aged 15 y, *n* = 569) were assessed by an interviewer mediated 24-hour recall, as part of the European Youth Heart Study. Group macronutrient intakes and their food sources were described, and dietary energy density (ED) and breakfast habits were employed as markers of dietary quality. The effect of socioeconomic status on these markers was investigated. The adequacy of energy-reporting in this population was also tested. The diets were close to population nutrition goals of most macronutrients, but fat, saturated fat and sucrose provided more than the recommended amounts of dietary energy (> 30 %, 10 % and 10 % of energy, respectively) in all age and gender groups. Consumption of energy dense, nutrient poor food groups (sweetened drinks, sweets and chocolate, cakes and biscuits, chips and crisps, and desserts) was prevalent, and these foods contributed significant amounts to energy, fat and sucrose intakes. Dietary ED was investigated as a potentially useful marker of total diet quality and decreasing ED was found to be significantly negatively associated with these food groups, but positively with fruit, vegetables, cereals, pasta rice and potatoes, and high fibre bread. Breakfast consumption was relatively high, but was lower in adolescents, especially in girls. Group energy reporting was lowest in overweight, female and older groups. Higher socioeconomic status was associated with healthier breakfasts in children, and tended towards a significant association with lower energy density in all. The burden of chronic diseases on public health is unlikely to improve until the diets of children and adolescents can be improved sustainably. This study provides valuable information for public health nutrition planning in Sweden.

DECLARATION

I certify that this thesis, which I now submit for examination for the award of MPhil, is entirely my own work and has not been taken from the work of others save and to the extent that such work has been cited and acknowledged within the text of my work.

This thesis was prepared according to the regulations for postgraduate study by research of the Dublin Institute of Technology and has not been submitted in whole or in part for an award in any other Institute or University.

The work reported on in this thesis conforms to the principles and requirements of the Institute's guidelines for ethics in research.

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Signature Emme Patterson Date Aug 2007

Candidate

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ABBREVIATIONS

AEE	Activity energy expenditure
BMI	Body mass index
BMR	Basal metabolic rate
CASI	Computer-assisted self-interview
CI	Confidence interval
CSFII	Continuing Survey of Food Intakes of Individuals
CV	Coefficient of variation
CVD	Cardiovascular disease
DALY	Disability-adjusted life-years
DLW	Doubly-labelled water
ED	Energy density
EE	Energy expenditure
EI	Energy intake
EU	European Union
EYHS	European Youth Heart Study
FAO	Food and Agricultural Organisation
FBDG	Food-based dietary guidelines
FFQ	Food frequency questionnaire
HBSC	Health Behaviour in School-age Children
HELENA	Healthy Lifestyle in Europe by Nutrition in Adolescence
IMP	Integrated marketing practices
kg	kilogram
kJ	kilojoule
LDL	Low density lipoprotein
m	metre
MJ	megajoule
NCD	Non-communicable disease
NHANES	National Health and Nutrition Examinations
PAL	Physical activity level
PDA	Personal digital assistant
RDI	Recommended Dietary Intakes
SES	Socioeconomic status
SLV	Svenska Livsmedelsverket [Swedish National Food Administration]
SNR	Swedish nutritional recommendations
TEE	Total energy expenditure
WHO	World Health Organisation
YANA-C	Young Adolescents' Nutrition Assessment on Computer

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1 INTRODUCTION

1.1 DIET AND HEALTH

The importance of diet to public health has, in recent times, been given support from the highest level. The publication of the World Health Organisation (WHO) report Diet, Nutrition and the Prevention of Chronic Diseases (2003) was perhaps the most influential document on this subject to be published in many years. The small storm of controversy, notably the food industry's response to the inclusion of guidelines on sugar intakes, that followed the publication of the draft (Boseley, 2003) and the report itself (Dyer, 2004) was proof that the document had far-reaching consequences. At the same time, the explosion of obesity, and in particular childhood obesity, into the public consciousness has focused attention on diet and other lifestyle factors as never before. And so the drive to monitor and understand dietary intakes in populations continues. New studies are undertaken, new research questions addressed, new methods employed, new statistical techniques developed and new findings published, continuously. The difficulties in assessing, interpreting and influencing diets, however, are considerable, and evidence-based knowledge advances slowly.

Chronic non-communicable diseases (NCDs) such as cancer and cardiovascular disease have certain characteristics in common. Firstly, they begin and progress insidiously long before any clinical signs or symptoms manifest themselves. For example, in the case of cardiovascular disease much work has been done to show that the atherosclerotic process (that, when continued at an advanced rate, causes coronary heart disease) begins in childhood (Berenson *et al.*, 1998). Autopsy studies have revealed the presence of atherosclerosis in very young children and by age 15 fatty streaks are established in all (Oalmann *et al.*, 1997; Zieske *et al.*, 2002). Secondly, these diseases have known or likely associations with diet. Of the ten leading global disease burden risk factors identified by the WHO's World Health Report (2002b), five are strongly related to diet and physical activity: high blood pressure, high cholesterol, obesity, physical inactivity and low fruit and vegetable intakes. The risk of developing a chronic NCD is the result of a complex interaction between genetics, lifestyle (including smoking, physical activity, diet and alcohol consumption), and environmental influences. Cardiovascular disease (CVD) remains the largest cause of death in the European Union (EU), accounting for over 1.9 million deaths each year (42 % of total deaths), and cost the EU economy an estimated €169 billion in 2003 (Leal *et al.*, 2006). In Sweden, the percentage of deaths and DALYs (disability-adjusted life years) lost attributable to CVD in 2002 was 47 and 19 %, respectively[1] (WHO, 2002a). The so-called traditional risk factors of cardiovascular disease, such as high blood pressure, high LDL and total cholesterol, reduced insulin sensitivity, are quite frequently present already in children, tend to cluster together, and importantly, have been shown to "track" (*i.e.* remain consistently high or low relative to their peers) reasonably steadily over time (Berenson *et al.*, 1989; Andersen *et al.*, 2003; Molnar, 2004). This, combined with the fact that children's lifestyle behaviours become established in childhood and may stay with them for life, means that efforts to tackle chronic NCDs must take a life-course approach.

1.1.1 Children and adolescent diets and health

Children are not just "little adults". Their body composition and their needs for energy and nutrients are different. Despite this, their exact requirements have historically not always

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[1] Corresponding figures for Ireland in 2002 – Deaths from CVD: 39 %; DALYs lost due to CVD: 16 %

been given the attention they deserve. Only recently, for example, did the FAO revise the estimations of infant energy needs, adjusting downwards the requirements to take into account the slower growth rate of breastfed babies, from a norm that had originally been calculated based on formula-fed infants (FAO/WHO/UNU, 2004). The chronic NCDs that have long affected only adults – *e.g.* obesity, type II diabetes and the metabolic syndrome – are now being seen with alarming frequency in children and adolescents (Rosenbloom *et al.*, 1999; Lobstein & Frelut, 2003; Zimmet *et al.*, 2007). Cut-offs for classifying overweight and obesity suitable for use in paediatric populations, to enable international comparisons, similar to those that have been available for adults, have been published only relatively recently (Cole *et al.*, 2000). Criteria suitable for diagnosing the metabolic syndrome in children are now urgently needed (Molnar, 2004). Many other nutritional requirements, *e.g.* for vitamins, minerals and fibre have often been extrapolated from adult requirements, without, perhaps, due consideration for the special growth and development needs of children and adolescents.

Advertisers, meanwhile, have been very quick to see children as a distinct population subgroup. This market sector has some money of its own to spend, has large amounts of power over adults with even more money to spend, and will grow up to become some of these adult consumers (Story & French, 2004). In the United States, fully half of all television advertising aimed at children surveyed recently was for food, of which 34 % was for sweets or snacks, and none was for fruits and vegetables. Food marketing is clearly massively skewed towards processed, energy dense, nutrient poor foods (Gantz *et al.*, 2007). Sweden has banned direct marketing to children (under the age of 12) since 1991, and this broad legislation covers television, print media and the internet (Hawkes, 2004). However, as opponents of this regulation like to point out, this hasn't stopped Swedish children becoming more overweight and obese in the years that followed the introduction of the ban. Only advertising originating in Sweden is subject to regulation, *i.e.* Swedish press, terrestrial television channels and Swedish websites. Most Swedish homes receive television channels from abroad, and the global medium of the internet means much of what is online is not restricted. The creativity of marketers can be seen on the many interactive sites specifically designed to appeal to children, particularly "advergaming" sites (with free online computer games that feature products, *e.g.* Wrigley's www.candystand.com) and the presence of food companies on popular social-networking sites (Skittles® on www.bebo.com). As the spending of food marketers far exceeds the budget of government spending to promote healthy eating (contrast the $7.3 billion spent by US food advertisers with the $333 million spent by the US Department of Agriculture on nutrition in 1999 (Story & French, 2004), public health nutritionists face a tough challenge if they are to ensure the diets of children and adolescents are as healthy as possible.

At the same time as children are being targeted as young consumers, they are acquiring the critical skills needed to assimilate information and are (hopefully) learning about health and nutrition. They are forming habits, including dietary and physical activity habits, which will determine their health in childhood and in adulthood. Tracking, as previously mentioned, can be defined as the maintenance of a distribution position such as a quintile or a percentile (Wang & Wang, 2003) over time. Whether children's habits remain very stable relative to their peers in a study population, *i.e.* whether those with high intakes continue to have high intakes as they get older, is uncertain. The evidence from longitudinal studies is conflicting (Kelder *et al.*, 1994; Twisk *et al.*, 1997; Demory-Luce *et al.*, 2004; Mikkila *et al.*, 2005; Gallagher *et al.*, 2006). It may be that only certain behaviours (*e.g.* certain food preferences) track, or that only preferences at one particular stage of development predict intakes at an older age while perhaps no effect is seen in interceding years. It is clear that children learn many skills in childhood that stay with them for life, but whether this is true for food-related habits is a difficult question that can only be addressed with more high-quality longitudinal studies (Twisk, 2003; Wang & Wang, 2003). Nonetheless, it is important that children eat well throughout childhood and adolescence, both to reach full growth and developmental potential, and because the risk factors for diseases such as CVD are relevant at all ages.

Neither children nor adults, adolescents are a heterogeneous group as genetic and lifestyle influences interact to transform them from childhood to adulthood at varying rates. While girls are generally more sexually and intellectually mature than boys of a similar age, marked individual variation is seen. This means that for a given age group, both appetite and nutritional requirements will vary depending on the stage of growth. Adolescents often have more choice over when, where and what they eat than children do (Livingstone & Robson, 2000). For example, in Sweden, all school pupils are provided a free hot school lunch. At age 15, however, students can choose not to eat it, and to bring lunch with them or to leave the premises at lunch time, whereas 9-year-olds cannot. They also typically have more pocket money/earnings to spend and they consume more of their energy outside the home than before. In addition, more independence means that parents may not always be present at meals such as breakfast and dinner.

1.2 CORRELATES OF FOOD CHOICE

Food choice is affected by many things. Availability, composition, price and promotion: age, income, knowledge and attitudes; and well as cultural and social, including governmental, factors can all influence foods eaten (Patrick & Nicklas, 2005; Haerens *et al.*, 2007). The ultimate decision often comes down to personal preferences (Drewnowski, 1997). While adults may consciously override their food preferences in the interest of consuming what they think is a healthy diet, children are not always similarly constrained. An innate preference for sweet foods is evident already in newborns (Rosenstein & Oster, 1988), and work by Birch *et al.* (1999) has shown that children prefer sweet, familiar and energy dense foods. This behaviour probably has its roots in human evolutionary history, as sweet-tasting foods were unlikely to be poisonous foods, and sweetness was a sure sign of energy. In times when food supply was neither continuous nor plentiful, energy dense foods were advantageous choices. Interestingly, the preference for sugary and fatty foods frequently found in children and adolescents (Benton, 2004; Cooke & Wardle, 2005) has been suggested as a reason for children's often low consumption of fruits and vegetables. Gibson and Wardle (2003) plotted children's liking of fruits and vegetables and found a positive relationship between increasing energy density and preferences (Figure 1.1).

In addition to personal preferences, and knowledge about what healthy foods are, many other factors affect food choices. For example, although children often rate some fruits and vegetables highly (Cooke & Wardle, 2005), fruit consumption among children is quite often inadequate (Yngve *et al.*, 2005). Accessibility, convenience, availability, peer and family modelling also affect food choices. Parents influence the intakes of their children both directly by the food they buy and prepare, but also by the atmosphere they create around meals and foods, and by the eating behaviours they model (Benton, 2004).

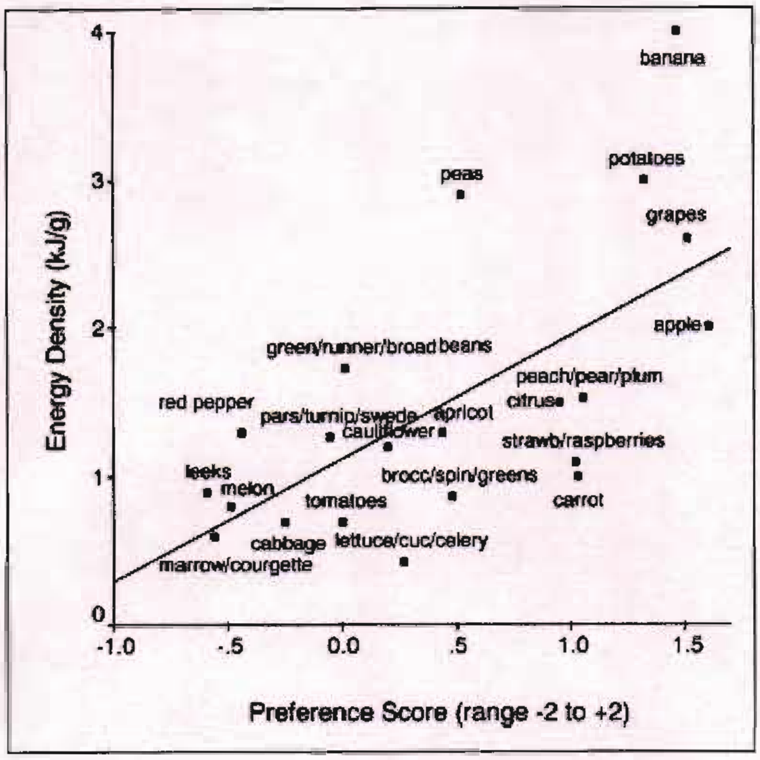

Figure 1.1 Energy density versus children's preference scores for fruit and vegetables. Children were aged 4 and 5 y (n = 644) and preference scores were averaged from the mothers' ratings of their children's preferences. Linear regression explained 42 % of the variance Pearson's r = 0.65. (Taken from Gibson and Wardle (2003))

1.2.1 Socioeconomic circumstances

Lower socioeconomic status (SES) has been associated with poorer health status in almost every industrialised country in which it has been studied (Mackenbach *et al.*, 1997; Adler & Ostrove, 1999). This relationship is not explained by an effect of outright poverty alone, as a gradient effect for both mortality and morbidity is seen all along the SES spectrum (Marmot *et al.*, 1984; Adler *et al.*, 1994). Not all diseases are associated with SES, but many of the chronic NCDs, with their large burden on public health, are, including hypertension, cardiovascular disease, diabetes, metabolic syndrome, arthritis and obesity (Adler & Ostrove, 1999). In addition, the well-established risk factors for these diseases such as smoking, poor diet and low physical activity have also been found to correlate with SES (Winkleby *et al.*, 1992). The direction of the association of SES and health could be in either direction, or even bi-directional. It can be due to social drift (where poor health results in lower SES over time), or social causation (where SES influences health), but the evidence seems to point towards the latter, especially for common, chronic non-communicable diseases (Mackenbach *et al.*, 1997; Adler & Ostrove, 1999). Although a relationship between SES and health has been shown in most developed nations, the nature of it varies between countries (Mackenbach *et al.*, 1997). Sweden, while being a well-recognised 'welfare state', is not immune to disparities in socioeconomic equality, and disadvantaged groups of society exist here as in all other developed nations, among adults and children (Halldórsson *et al.*, 2000; Bremberg, 2002). The reason that the burden of chronic diseases falls more heavily on lower socioeconomic groups is multi-factorial, and could be a result of lower education and lower income leading in turn to less knowledge about health, less access to healthcare information and resources, and less access to health-promoting 'capital', such as affordable good quality food, and exercise facilities. The exact mechanisms remain unknown (Winkleby *et al.*, 1992).

In children, it is hypothesised that high socioeconomic status affects childhood development and growth as parents can afford their children a better array of services, goods, parental actions, and social connections (Bradley & Corwyn, 2002). Effects of SES on health have been documented from birth to older childhood, including prenatal conditions, such as inadequate growth, prematurity; neonatal mortality; stunting and respiratory illnesses (Bradley & Corwyn, 2002). In Sweden, differences in mortality, some illnesses, injuries, mental health problems, and risk factors (*e.g.* not being breastfed, being overweight, smoking and skipping breakfast or lunch) have all been reported in children according to SES (Bremberg, 2002). In adolescents, it has been theorised that the effect of SES on health and health behaviours is weaker (West, 1997). However, in a large sample of US adolescents, SES was related to depression, obesity and self-perceived overall health

(Goodman, 1999), and a recent meta-analysis of health behaviours by Hanson and Chen (2007) found that, overall, that while the effects on marijuana and alcohol use were mixed, the socioeconomic gradient found in adult populations regarding poor diet, smoking and low physical activity were consistent in adolescents too.

Socioeconomic status is a complex concept, reflecting a person's standing in relation to others in a group and is often simplified for the purposes of epidemiological studies as a construct of one or a composite of the following factors: education, income and occupation. A child would therefore be assigned to the socioeconomic group of its family – which ideally means taking into account both parents' income and education and occupation. Not every child lives full-time with two parents, and parental education can be low, but income high, *etc.*, and the logistics of assessing socioeconomic status in an epidemiological setting becomes difficult. The choice of indicator for SES varies from study to study, with no clear consensus on the best method (Bradley & Corwyn, 2002). It is determined by the research question, by practical considerations regarding data collection, and by the population from whom the data are collected. Education has been proposed as suitable if time or resources force the use of just one. Information on education is available for all individuals regardless of employment status, it has high reliability and validity, is generally stable after early adulthood, and is easily reported (Liberatos *et al.*, 1988). The pathway by which parental education could affect child health is possibly through improved nutrition knowledge, healthier food choices, and better modeling of eating practices (Winkleby *et al.*, 1992). Studies have found high parental education to be associated with children's overall diet quality (Currie *et al.*, 2000; North & Emmett, 2000; Goodwin *et al.*, 2006), sugar intakes (Kranz & Siega-Riz, 2002), fat intakes (Crawford *et al.*, 1995) and overweight (Gnavi *et al.*, 2000; Klein-Platat *et al.*, 2003)

1.3 CURRENT DIETS OF CHILDREN AND ADOLESCENTS

Data on the nutritional intakes of children and adolescents across Europe is not comprehensive (Lambert *et al.*, 2004). Unlike the United States, where the NHANES and CSFII surveys have included subjects as young as two months old for many years (Rockett & Colditz, 1997), many countries in Europe do not routinely carry out nutritional surveys on their young populations. This makes it difficult to assess trends, to make meaningful comparisons between countries and to describe the nutritional status of children and adolescents from a European perspective. Some of the most suitable data for this purpose comes from the Health Behaviour in School-age Children (HBSC) survey - a large systematic surveillance survey that has been running since 1983/84 and is now conducted in 41 countries (www.hbsc.org). Large international epidemiological studies such as the European Youth Heart Study (EYHS) (Riddoch *et al.*, 2005), the ProChildren study (Brug *et al.*, 2005) and the HELENA (Moreno *et al.*, 2007) study are also valuable sources of information on these age groups.

1.3.1 Sweden

Nutritional surveys are not carried out on a regular basis in Sweden, in either adults or children. Only three national surveys to date have included children, the most recent of which was conducted in 2003 by Sveriges Livsmedelsverket (SLV, the National Food Adminstration) and published recently (SLV, 2006). Prior to this, most of the information available was from disparate studies that had been conducted in Sweden and other Nordic countries, with age groups and methodologies varying from study to study. Almost 2,500 children, 4, 8 and 11 y, were surveyed in the SLV study, and kept a 4-day (estimated) food diary. Intakes of sugar, saturated fat (providing 12-14 %, and 14 % of energy, respectively) and salt were found to be high and fibre, polyunsaturated fatty acids and fruit and vegetable intakes were low. Other studies also show that the fat and sugar intakes, as a percentage of energy, reported in Danish, Swedish and Finnish adolescents remains above the Nordic Nutrition Recommendation (Samuelson, 2000; SLV, 2006) levels of 30 % and 10 %, respectively (Nordic Council of Ministers, 2004). When the recent Swedish children's survey (SLV, 2006) is compared to previous SLV studies (Becker, 1994), the fat energy percentage appears to have decreased, and the carbohydrate energy percentage, including sucrose, increased.

A summary by Samuelson *et al.* (1996) of the available information on adolescents from studies conducted in the Nordic countries showed generally low fruit and vegetable intakes, moderate rates of breakfast skipping, and almost no micronutrient deficiencies. More recent data on fruit and vegetable intakes support those earlier findings. The 2001/02 HBSC survey results show Sweden close to the bottom of the international league table, with just 23 % of 13-year-olds, and 22 % of 15-year-olds reporting daily fruit consumption. Differences between boys and girls were small (Currie *et al.*, 2004). The recommended intake of fruits and vegetables[2] in Sweden is 500 g for children over the age of four (Table 1.1). The Swedish section of the European ProChildren study on fruit and vegetable consumption also found a low frequency of daily fruit consumption, and median fruit intakes of 100 g per day in both boys and girls, and median vegetable intakes of 75 g (Yngve *et al.*, 2005). Breakfast consumption on all school days was assessed in the most recent HBSC survey and was relatively high in Sweden in 11-year-olds, at 84 % (Currie *et al.*, 2004). This dropped to 70 % of 13 and 15-year-olds. As in all other countries,

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[2] Potatoes are not counted towards fruit and vegetable intake.

considerably more boys than girls reported breakfast on all school days at these older age groups.

Longitudinal trends in food balance data show a 15 % reduction in per capita supply of whole milk between 1975 and 1995 in Sweden, and a doubling in the share of low-fat products, although the decrease in supply of milk and butter was matched by an increase in supply of cream and cheese. The net result is that, according to Swedish food balance sheets, the percentage of total fat energy in the food supply has remained at roughly 37 %, and milk fat at 11 % in 1995 (Brege, 1997). Fat intakes in Finland and Northern Sweden were traditionally very high (approx. 40% of dietary energy) in the 1960s/70s, but this has reduced (Samuelson, 2000). Rates of overweight and obesity have historically been relatively low. However, studies in both Finland and Sweden suggest that BMI levels, particularly in young children are increasing in Sweden as in almost every other nation (Holmbäck *et al.*, 2007).

Table 1.1 Swedish food-based dietary guidelines (SLV, 2005)

Eat lots of fruit and vegetables, at least 500 g per day (approximately 3 pieces of fruit and 2 large servings of vegetables)
Choose products carrying the "Keyhole"* symbol
Eat fish often, preferably three times a week
Use soft margarines or oils on bread or when cooking
Eat bread, preferably wholegrain, with every meal

* Foods in a particular food group with better profiles of salt, fibre, sugar and fat content. See Appendix A.

1.4 ASSESSMENT OF DIETARY INTAKES

Any epidemiological study of the effects of diet and health in a population relies heavily on a) the accuracy of the dietary data that is collected, and b) the appropriate interpretation of that data. Diet is a notoriously complex exposure to quantify and assess (being in fact a multifaceted set of strongly inter-correlated continuous exposures) but, for various reasons, we remain forced to assess it with often rather blunt and inadequate tools (Kohlmeier, 1995), and an entire branch of epidemiology has evolved to deal specifically with the issues inherent in this field (Willett, 1987; Willett, 1998). It is also an exposure that is unique to every person and is the result of a lifetime of choices and influences – individual, environmental, social and cultural. To study someone's diet is to ask them about a deeply personal behaviour, and to require them to complete a demanding cognitive task in order to provide this information (Blundell, 2000). When the subjects are children and adolescents, the problem of measuring dietary intake faces further challenges (Rockett & Colditz, 1997). The cognitive skills of children are not as developed as adults' (Table 1.2), and the processes involved in completing a dietary recall are complex and demanding, involving long-term memory and abstract thought. Over-reporting, under-reporting and mis-reporting of foods have all been found in studies of children's recall abilities (Livingstone & Robson, 2000).

Methods of dietary assessment can be either prospective or retrospective, and grouped into three main categories: written/weighed food records, food-frequency questionnaires (FFQ), and diet history interviews (usual diet or 24-hour recall). Each method has its own advantages and disadvantages (Table 1.3), and the choice of method carries with it implications for data analysis and interpretation.

Table 1.2 Issues specific to the assessment of diets in children and adolescents

Children	Adolescents
Cognitive abilities	
Low literacy skills Limited attention span Limited concept of time Limited memory	Literacy, attention, memory, concept of time similar to adult level
Limited knowledge of food and food preparation	Extensive knowledge of foods, but maybe not of food preparation
Dietary habits	
Rapidly changing habits but (more) structured patterns	Rapidly changing habits, and more unstructured eating pattern
More meals eaten at home	More meals eaten away from home
Meals under supervision of parents	Meals not supervised
Parental influence important	Peer influence also important
Psychological	
Food satisfies hunger Certain foods as reward/treat	Food is a means of self-expression and independence

Adapted from Livingstone and Robson (2000)

In prospective measurements, a food diary (weighed or estimated) is usually used to record the participant's food intake for a number of days (typically 4 - 7) and they are generally considered suitable as an accurate measurement of habitual or usual intakes at individual level. This method places a high burden on the participants and can contribute to low participation rates, a bias towards highly motivated participants, and/or high attrition rates during a study. The subject's eating habits may be altered (consciously or unconsciously) so that they eat somewhat differently during the study period. This may be due to a desire to be able to record a favourable diet, or so that foods that are more complicated to record (*e.g.* mixed dishes) are avoided. The need for special equipment (diaries and/or weighing scales) and the labour intensive process of recording and analysing detailed dietary data makes this method unsuitable for large-scale studies. Food-record methods require motivated, literate and educated subjects. For child and adolescent populations it is therefore particularly unsuitable because of the demands on time, literacy and responsibility it places on them. Under-eating (where the subject eats less than they normally would) and/or under-reporting is a particularly common problem with this method (Livingstone *et al.*, 2004).

Table 1.3 A brief overview of dietary assessment methods

Method	Advantages	Disadvantages
Written record (*e.g.*7 day diary)	Detailed information provided (quantities, quality) Probably valid at individual level	High participant burden Risk of under-eating, or altered habits during recording period
Food Frequency Questionnaire (FFQ)	Reflects behaviour over long time period	Risk of over-reporting, if questionnaire is very long
	Can be tailored to foods or nutrients of interest	Time-consuming if detailed Relies on accurate recall of past behaviour
24-hour recall	Low participant burden Suitable for assessment of current, group intakes	May not reflect usual intake Relies on accurate recall Knowledge needed of amounts, brands consumed

Adapted from Patterson and Pietinen (2004)

The FFQ is a retrospective method that provides information about a participant's habitual intake over a past period of time (*e.g.* 6 months, one year). Unless a semi-quantitative FFQ is used, no information is obtained about amounts of foods eaten. This method assumes a certain stability of intakes over time, and also requires participants to aggregate a large amount of data, across months and seasons, and average this into an amount per day/week/month for the entire period. Because the questionnaires are not open-ended, they are often lengthy in order to cover all potential or study-specific foods of interest, which may lead to overestimation of intakes (Kaskoun *et al.*, 1994). This high burden can cause respondent fatigue and result in incomplete data (Kohlmeier, 1995). The advantage of this method is its ability to rank subjects relative to one another by their intakes. The particular cognitive demands of a FFQ make this method a poor choice for children, and possibly adolescents. In addition, as FFQs assume a certain dietary stability, this may be particularly problematic as child and adolescent diets are likely to change over time.

The 24-hour recall diet history is suitable for large studies because of several practical advantages: it is relatively cheap; does not require special materials (*e.g.* lengthy questionnaires or weighing apparatus); participants do not have to do anything other than be interviewed; participants do not need the high level of literacy skills required by other methods; it is quick and straightforward. The disadvantages are that either the interviewer or the participant must travel if the interview is conducted face-to-face (although telephone interviews are possible); the interview must be scheduled to be at a set time; unless one researcher performs all interviews, there may be an interviewer-effect. As it is a retrospective method, it relies on the subject's ability to recall accurately. The interviewer must also guide the subject through the recall in a way that elicits as much information as possible, without unduly 'leading' or influencing the participant. There is no clear rule as to when a child is old enough to complete an interview by him- or herself, and this may vary from population to population. As a guideline, older children (approximately above the age of 8) are considered to be able to provide adequate information about their food intake (Livingstone *et al.*, 2004). This interview can also be supported by supplemental information, for example, by an interview of a parent as well, or with a food record or direct (covert) observation of the child on the day before a 24-hour recall.

The biggest limitation of 24-hour recalls is that, at individual level, they are inaccurate as estimates of usual or habitual intakes. However, well-conducted recalls on large samples can provide adequate information on group level (Beaton *et al.*, 1979; Rockett & Colditz, 1997; Kubena, 2000).

1.4.1 Potential sources of error

At every step of the assessment process, error can be introduced, where error means not just "mistake" but a source of variance that reduces the reliability of the data (Beaton *et al.*, 1979). Dietary intakes "cannot be estimated without error and probably never will be" (Beaton, 1994). Two broad categories of error exist that have implications for epidemiological studies: systematic error (bias) and random error. If a source of error is random, then some subjects are likely to be affected in one way and some in another, so that the effect is cancelled out across the sample. In other words, variability is added to the data, but the true mean of the population is unchanged, and so the overall effect will be to reduce the strength of any associations found between this independent variable and any outcome variable. The day-to-day within-person fluctuation of dietary intake is such an example. Large day-to-day variation exists in dietary intake, and is without an obvious pattern (Willett, 1998). This tends to be higher for micronutrients than for energy and macronutrients. This is logical, as macronutrients (hence energy) are present in almost all foods, and will be consumed every day, but micronutrients are more likely to be concentrated in certain foods that may not be consumed daily. It is this variation that makes single 24-hour recall data unsuitable for estimating individual intakes with confidence. When the within-person variance is greater than the between-person variance, then differences in intakes may not reflect true differences between subjects, hence it will tend to mask relationships with dependent variables (Beaton *et al.*, 1979; Beaton, 1994). It is also unsuitable for accurately classifying the proportion of a population which is above or below a particular cut-off point (*e.g.* a recommended daily intake) and will lead erroneously to large numbers of "inadequate" intakes being reported (Beaton *et al.*, 1979).

If an error is not random, then it is systematic, and if this is differential, it has implications for data analysis. An example of systematic bias is a recurring error in the nutrient composition data of food databases, which will affect all subjects similarly (by inflating or decreasing intakes of a particular nutrient across the population). Another is under-reporting of energy intakes. As this often occurs more among overweight subjects than among normal weight (see Section 1.4.2.1), it does not affect all subjects equally. Systematic error can affect the *strength* of a relationship between variables, but may not affect seriously the question of *whether* there is a relationship (Beaton, 1994).

In retrospective assessments, subjects may have genuine difficulty recalling their diet in detail, due to the long period of interest (*e.g.* weeks or months in the case of FFQ), failure to understand what is being asked of them, lack of motivation, or because they do not pay attention to certain aspects of their diet that may be of interest to the researcher (*e.g.* the fat content of milk, fibre content of bread). Children are generally not in control of the types or brands of the foods bought at the household level, or the cooking methods used, and therefore may not be able to provide the level of detail required of them. The interviewer may bias the information given by the use of leading questions or inappropriate prompts. If foods are accurately recalled, precise portion sizes must also be remembered and estimated.

At the data entering stage, errors may be introduced if assumptions need to be made, for example, if the data recorded is ambiguous or clearly contains a mistake. The data collected must then be used appropriately. Failure to appreciate the limitations of the methods, the nature of the variable studied and/or the use of inappropriate statistics can produce spurious and misleading results. One specific issue that deserves attention is the under-reporting of energy intake, which is a frequent problem in dietary surveys, regardless of method or population group (see Section 1.4.2.1).

1.4.2 Overcoming the methodological issues

As a discipline, the assessment of dietary intakes is quite new, and the first International Conference on Dietary Assessment Methods was not held until 1992. The research gaps and issues identified then are still relevant today, including the need for improved understanding of the cognitive and communication processes involved in assessing diet intake; improved approaches to identifying and minimising sources of error in assessment; improved statistical modelling; dealing with under-reporting; and improving food-composition databases (Buzzard & Sievert, 1994).

The awareness of the concept of the "usual" diet as being the real variable of interest in nutritional epidemiology when studying chronic NCDs, along with the realisation of the shortcomings in dietary assessment, led to many studies in recent decades quantifying the inter-individual variance and other measurement errors. As it is accepted that dietary assessment will never be without error, it is necessary to realise that it is not necessarily the errors that are hindering nutritional epidemiology, but the "failure to appreciate the nature of these errors" (Beaton, 1994).

While no dietary assessment tool will ever be perfect, there remains room for some improvement of existing methods. The increasing variety and availability of powerful and portable technology has the potential to refine certain aspects of assessment. It is perhaps indicative of the rate at which technology is advancing that, as recently as 1995, Kohlmeier, considering the future of dietary assessment, was only able to speculate that "perhaps" new computer-assisted self-interviewing (CASI) methods could be sent to subjects "over the 'information highway' using the television [*sic*] connection" (Kohlmeier, 1995). The HELENA (Healthy Lifestyle in Europe by Nutrition in Adolescence) study (Moreno *et al.*, 2007), a large multi-centre EU–funded project has developed and piloted a CASI programme for recording intakes in young people. The YANA-C software (Young Adolescents' Nutrition Assessment on Computer) enables subjects to complete a 24-hour dietary recall on a computer as they are guided through the day by the programme. Subjects can choose from pictures of a wide range of portion sizes, and the programme can prompt for certain foods (*e.g.* for spreads, if bread is reported). This type of CASI has the potential to be both cost-effective and timesaving, as it can be administered in a standardised way, simultaneously to large numbers, and removes the need for interviewers and for data entry (Kohlmeier, 1995). Country-specific versions have been developed in relevant languages and with culturally appropriate foods. It has been validated in Belgian adolescents (Vereecken *et al.*, 2005) and is undergoing testing in other countries. The YANA-C is not the first such CASI method, but it has been developed with a specific population group in mind (adolescents) and will enable comparison of results across countries.

The availability of portable devices such as Personal Digital Assistants (PDAs) could also facilitate dietary recording, making it easier for the (computer-literate) subject and eliminating the time-consuming data-entry stage. Camera-equipped mobile phones, popular and increasingly common particularly among young people could be used in conjunction with a dietary recall, by serving as a prompt if photographs are taken of foods consumed on the day prior to the recall, and allowing the researcher to help in estimating portion sizes. Few reports of these technologies in use have been published, although the use of a camera during one food diary completion increased the energy intake by more than 8 %, and fat by 11 %, when foods omitted from the diary, but photographed, were subsequently included (de Castro, 1997). As children and adolescents are usually quick to embrace new technology, more hi-tech options for assessing diet may be particularly suitable for use in this age group.

However, the fundamental flaws inherent in dietary assessment are unlikely to be corrected using the foreseeable developments in measurement methods. Therefore the solution is to improve the handling, interpretation and application of the data currently gathered. At a minimum, practical steps must be taken when performing a study to ensure data integrity. A clear, standardised protocol is essential for multi-centre studies, as is good training of all interviewers. Data entry of interviews by the researchers who conducted them can also minimise transcription errors. A pilot study can identify potential problems before data collection begins, and can improve the quality of the data subsequently collected. Where possible, a validation study should also be performed using a gold-standard measurement, such as using doubly-labelled water to validate energy intakes, or energy expenditure. Ideally, if just one measurement of diet is obtained for each subject, a repeat measurement should be performed in a subsample so that reliability can be tested, and an estimate of variance specific to the study population for the nutrients/foods under study can be calculated.

Beaton (1994) argues that careful development of a hypothesis can ensure that the data is treated appropriately and result in more intelligent use of 24-hour recall data. If the objective is to describe the group mean with a 24-hour recall, then either increasing the number of days of intake or the number of subjects will improve the quality of the data (Beaton *et al.*, 1979). It may reduce the effect of random variation, but evidence exists that repeated 24-hour recalls may not address the issue of systemic bias – people who mis-report on one day are likely to do so on subsequent occasions, even if a different method of assessment is used (Black & Cole, 2001). As mentioned above, the presence of systematic error may still permit detection of a relationship, if not the true strength of this relationship. Grouping data by intervals of the dependent (usually biological) variable (*e.g.* blood pressure, or insulin), which are less likely to have such within-person variation, instead of by dietary intake may reduce the risk of misclassification and hence increase the probability of detecting a true relationship (Beaton *et al.*, 1979; Beaton, 1994).

In summary, Kubena (2000) cautions that nutritional epidemiologists may have been overly optimistic about the quality of the data they were able to collect for a long time, and Beaton concluded in his paper presented at the 1st International Conference on Dietary Assessment Methods that relatively less progress has been made in addressing the dietary assessment issues at the individual level than at the group level (Beaton, 1994). Further validation studies are required to deal with the statistical implications of the error structures of various data sets, and means to overcome them are needed (Beaton *et al.*, 1997). Perhaps just as importantly, there is a need for a deeper understanding of the enigma that is the psychological and behavioural processes that affect people's abilities and willingness to frankly and accurately disclose what they eat (Blundell, 2000).

1.4.2.1 Energy under-reporting

Over-, under- and mis-reporting have all been identified in dietary surveys (Macdiarmid & Blundell, 1998), but the most common problem is energy under-reporting (Black, 2000b; Blundell, 2000; Livingstone & Black, 2003). This is a poorly understood reality of dietary surveys, and a serious challenge to nutritional epidemiology (Blundell, 2000). The issue of under-reporting distorts the real picture of intakes and can confound true associations between dietary exposures and disease (*e.g.* the phenomenon of increased obesity in the face of apparent low energy intakes), and can hamper the development of public health policies and dietary guidelines (Becker, 1999; Becker & Welten, 2001). In essence, under-reporting is due to either deliberate under-eating during a study period, deliberate failure to disclose or report intakes, or genuine error in recalling foods. The estimates of under-reporting in dietary surveys ranges from 18 – 54 % (Macdiarmid & Blundell, 1998), and occurs in all ages and genders, but more frequently in females and overweight subjects (Macdiarmid & Blundell, 1998; Livingstone & Black, 2003).

The identification of energy under-reporting in dietary studies is based on the rationale that if a person's reported intake is significantly less than their energy requirements (either estimated or measured), then the intake is not likely to be plausible. The within person variation described previously (Section 1.4.1) means that this is more difficult to identify when the studied period of time is brief, as one or two days intake may differ considerably from the long-term mean intake – *i.e.* while the reported intake may be *atypical* of usual intake, this is not the same thing as being *inaccurate*. The identification of under-reporters of short-term dietary records is therefore particularly problematic.

When body weight is constant, energy intake (EI) matches total energy expenditure (TEE). Basal metabolic rate (BMR) is the largest componant of total daily energy expenditure (TEE), with the remainder accounted for by diet induced thermogenesis (DIT) and activity energy expenditure (AEE). TEE can therefore be expressed as BMR multiplied by a factor for AEE, known as a physical activity level (PAL) value:

$$\text{TEE} = \text{BMR} \times \text{PAL}$$

Substituting EI for TEE (as these should be equal if a subject is in energy equilibrium) gives:

$$\text{EI} = (\text{BMR} \times \text{PAL})$$

Stated another way, the reported energy intake (EI_{rep}) expressed over estimated basal requirements (BMR_{est}) should be equal to the subject's PAL. Subjects whose energy intake falls below a stated PAL threshold could be considered an under-reporter.

This approach led to the development of a formula by Goldberg *et al.* (1991) to calculate an upper and lower cut-off value (95 % CI) of the expected agreement between mean EI_{rep} to BMR_{est}, based on the population being studied, variation in BMR and PAL, number of days of dietary data available and variation in energy intakes. Determining an appropriate PAL value is difficult, especially in children and adolescents, where less work has been done to establish these figures. Where available, it has been proposed that population-specific cut-offs are used, ideally classifying subjects into low-, medium- and high-physical activity subgroups and using relevant PAL values (Black, 2000a).

1.4.3 Analysis of dietary data

Ideally, a dietary assessment method should be chosen with a specific research question in mind. However, this is not always possible, especially in large studies that are ongoing and evolving, and where new research questions may arise. But once data is collected, several analysis strategies are possible, some of which are described below.

1.4.3.1 Distributional analysis

This can be used to compare intakes to reference amounts, for example to Recommended Dietary Intakes (RDIs) at individual level. The proportion of the population meeting the RDIs can thus be calculated, but accurate measures of usual individual intakes are necessary if this is to be meaningful. Group means can however be compared to population nutrition recommendations. Most countries and regions set nutritional population goals. Sweden devises its nutritional guidelines (see Table 4.2) in co-operation with the Nordic Nutrition Council (Nordic Council of Ministers, 2004), for example, who in turn take their lead largely from the regional guidelines set by the WHO (2003). In addition to nutritional guidelines, many countries also devise food based dietary guidelines (FBDGs). FBDGs should be based on prevailing public health issues (Figure 1.2), not just discrepancies between intakes and recommendations (FAO/WHO, 1998). They are a translation of a response to a public health nutrition issue into advice to eat more or less of certain foods, making them achievable for the general populace (Figure 1.2). It is important that these are set a country/population level, as they should be developed within an appropriate cultural context (*i.e.*, relevant to the population and its particular habits that they are intended for) (Gibney, 1999b; Gibney, 1999a; Matthys *et al.*, 2006). Sweden's FBDGs are shown in Table 1.1. For these to be developed, information about public health nutrition issues, consumption patterns in the population, and food sources of nutrients, among other factors, are required (Figure 1.2).

1.4.3.2 Consumers

The proportion of a population consuming a particular food group is a measure of how commonly that food group is eaten. Thus, when several food groups are examined, the staple food groups of a diet can be seen. While the amount of food eaten will often vary by age and gender, this could be a product of size and requirements. The prevalence of food group consumption, however, is not dependent on these, and so reflects preference and/or habits. Looking at consumption patterns is one way of looking at behavioural differences between ages and genders. In addition, information about the consumption patterns is necessary when interpreting absolute intakes, particularly at group level. For example, if a group mean intake is low, but the proportion of consumers is also low, this suggests that only some people are eating the food, but those that are may be eating significant amounts.

1.4.3.3 Dietary sources of nutrient intakes

In addition to information on consumers of food groups, another crucial piece of information is how those foods contribute to overall intakes. If particular nutrients are of concern in the diet, it is necessary to know what food groups are the biggest sources in the typical diet. Foods that are rich in the source nutrient may not necessarily be providing the most to the diet, if a food with less of that nutrient is consumed more frequently or more widely. With knowledge about both consumers and sources it is possible to begin to develop potential approaches to implement in altering food intakes in a real population (Gibney, 1999b; Gibney, 1999a; Matthys *et al.*, 2006).

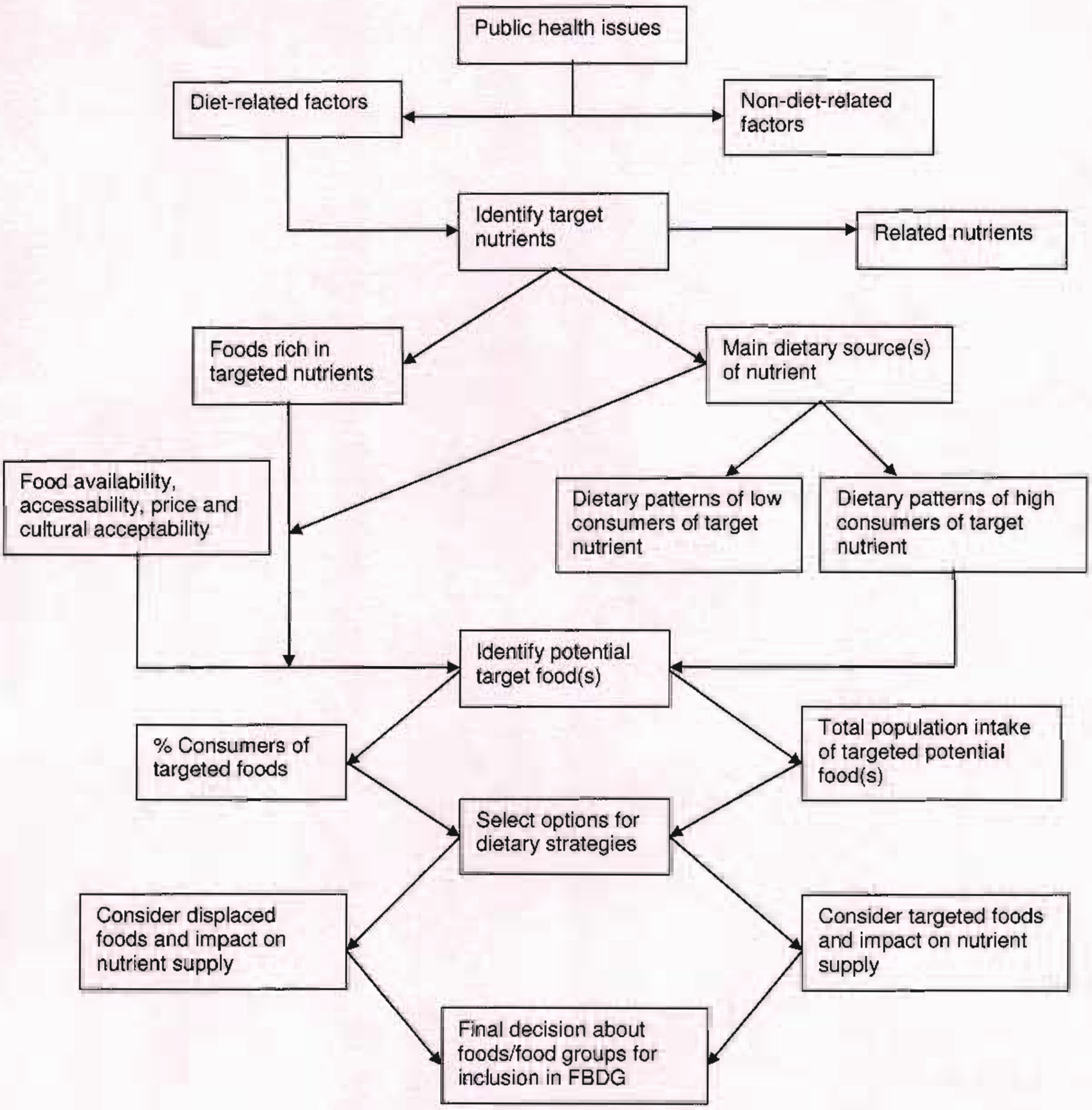

Figure 1.2 Steps in the formulation of FBDGs (Taken from FAO/WHO, 1998)

1.4.3.4 Dietary pattern analysis

FBDGs reflect the fact that people eat foods, not nutrients, and also the fact that foods are not consumed in isolation, but together in an overall dietary pattern. The concept of dietary patterns, and the attention received by certain characteristic diets (*e.g.* the "Mediterranean" diet (Willett, 2006)), has been the focus of a more recent development in nutritional epidemiology – to identify distinct patterns of foods intakes within populations (Michels & Schulze, 2005). This approach utilises statistical models to analyse the diet as a whole, rather than focusing on nutrients or foods. Such methods can be knowledge driven (based on *a priori* assumptions about diets and health) or data driven. Examples of the former include the use of scores or indexes, where a point is assigned to an individual diet that meets certain pre-determined criteria, such as nutritional (*e.g.* less than 10 % of energy from saturated fat, 35 g of fibre *etc.*) and/or food-based (*e.g.* 400 g fruits and vegetables, 3 servings of dairy products *etc.*) guidelines. The Healthy Eating Index and the Nutrient Density Scores are examples of some currently used methods (Kennedy *et al.*, 1995; Drewnowski, 2005; McCullough & Willett, 2006).

Data driven methods are more complex and use clustering or factoring statistics to identify *clusters* of people within a population with similar diets, or diets with common *factors* within the population (Newby & Tucker, 2004; Schulze & Hoffmann, 2006). As they are based on data from a specific study, they are unique to that dataset, and may not be relevant for other populations, leading to difficulties in with comparing results across studies. They also require many subjective decisions to be taken by the researcher when deciding on numbers of clusters/factors and in interpreting and describing the results. At the 6th International Conference on Dietary Assessment Methods in 2006, a specific day-long workshop was devoted to this topic. The occasional heated debate ensued between the proponents of these new methods, who argued that it is more intuitive to take a more holistic approach, and those who failed to see that these more challenging models would add anything more to the field than the current approaches yield. The topic is still a new and emerging one, and whether the new approaches are more accurate, more informative or more reliable remains to be seen. Without co-ordination of the area, there is a risk that too many researchers will develop methods to suit their own purposes (especially with the knowledge driven methods (Maynard *et al.*, 2005), and the lack of comparability across studies is an issue for data-driven methods that needs to be addressed (Newby & Tucker, 2004).

1.5 MARKERS OF DIETARY QUALITY

While not as statistically advanced as dietary pattern analysis, using markers of dietary quality is another way to look at the overall diet. Certain features or behaviours, which appear to be just one small aspect, can be informative about the diet as a whole. Breakfast habits and energy density and are two such proposed markers.

1.5.1 Breakfast

Breakfast is widely held, by both lay people and health professionals, to be "the most important meal of the day". It is well established that breakfast consumption contributes positively to nutritional status and overall dietary intakes (Nicklas *et al.*, 2004; Rampersaud *et al.*, 2005; Matthys *et al.*, 2007). In addition, in children and adolescents, good breakfast habits have been proposed to be associated with improved cognition and better academic performance in school (Pollitt & Mathews, 1998; Taras, 2005) and possibly also with healthy weight status (Moreno & Rodriguez, 2007).

The practice among children of skipping breakfast is common in many countries, both in Europe and in the USA (Rampersaud *et al.*, 2005), and appears to have increased in recent decades (Siega-Riz *et al.*, 1998). Data from the most recent published HBSC study (Currie *et* *al.*, 2004) shows a decreasing proportion of subjects reporting eating breakfast every school day with increasing age, and a tendency for girls to skip breakfast more than boys. An association between socioeconomic status and breakfast habits has been observed, with those from lower socioeconomic backgrounds reporting poorer habits in many countries (Höglund *et al.*, 1998; O'Dea & Caputi, 2001; Molcho *et al.*, 2007; Moore *et al.*, 2007).

Poor breakfast habits have also been associated with clustering of other unhealthy lifestyle behaviours such as smoking, and low physical activity (Höglund *et al.*, 1998; Keski-Rahkonen *et al.*, 2003; Sjöberg *et al.*, 2003) and risky dieting behaviour (Zullig *et al.*, 2006).

1.5.2 Energy density

The term "obesogenic environment" (Swinburn & Egger, 2004) has been proposed to describe the situation where energy is abundantly available and often over-consumed and under-expended. There is evidence to suggest that young children can self-regulate their energy intake (Fox *et al.*, 2006), at least in the short term (Zandstra *et al.*, 2000), but these defences are often over-whelmed (Stubbs & Whybrow, 2004). It is hypothesised that the lower satiating properties of energy dense foods may lead to passive-over consumption, but this remains an area of controversy (Westerterp-Plantenga, 2004). The idea that a healthy diet is "nutritionally dense" is somewhat intuitive – the provision of the most nutrients for the least amount of kilocalories. Conversely, energy dense diets provide an excess of energy in relation to nutrients. Thus the concept of energy density has been investigated as a potentially useful marker of dietary quality (Ledikwe *et al.*, 2006). The WHO, the American Diabetes Association, the North American Association for the Study of Obesity and the American Society for Clinical Nutrition are some of the notable public health bodies that have recommended diets with low energy density as appropriate weight management and diabetes prevention strategies (Klein *et al.*, 2004).

Terms such as "nutrient dilute" foods and "empty calories" to describe "junk" foods are all based on this concept of energy density. It is defined as energy per unit weight, *i.e.* kJ per gram. Water therefore has an energy density of zero kJ/g, while fat has an energy density of 37 kJ/g. Thus, foods high in fat content (and/or low in water) will have a high energy density, while foods with high water content, including fruits and vegetables will have low energy densities. The calculation of energy density itself is an area of some debate. Working out the energy density of a food is straightforward, but assigning an energy density to a diet is more complex. Although energy density has received attention in recent years, the definition of *dietary* energy density is not yet clearly established. Which foods and beverages should be included when calculating it? Beverages have low energy densities and require special consideration in the calculation of energy density, particularly as they have been shown to have large intra-individual variation, and are sharply affected by daily activity and temperature levels. The effect of excluding beverages from the calculation has been investigated by Cox and Mela (2000), and five years later, by Ledikwe *et al.* (2005). Both papers agreed on the need for careful consideration of the foods and beverages to be used, for detailed methodologies to be provided, and for the use of a "foods only" as an absolute minimum, a method that has been used in subsequent studies (Kant & Graubard, 2005; Mendoza *et al.*, 2007).

Despite this uncertainty, energy density remains a potentially useful concept as a marker of diet quality.

2 AIMS

Given the importance of child and adolescent diets to their current and future health, the aim of this work was to describe the diets of Swedish children and adolescents, with due consideration given to the methodological issues raised in Section 1.4.

The subjects were participants of a large cross-sectional and longitudinal study into cardiovascular disease risk factors in children and adolescents in Europe – the European Youth Heart Study (EYHS).

Specifically, the aims were:

- to compare the diets of Swedish children and adolescents to population goals;
- to identify the main food sources of macronutrients in the diets of these subjects;
- to identify differences in food group consumption between children and adolescents, and between boys and girls;
- to explore the use of energy density as a marker of dietary quality;
- to test if diet quality markers (*i.e.* breakfast consumption and energy density) differed across socioeconomic groups;
- to identify the practice of under-reporting in this population.

3 METHODS

3.1 STUDY DESIGN AND SAMPLING

The European Youth Heart Study (EYHS) is a multi-centre, international study examining cardiovascular disease risk factor prevalence and development in children and adolescents in 5 countries (Riddoch *et al.*, 2005). The project has both cross-sectional and longitudinal components.

The first cross-sectional data were collected during the academic year 1998-1999. The study used a two-stage cluster sampling procedure, representative of the source population, with the aim of recruiting more than 1,000 participants. Schools (*n* = 37) from Stockholm and a smaller town, Örebro, were randomly chosen (see Appendix B). From those schools, a class of an appropriate size (*i.e.* with more than 20 pupils) randomly chosen. Pupils (*n* = 2,313) were enlisted from two school grades; grade 3 (mean age 9.5 y) and grade 9 (mean age 15.6 y) (Figure 3.1). A lower than expected response rate of 49 % prompted an analysis of the non-participants. This showed a slight bias towards under-representation of more disadvantaged groups as defined by parental education and occupation (Wennlöf *et al.*, 2003). Despite this, the selection bias was deemed to be small, and the results externally valid. Ethical permission was granted by the ethical committees at Huddinge University Hospital, Stockholm and Örebro University Hospital. Written information was provided to the parents and children and written permission was obtained from the parents of the 9-year-olds and from the 15-year-olds themselves.

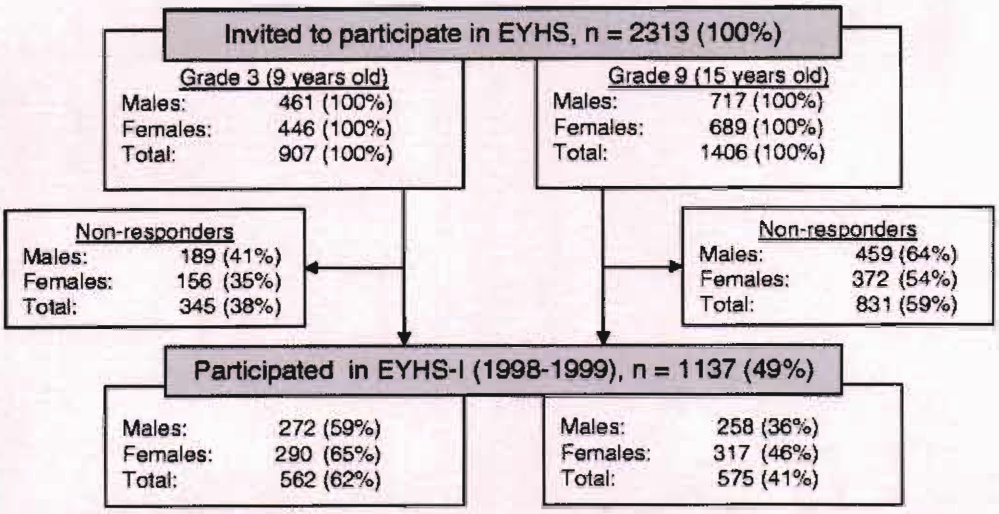

Figure 3.1 Participation rates in EYHS (Adapted from (Grjibovski *et al.*, 2006))

3.2 DATA COLLECTION

Data collection took place on-site at each school, and was spread throughout the school year in order to minimise the potential effect of seasonal variation on dietary intake or physical activity patterns.

3.2.1 Dietary data collection

Data on food intake was collected using an interviewer-mediated, 24-hour recall. All interviewers were trained according to a standardised protocol and followed the same procedure. The subjects were interviewed in the morning, and asked to recall what they had eaten and drunk from midnight to midnight the previous day. To assist with portion size estimation, a food atlas with photographs of commonly eaten foods was used, along with samples of common glass, bowl and plate sizes (see Appendix C). The interviewer who recorded the data also entered the data into the computer, to avoid misinterpretation of the written record by another researcher. Amounts of each food were pre-determined for all possible serving sizes, so the risk of different interpretations of food portion quantities by different interviewers was eliminated.

A written food record kept by the parents of the 9-year-olds served as a prompt for the interviewer after the 24-hour recall, to check for obvious omissions or errors in the data reported. If something appeared to be missing from the 24-hour recall, the child could be prompted for it. If, after this, it was not reported, it was not included in the recall. The written transcripts of the 24-hour recalls are kept for archiving on site at the Unit for Preventive Nutrition, Karolinska Institutet, and were consulted when necessary during data cleaning.

3.2.2 Data collection of non-dietary variables

Many lifestyle and physiological factors were investigated in EYHS. Information on diet, physical activity, physical fitness, anthropometry, blood pressure, and blood biochemistry was collected. In addition, questionnaires completed by both the subjects and a parent provided valuable background information on health and health markers, sociodemographic information and on attitudes, opinions and behaviour. Some genetic analysis has also been performed to date.

Physical activity was objectively measured using an accelerometer (ActiGraph LLC, Florida). This device detects movement (or 'counts') in a vertical plane and measures both intensity and frequency of activity. A filter removes background movement so that only intentional physical movement is recorded. The accelerometer is worn as close to the centre of gravity as possible (*i.e.* at the lower back), on an elasticated belt. The instrument cannot be worn in water, and was not worn during sleep. Apart from its unsuitability for measuring water-activities, the accelerometer will also not record accurate data on cycling, stair climbing or carrying heavy loads because, despite the increased physical effort required, little or no extra movement in the vertical plane occurs. Data is recorded at regular time intervals (epochs) and uploaded to a computer when the registration period is completed. The epoch used in this study was 60 seconds. The total number of counts recorded (calculated by the accompanying ActiGraph software) is then divided over the total time of registration to give an average value of counts per minute for the study period.

Anthropometric measurements were taken by a researcher of the same sex as the subject, when possible. Height was measured using a portable Harpenden stadiometer, while the subject stood without their shoes, and was recorded to the nearest cm. Weight was measured with a calibrated electronic scales, and recorded to the nearest 0.1 kg.

3.3 DATA MANAGEMENT

After collection, all data, with the exception of the dietary data, were entered into a database in Microsoft Office Access (2003). Dietary data was entered into the diet analysis software StorMats (version 4.02; Rudans Lättdata, Västerås, Sweden) and analysed using the Swedish National Food Database, version 99.1 (www.slv.se). The nutritional output from the dietary analysis was, together with the raw dietary intake data, imported into the Access database. A table within the database was created for each of the major aspects of the data (anthropometry, blood data, diet, fitness, physical activity, parental questionnaires, subject questionnaires *etc.*). The database was then locked, to prevent unauthorised access or unintentional modification. Only a few people have unrestricted access to the data. The data is de-identified, meaning that no person can be identified from the data that is held on them in the database. However, a file does exist that connects each person's personal number (the unique number assigned to every Swedish resident, based on birth date and gender) with the ID code used in this study. For security, and to comply with ethical guidelines, this file is kept in a separate location to the database, and access is restricted.

Because a second wave of data collection was planned between January and April 2005, the full database was not converted to a master file until this was completed. To merge the tables from the EYHS I database together, each table (anthropometry, dietary intake, *etc.*) from the database was first imported into SPSS, and merged together using the primary identification code unique to every subject. The EYHS I master file was thus created. All the steps in this process were carefully documented. For the present study, only data from the first wave of data collection (EYHS I) is analysed.

All requests by researchers for data from this file are handled by the person responsible for the database (EP). Copies of the master file are made before data is selected for use by anyone. The data is mainly in its raw form, but some basic treatment, for example the calculation of the anthropometric means from the two or three raw measurements taken, has been performed and is included in the master file. The instructions for these are documented in an SPSS syntax document and are available for consultation, and double-checking is recommended before the computed variables are used by a new user. Any new syntax created for common use by the group is saved, together with a detailed description, in a "syntax library", that is available for reference by future researchers.

3.4 TREATMENT OF THE DIETARY DATA

3.4.1 Food groups

As described previously, the dietary data was analysed for macro- and micro-nutrient content according to the Swedish National Food Database. Every food in the database contained a food description, a food code, and belonged to a main food group and a subgroup. Originally, 37 main groups were listed (Appendix D).

On consideration of these pre-determined groups, it was felt that these would not be adequate to answer several of the preliminary research questions. The groups included both very broad groups – *milk and yoghurt* of all fat contents was one group, all *meat and poultry* was another – and very narrow groups – such as *root vegetables*, and *porridge*. The subgroups within each main group were not always similar, for example *vegetable dishes with meat* and *fresh vegetables* in the *vegetable* group (see Appendix D).

Foods were therefore reassigned to new food groups. This established familiarity with the dietary data, was a way of checking for any abnormalities, and ensured that the food groups were planned in a way that would facilitate subsequent analysis. Firstly, new food groups were conceptualised based initially on the original food groups. One issue with the original groups was that no distinction had been made in quantitatively and qualitatively important foods *e.g.* – between high and low fat dairy products, and between high and low fibre breads. The assignment of a cut-point at which to differentiate high- and low- versions was subjective, and so the proposed values were discussed with other nutritionists in the research group before proceeding (Table 3.1).

Table 3.1 Criteria used to assign foods to new food subgroups

Spreads:	High fat: > 40 % fat	Low fat: ≤ 40 % fat
Cheese:	High fat; ≥ 20 % fat	Low fat: < 20 % fat
Milk and yoghurt:	Full fat: ≥ 2 %	Reduced fat: < 2 %
Bread:	High fibre: ≥ 7 % fibre <u>or</u> wholemeal	Low fibre: < 7 % fibre
Sauces:	High fat: regular, creamy sauces	Low fat: low/reduced fat versions
Beverages:	Regular: soft/fruit drinks	Light: containing sweetener

Some food groups were therefore subdivided (*bread* into *high fibre bread* and *low fibre bread*). Each food was considered individually – translated from Swedish to English, its fat or fibre content estimated where necessary, and its primary ingredient or food determined - and assigned to the appropriate new food group. Special consideration was given to mixed dishes *e.g.* chilli con carne. Where foods could not be placed satisfactorily into an appropriate food group, they were classed as miscellaneous. Only a small number of foods were unclassifiable. Certain foods did not have a food code, or belong to an original food group, but these were assigned to new groups.

In the end, 57 new food subgroups were created. Although some of the new subgroups are quite specific, *e.g. coffee and tea*, or *sausages*, these groups can be re-aggregated when necessary (see Appendix D),

e.g. if the variable of interest is meat, then:

meat = *offal* + *sausage* + *red meat* + *burgers* + *meat dishes;*

and if fatty meats are of interest, then:

high-fat meats = *sausage* + *burgers.*

The 57 food subgroups identified were eventually re-aggregated to 23 food groups, and 20 of these were then used in subsequent analyses (*light beverages, alcoholic beverages* and the *miscellaneous* group were excluded). In addition, seven of the subgroups were also analysed: *full fat milk and yoghurt, high fat cheese, full fat spreads, high fibre bread, full fat sauces, sweetened cereal* and *burgers and sausages* (Appendix D).

A piece of syntax (code) was written to copy the amount of a food eaten (in grams) to the relevant new food group. In this way, the total amount of food eaten per day per person was split into the respective food groups. Similarly, the amount of macronutrients consumed was split into the relevant contributing food groups (Table 3.2).

3.4.2 Data aggregated to individual level

At this stage, the dietary file consisted of one line of code for every food or drink eaten at every meal occasion. To get information for each subject at a daily level, the information at food level was aggregated. The resulting file contained, on each line, a subject ID, the total amount of food and drink consumed on the recall day, the macro- and micro-nutrient intake (from the dietary analysis), and the amount eaten in each of the new food groups (from the previous step) (Table 3.2). Information on age, gender, socioeconomic status, height, weight and activity was then merged with this data file.

Table 3.2 Sample line of data for one subject (selected nutrients, food groups and nutrients from food groups shown only)

Subject ID	Amount (g)	Energy (MJ)	Fat (g)	High fibre bread (g)	Fat from high fibre bread (g)	...
10200001	2550	8.94	76.2	25	0.3	...

3.4.3 Data cleaning

The data was first visually inspected for errors. Occasional transcription errors were noticed, rectified and documented (*e.g.* 10,000 g water corrected to 1,000 g). Some foods reported were not found in the database and either had to be assigned the values of the nearest food or the nutritional values had to be entered manually from the manufacturer's information.

Subjects for whom information on gender or age was missing were excluded ($n = 4$). The total number of eligible dietary records was 1,121. Only 802 subjects provided valid accelerometer data, and four subjects had no height and/or weight measured. All 1,121 were kept as the base data file, and subjects with incomplete data only excluded from certain analyses when necessary.

3.5 CALCULATION OF DIETARY VARIABLES

3.5.1 Consumers

The proportion of subjects consuming food groups was calculated in each age and gender group. The intakes of all food groups was also calculated, both for all subjects and for consumers only. The proportion of subjects consuming each food group was calculated simply as the proportion who reported eating *any* amount of that food group. Information was not available on servings of the different food groups consumed so it was not possible to set an alternative lower limit to classify subjects as consumers.

3.5.1.1 *Food group sources of macronutrients*

To calculate the contribution to macronutrient intakes of differing food groups, the amount of nutrient from each food group was expressed as a proportion of the total intake of that nutrient. Two methods are possible, as shown below. One is to calculate the proportion for each individual and then find the mean for the whole group (the mean proportion). The other is to calculate the proportion for the whole group (the population proportion).

$$\text{Mean proportion} = \frac{\sum_{i=1}^{n}(F_i/T_i)}{n} \qquad \text{Population proportion} = \frac{\sum_{i=1}^{n}F_i}{\sum_{i=1}^{n}T_i}$$

Where F_i is the amount of the food component contributed by the particular food group for the *i*th individual; T_i is the total amount of the food component from all foods for the *i*th individual; and *n* is the number of individuals in the population. For example, the fat in the diet that comes from full fat cheese (F_i) expressed over the total amount of fat in the diet (T_i). As only one day of data was available, the population proportion method was used, as proposed by Krebs-Smith *et al.* (1989) who argued that this proportion is less influenced by within-person variation and more closely approximated the true group mean.

3.5.2 Breakfast

Breakfast habits were determined based on the responses obtained from the 24-hour recall. For the purposes of this study, meals were recorded as 'breakfast' if they were consumed between the hours of 5am and 11am, or if they were clearly the first meal of the day and were followed by meals that could easily be considered as lunch and dinner.

In addition to defining subjects as consumers and non-consumers of breakfast, an index was also used to indicate the relative quality of the meal. A score was assigned to each breakfast based on the food groups included in it. One point was awarded if the breakfast included something from the *milk and yoghurt* or the *cheese* food group, another if it included *bread* or *cereal*, and a third if *fruit* or *juice* or *vegetables* were consumed. The points were summed to give a range of possible scores from zero ('very poor') to three ('good' quality). This score has been used previously by a Spanish research group in the EnKid project (Aranceta *et al.*, 2001; Serra-Majem *et al.*, 2002), and was adapted for use in Sweden by the inclusion of vegetables as a breakfast food group, since sandwiches, consisting of bread, cheese and vegetables such as peppers or cucumber, are a common breakfast in Sweden.

3.5.3 Energy density

No strict definition for energy density exists, nor for its calculation. Broadly speaking, energy density is the amount of energy expressed per unit weight (*e.g.*, kJ/g). Based upon the work by Ledikwe *et al.* (2005) and by Cox and Mela (2000), energy density was calculated as the amount of energy (kJ) from food only, divided by the amount of food eaten (g). This includes all solid foods and liquid foods (*e.g.* soups, yoghurt) but excludes water, non-energy containing beverages (*e.g.* coffee, 'light' drinks) and all other beverages (*e.g.* sweetened drinks, fruit juices, milk).

Subjects were assigned to age- and gender-specific low, medium and high energy density tertiles. Subjects were also assigned to age- and gender-specific tertiles of consumption (low, medium and high) for each food group. The association between energy density tertile and food group tertile was then analysed.

3.6 NON-DIETARY VARIABLES

3.6.1 Socioeconomic status

Maternal education was used as a proxy of socioeconomic status. Of the indicators of socioeconomic status, education has been proposed as one of the best to use if time or resources force the use of just one. Information on education is available for all individuals regardless of employment status, it has high reliability and validity (Liberatos *et al.*, 1988) is generally stable after early adulthood, and is easily reported. Mothers were asked whether they had completed basic, secondary or higher levels of education, and were subsequently grouped into a dichotomous variable: having high (above secondary) or low (basic or secondary) education.

3.6.2 Overweight and obesity

BMI was calculated as body weight (kg) divided by the square of height (m^2). Subjects were assigned to categories of weight status (normal / overweight / obese) according to the age- and gender-specific cut-off points derived by Cole *et al.* (2000). These are based on growth curves during childhood that would result in a BMI of more than 25 kg/m^2 (overweight) or 30 kg/m^2 (obese) at 18 y.

3.7 ENERGY REPORTING

3.7.1 EYHS pilot study

A pilot study for EYHS evaluated the use of a 24-hour recall in 9-year-old children. The subjects were recruited from the Danish sampling frame of the study, but the protocol used for sampling, 24-hour recall dietary assessment and anthropometric measurements was common to all countries. Twenty-six children completed a 4-day weighed day food diary (with the help of their parents) and two non-consecutive 24-hour recalls. Total energy expenditure was measured using the gold standard technique of doubly-labelled water (DLW) (Torun *et al.*, 1996).

The two 24-hour recalls were used to estimate the within-person variation of energy intake (CV_{wEI}). This was found to be 24.7 % (Poortvliet *et al.*, unpublished results), which was just above the averaged published values of 21 – 23 % (Black, 2000a). This would suggest that the daily variation in children's diets is not necessarily any greater than that of adults. Energy intake reported with the 24-hr recall did not differ significantly from TEE. Compared to the weighed 4-day record, energy intakes were only slightly lower (not significant) and the distribution of macronutrients was almost identical. It was therefore concluded that a single 24-hr recall was a practical and appropriate method for this study to reasonably assess diet in this age group (Poortvliet *et al.*, unpublished results).

3.7.2 Adequacy of energy reporting

As stated in Section 1.4.2.1, the adequacy of energy reporting can be checked by calculating an upper and lower cut-off value (95 % CI) of the expected agreement between mean energy intake (EI_{rep}) over estimated basal requirements (BMR_{est}) based on the population being studied, the variation in BMR and PAL, number of days of dietary data available and variation in energy intakes. While the measurement of either BMR or TEE is expensive and technically challenging, precluding its use in the community and/or in large studies, BMR is easily estimated from predictive age-and gender-pecific equations using height and weight.

The assigning of an appropriate PAL requires consideration of age, gender and activity level. All subjects with physical activity (as measured by the accelerometer, $n = 802$) were ranked by age and gender into tertiles of activity (low, moderate and high), based on the average counts$\cdot$min^{-1} recorded. According to their age, gender and activity level, an appropriate PAL value was assigned from published tables (FAO/WHO/UNU, 2004) (Table 4.10). A PAL value was also assigned to differing populations (*e.g.*, overweight *vs.* normal weight, girls and boys) by calculating the mean of the PALs of the individuals in each group.

The Goldberg equation (Goldberg *et al.*, 1991) was derived to calculate confidence intervals (CI) limits of an expected energy intake for a population whose activity level (PAL) is known, and is given by:

$$EI_{rep} : BMR > PAL \times \exp\left[s.d._{\min} \times \frac{(S/100)}{\sqrt{n}} \right]$$

and:

$$EI_{rep} : BMR < PAL \times \exp\left[s.d._{\max} \times \frac{(S/100)}{\sqrt{n}} \right]$$

where $s.d._{\min}$ is -2 to give the lower 95 % CI, and $s.d._{\max}$ is 2 for the upper 95 % limit.

S is calculated as:

$$S = \sqrt{\frac{CV_{wEI}^2}{d} + CV_{wB}^2 + CV_{tP}^2}$$

where CV_{wEI} is the within person variation for energy intake, CV_{wB} the variation for BMR (estimated or measured) and CV_{tP} is the variation for physical activity expenditure. The values chosen were taken from the literature, with the exception of CV_{wEI} for the 9-year-olds, where the value calculated from the EYHS pilot study was used (Table 3.3).

Table **3.3** Factors for substitution into the Goldberg equation (Goldberg *et al.* 1991)

	9-year-olds		15-year-olds		Source
CV	Girls	Boys	Girls	Boys	
					^{a} Poortvliet (unpublished)
CV_{wEI}	24.7^a	24.7^a	23^b	23^b	^{b} Black (2000)
CV_{wB}	7.6	6.8	9.3	7.5	Schofield (1985)
CV_{tP}	15	15	15	15	Black (1996)

For each population, the mean EI_{rep}:BMR_{est} was calculated and compared to the cut-offs. The population was then determined to have under-reported (energy intakes < the lower CI limit), adequately reported (EI > lower CI limit, < upper CI limit), or over-reported (EI > upper CI limit).

As individual data should not be compared to Goldberg cut-offs, and no other satisfactory method for identifying misreporting exists, no subjects were excluded from further analysis after calculation of their EI_{rep}:BMR_{est}. Although designed for use at population level, the formula can theoretically, and has been, used where $n = 1$, *i.e.* to compare individual EI to the cut-offs. This approach is not recommended by the original authors (Black, 2000b). In the present study, EI_{rep}:BMR_{est} are compared to Goldberg cut-offs at group level. However to show the estimated proportion of subjects under- and over-reporting, these individual level figures are given for illustrative purposes.

3.8 STATISTICAL ANALYSIS

Summary descriptive statistics are presented as means and standard deviation, unless otherwise indicated. Results are given for the four age and gender subgroups separately (girls and boys aged 9 y, and girls and boys aged 15 y).

Consumers are presented as a proportion of the population consuming the food group, and intakes are shown for both consumers only and for the whole group.

Data on the food sources of macronutrients are presented as a proportion only, as the population proportion method does not produce a standard deviation.

Where tertiles were created (*i.e.* energy density and physical activity), the cut-off values that defined the tertiles are presented in tables.

Differences in the proportion of consumers at both age groups were tested for significance using the Mann-Whitney non-parametric test.

Breakfast habits are presented as the proportion consuming any breakfast, and as the proportions consuming breakfasts of differing quality. To investigate the effect of maternal education on breakfast habits, a binary logistic regression was performed, with maternal education as the independent variable, and consumption of a healthy breakfast (yes/no) as the binary dependant outcome variable.

The association of energy density and consumption of food groups was analysed using cross-tabulation and Kendall's tau-β to indicate the strength of the association.

After log transformation to achieve a normal distribution, energy density was compared across socioeconomic status by Student's t-test. Percentage energy from macronutrients was also compared between subjects of low and highly-educated mothers by means of a Student's t-test. A χ^2 cross-tabulation was performed to examine overweight status by maternal education. The association between macronutrient intake and % energy from macronutrients across low, medium and high energy density diets was analysed by one-way ANOVA, with Tukeys post-hoc test to identify between group differences.

All statistical analysis was performed using SPSS for Windows, Version 15, Chicago: SPSS Inc. A significance level of $P < 0.05$ was assumed for all tests. Bonferroni's adjustment for multiple testing was applied where appropriate.

4 RESULTS

4.1 SAMPLE CHARACTERISTICS

Complete dietary information from the 24-hour recall was provided by 1,121 children (*n* = 552, 52 % girls) and adolescents (*n* = 569, 55 % girls). This formed the basic dataset, even though some lacked data on maternal education (*n* = 63), some missed height and weight information (*n* = 4) and some did not have valid accelerometry data (*n* = 337). Information on the age, gender, anthropometric and socioeconomic characteristics of the sample are presented in Table 4.1, and on the dietary characteristics in Table 4.2, by age and gender.

Table 4.1 General characteristics of the sample, *n* = 1121, by age and gender

	9 y		15 y	
	Girls	Boys	Girls	Boys
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD
n	*287*	*265*	*312*	*257*
Age (y)	9.5 ± 0.4	9.5 ± 0.3	15.6 ± 0.4	15.6 ± 0.4
n	*286*	*264*	*311*	*256*
Height (cm)	139 ± 7	139 ± 6	165 ± 6	176 ± 7
Weight (kg)	33.7 ± 6.7	33.4 ± 6.2	57.8 ± 8.8	64.2 ± 10.7
BMI				
normal weight (%)	82.2	86.4	87.5	87.5
overweight (%)	16.1	9.8	11.6	11.3
obese (%)	1.7	3.8	1.0	1.2
n	*278*	*252*	*290*	*238*
SES				
high maternal education (%)	30.6	31.0	40.7	35.7
n	*230*	*198*	*201*	*155*
Physical activity (counts·min^{-1})	664 ± 189	803 ± 259	489 ± 154	555 ± 198

SES Socioeconomic status
BMI Body mass index

At 9 y, weight and height were similar in boys and girls, but by 15 y, boys were significantly taller and heavier ($P < 0.001$) (Table 4.1). Boys recorded significantly more activity than girls at both ages ($P < 0.001$), but both genders showed a significant decline with increasing age ($P < 0.001$). The proportion of subjects with mothers who achieved a high level of education (above secondary level) was significantly higher in the 15-year-olds than in the 9-year-olds. The level of obesity detected in this sample was low, with 2 - 4 % of 9-year-olds classified as obese, and only 1 % of all 15-year-olds.

Significant absolute increases in intakes (g) are seen for all macronutrients between boys aged 9 and 15 y, but not for girls (Table 4.2). The percent of energy from protein and carbohydrates were within the ranges of the Swedish Nutritional Recommendations (SNR) for all age and gender groups, but percentage energy from fat, and particularly for saturated fat was significantly higher than the population target of < 30 % and < 10 % of energy, respectively (P for both < 0.001), and were higher in children (33.1 and 15.2 %) than in adolescents (31.4 and 14.1 %, $P < 0.001$). Sucrose intakes as a percentage of energy were higher in adolescents (12.2 %) than in children (10.6 %, $P < 0.001$) but both were significantly above the recommended levels ($P < 0.05$).

Table 4.2 Dietary characteristics of the sample, *n* = 1121, by age and gender

	9 y		15 y		
	Girls	Boys	Girls	Boys	
n	*287*	*265*	*312*	*257*	
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD	
Energy (MJ)	8.20 ± 2.02	8.97 ± 2.30	8.60 ± 2.72	12.44 ± 3.78	
Protein (g)	73 ± 22	84 ± 27	75 ± 27	114 ± 43	
Fat (g)	73 ± 25	79 ± 27	72 ± 31	106 ± 41	
saturated fat (g)	33 ± 12	37 ± 13	32 ± 15	48 ± 21	
Carbohydrates (g)	251 ± 67	272 ± 76	274 ± 90	387 ± 126	
sucrose (g)	54 ± 31	56 ± 31	64 ± 39	87 ± 57	
fibre (g)	14 ± 6	15 ± 6	16 ± 8	20 ± 9	
					SNR
Protein (% E)	15.1 ± 3.1	15.6 ± 3.3	14.7 ± 3.5	15.4 ± 3.5	10-20
Fat (% E)	33.3 ± 6.7	33.0 ± 6.2	31.1 ± 6.9	31.8 ± 6.9	< 30
saturated fat (% E)	15.2 ± 3.6	15.2 ± 3.2	13.8 ± 3.7	14.4 ± 3.6	< 10
Carbohydrates (% E)	51.4 ± 7.3	51.0 ± 6.9	53.7 ± 7.5	52.3 ± 7.6	50-60
sucrose (% E)	10.9 ± 5.4	10.3 ± 5.0	12.5 ± 6.2	11.7 ± 6.4	< 10

SNR Swedish Nutrition Recommendations

4.2 CONSUMERS AND NON-CONSUMERS

The proportion of children and adolescents consuming different food groups is illustrated by the lines on the radar graph in Figure 4.1, where the outermost circle of the graph represents 100 % and the inner point represents 0 %. The most frequently consumed food groups were *bread, milk and yoghurt; spreads and oils; vegetables; pasta, rice and potatoes* and *meat*, reported by more than 75 % of all age and gender groups.

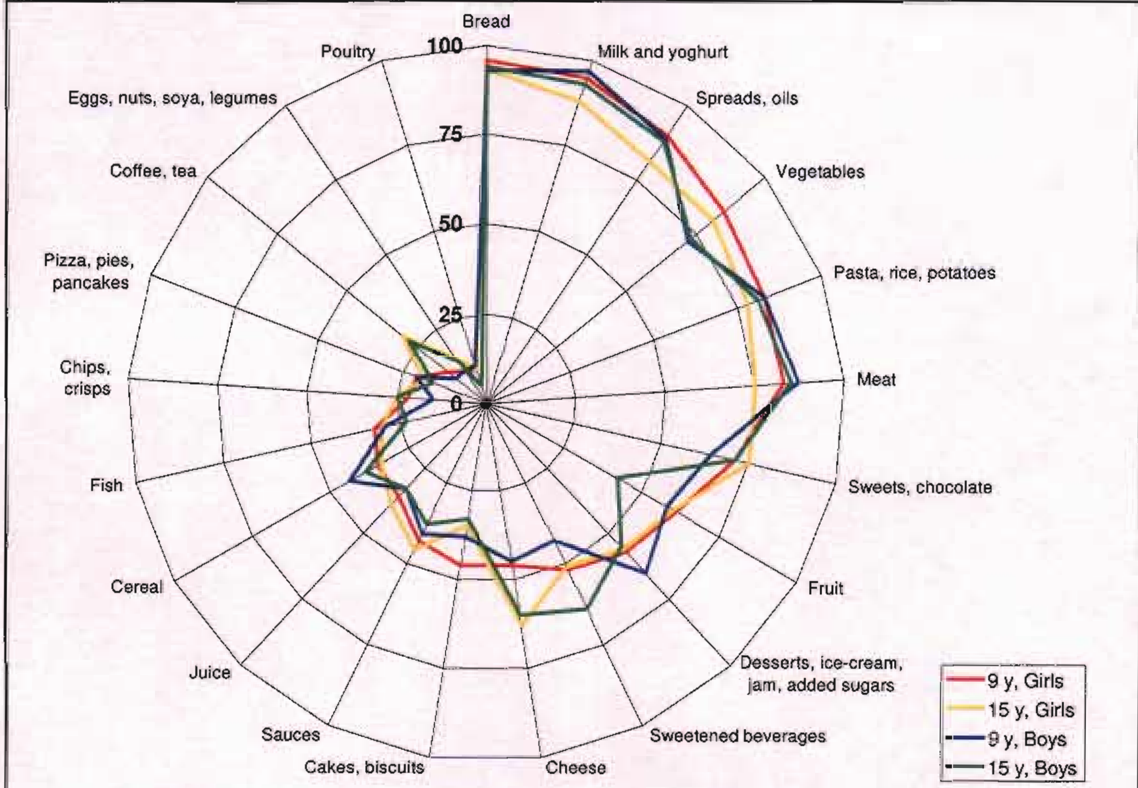

Figure 4.1 Prevalence of food group consumption, by age and gender. The outer edge represents 100 %, the innermost point 0 %.

While broadly similar consumption patterns can be seen in the four subgroups, certain differences appear. A Mann-Whitney U test to check for significance suggests that 15-year-olds consume *milk and yoghurt* less frequently, but *cheese* and *coffee and tea* more frequently than 9-year-olds. Consumption of certain food groups between age groups differed significantly only within genders (Table 4.3). For example, *fruit* and *chips and crisps* in boys only; *cakes and biscuits* and *meat* in girls only. After the application of Bonferroni's correction for multiple testing ($n = 28$), several significant differences remained. Between ages 9 and 15, differences in *cheese*, *milk and yoghurt*, and *coffee and tea* consumption remained significant in girls; *cheese*, *fruit*, *sweetened drinks* and *coffee and tea* remained significant in boys (results not shown). Similarly, Figure 4.1 and Table 4.3 also highlight gender differences that persist across ages. For example, it can be seen that more girls than boys consume *fruit*, *vegetables* and *fish*, and less *cereal* at both ages.

Table 4.3 Age and gender differences in the prevalence of food group consumption

	9 y		15 y		Between ages	
Food group	Girls	Boys	Girls	Boys	Girls	Boys
	%	%	%	%	P	P
Spreads, oils	90	89	81	88 *	0.005	ns
high fat	*52*	*54*	*48*	*45*	ns	0.036
Milk and yoghurt	95	97	88	93	0.002	0.043
full-fat	*51*	*57*	*38*	*46*	0.002	0.007
Cheese	46	45	63	60	0.000	0.001
high fat	*39*	*39*	*54*	*52*	0.000	0.003
Bread	96	93	93	94	ns	ns
low fibre	*87*	*85*	*81*	*85*	ns	ns
Cereal	35	44 *	34	39	ns	ns
sweetened	*11*	*21* **	*11*	*16*	ns	ns
Pasta, rice, potatoes	83	83	78	81	ns	ns
Pizza, pies, pancakes	21	21	19	16	ns	ns
Meat	83	87	75	85 **	0.010	ns
burgers, sausages	*62*	*67*	*52*	*61* *	0.013	ns
Poultry	10	11	10	5	ns	0.032
Fish	32	29	30	23	ns	ns
Eggs, nuts, soya, legumes	11	11	15	14	ns	ns
Fruit	61	58	60	42 **	ns	0.000
Vegetables	85	72 **	81	73 *	ns	ns
Juice	36	33	39	33	ns	ns
Desserts, ice-cream, jam, added sugars	57	65	56	55	ns	0.024
Cakes, biscuits	46	38	35	33	0.005	ns
Sweets, chocolate	71	64	75	71	ns	ns
Chips, crisps	22	15	25	25	ns	0.005
Sauces	43	41	46	38	ns	ns
full-fat	*16*	*17*	*18*	*13*	ns	ns
Coffee, tea	14	11	30	28	0.000	0.000
Sweetened beverages	52	43 *	51	64 **	ns	0.000

* Gender difference, $P < 0.05$

** Gender difference, $P < 0.01$

4.2.1 Intakes of consumers *vs.* non-consumers

The effect of considering the proportion of consumers in a group when reporting mean intakes can be seen in Table 4.4. For commonly consumed foods, such as *milk and yoghurt*, or *bread*, the differences between the intakes of all and of consumers only are smaller. However, when the proportion of consumers is relatively low, for example as with *juice*, the difference is approximately three-fold. In the case of *fruit*, while the mean intake for all 15-year-old boys is just 87 g, only 42 % of the group reported eating any fruit, but those that did, consumed 210 g. The intake of *sweetened beverages* is 389 g for all 15-year-old boys, but 606 g for consumers. Between 84 and 122 g of *fish* is eaten by consumers, but only by 23 to 32 % of subjects. The intake of *cheese* (including high fat cheeses) is approximately double among consumers only compared to all.

Table 4.4 Intakes of food groups by all and by consumers only

	9 y				15 y			
	Girls		Boys		Girls		Boys	
Food group	All (g)	Cons. (g)	All (g)	Cons. (g)	All (g)	Cons. (g)	All (g)	Cons. (g)
Spreads, oils	16	18	18	20	13	15	21	24
high fat	*8*	*15*	*9*	*17*	*6*	*13*	*9*	*19*
Milk and yoghurt	517	543	644	667	481	547	784	846
full-fat	*192*	*377*	*243*	*423*	*123*	*323*	*256*	*562*
Cheese	22	48	26	57	30	47	47	80
high fat	*20*	*52*	*24*	*61*	*23*	*43*	*40*	*78*
Bread	93	97	107	115	101	108	168	178
low fibre	*82*	*94*	*92*	*109*	*78*	*96*	*145*	*171*
Cereal	30	85	51	115	28	83	47	120
sweetened	*4*	*31*	*8*	*37*	*4*	*38*	*9*	*58*
Pasta, rice, potatoes	178	214	203	243	157	203	249	309
Pizza, pies, pancakes	42	197	44	207	36	185	44	278
Meat	133	160	155	179	112	150	219	257
burgers, sausages	*85*	*138*	*100*	*149*	*72*	*140*	*137*	*223*
Poultry	9	95	15	138	12	128	9	168
Fish	28	88	24	84	31	101	28	122
Eggs, nuts, soya, legumes	8	66	8	75	10	66	10	71
Fruit	136	222	104	181	145	243	87	210
Vegetables	61	72	57	79	108	132	83	113
Juice	91	254	103	313	139	358	131	397
Desserts, ice-cream, jam, added sugars	59	91	87	122	63	104	81	127
Cakes, biscuits	28	62	22	58	23	65	25	75
Sweets, chocolate	22	31	16	26	41	55	42	59
Chips, crisps	24	113	14	93	25	98	41	162
Sauces	27	62	28	69	24	53	35	92
full-fat	*7*	*46*	*9*	*55*	*8*	*46*	*10*	*81*
Coffee, tea	33	233	23	211	88	290	84	303
Sweetened beverages	178	342	162	372	192	380	389	606

4.3 CONTRIBUTION OF FOODS TO MACRONUTRIENT INTAKES

The food groups that contribute most to energy, protein, fat, saturated fat, carbohydrates and sucrose are presented in Tables 4.5a-f, in descending order of magnitude. Some groups are divided further and the contribution from the subgroup is also presented. The contribution of four food groups to energy, carbohydrate and sucrose sources are given special consideration as energy dense food groups: *sweets and chocolate*; *cakes and biscuits*; *desserts, ice cream, jams, added sugars* and *sweetened drinks;* and to fat and saturated fat sources, *chips and crisps* were also included.

4.3.1 Energy and protein

Milk and yoghurt, *meat*, *bread* and *pasta, rice and potatoes* are the food groups that provide most energy in all age and gender groups (Table 4.5a), with the exception of 15-year-old girls where *sweets and chocolate* provided more energy than *pasta, rice and potatoes. Desserts, ice cream, jams, added sugars* was the fifth biggest source in the 9-year-olds, and *sweets and chocolate* in 15-year-old boys. In the younger age group, half of the energy from the *milk and yoghurt* group was from *full-fat milk and yoghurt*, but this decreased to a third or a quarter in the older group. Between 17 and 25 % of all energy came from the energy dense food groups mentioned above.

The seven biggest sources of protein are: *milk and yoghurt*; *meat; bread; cheese; pasta, rice, potatoes; fish* and *pizza, pies and pancakes*, in somewhat similar order in all groups (Table 4.5b).

4.3.2 Fat, including saturated fat

Meat, followed by *milk and yoghurt*, contributed most to fat intakes. *Burgers and sausages* accounted for approximately two-thirds of the fat contribution of the *meat* group, and *full fat* products for half of the *milk and yoghurt* contribution (Table 4.5c). *Spreads and oils* (two-thirds of which was *high fat*) and *cheese* (almost all of which was *high fat*) were either the third or fourth biggest sources. Saturated fat sources in the diet were similar and came mostly from *milk and yoghurt* and *meat* (Table 4.5d). *Spreads and oils* were the third biggest contributor in 9-year-olds, followed by *cheese*. This order was reversed in the 15-year-olds. *Burgers and sausages* provided about three-quarters of the saturated fat contributed by the *meat* group. Similar to the total fat sources, *full fat cheese* contributed almost all of the saturated fat of the *cheese* group. The proportion of fat from the five food groups with low nutrient-density mentioned above ranged from 13 % in boys, to 18 % in 15-year-old girls, and the proportion of saturated fat was almost identical (13 % to 23 %, lowest in 9-year-old boys, highest in 15-year-old girls). When *chips and crisps* were included, the figures for total fat ranged from 15 to 22 %, and, for saturated fat, from 15 to 23 %.

4.3.3 Carbohydrate, including sucrose

The major carbohydrate sources identified for most groups were (in order): *bread*; *pasta, rice and potatoes*; and *milk and yoghurt* (Table 4.5e). The exception was 15-year-old girls, where *sweets and chocolate* was ranked third ahead of *milk and yoghurt*. Of the *bread* food group, the subgroup *low fibre bread* was by far the largest component, while of the *milk and yoghurt* group, *full fat milk and yoghurt* was a small contributor. In boys, *sweetened drinks* provided 5.8 % of carbohydrates in 9-year-olds, and 9.8 % in 15-year-olds. Together, *sweetened drinks*,

Table 4.5a Proportion of energy from food groups, by age and gender

9 y				15 y			
Girls	%	Boys	%	Girls	%	Boys	%
Milk, yoghurt	14.0	Milk, yoghurt	15.9	Bread	12.9	Bread	14.8
full fat	*6.3*	*full fat*	*7.2*	*low fibre*	*10.1*	*low fibre*	*12.8*
Bread	12.7	Meat, meat dishes	13.5	Milk, yoghurt	11.8	Milk, yoghurt	13.6
low fibre	*11.0*	*burgers, sausages*	*9.3*	*full fat*	*3.9*	*full fat*	*5.5*
Meat, meat dishes	12.5	Bread	13.4	Meat, meat dishes	9.6	Meat, meat dishes	12.9
burgers, sausages	*8.6*	*low fibre*	*11.3*	*burgers, sausages*	*6.6*	*burgers, sausages*	*8.6*
Pasta, rice, potatoes	8.7	Pasta, rice, potatoes	9.4	Sweets, chocolate	8.7	Pasta, rice, potatoes	8.6
Desserts, sugar, etc	5.4	Desserts, sugar, etc	6.7	Pasta, rice, potatoes	8.0	Sweets, chocolate	6.0
Cakes, biscuits	5.4	Pizza, pies, pancakes	4.5	Cheese	4.9	Cheese	5.5
Sweets, chocolate	4.8	Spreads, oils	4.5	*high fat cheese*	*4.1*	*high fat cheese*	*5.0*
Pizza, pies, pancakes	4.5	*high fat*	*2.9*	Desserts, sugar, etc	5.2	Sweetened drinks	5.3
Spreads, oils	4.3	Cheese	4.3	Cakes, biscuits	4.3	Desserts, sugar, etc	5.0
high fat	*2.7*	*high fat cheese*	*4.0*	Fruit	4.1	Spreads, oils	3.6
Cheese	4.1	Cakes, biscuits	4.0	Sweetened drinks	3.9	*high fat*	*1.9*
high fat cheese	*3.8*	Sweets, chocolate	3.4	Pizza, pies, pancakes	3.8	Chips, crisps	3.3
Fruit	3.8	Cereal	3.3	Spreads, oils	3.2	Cakes, biscuits	3.2
Sweetened drinks	3.7	*sweetened*	*1.4*	*high fat*	*2.1*	Pizza, pies, pancakes	3.2
Chips, crisps	2.5	Sweetened drinks	3.2	Chips, crisps	2.9	Cereal	3.0
Cereal	2.4	Fruit	2.7	Juice	2.9	*sweetened*	*1.2*
sweetened	*0.7*	Juice	2.1	Cereal	2.7	Fruit	1.9
Fish, fish dishes	2.1	Fish, fish dishes	1.7	*sweetened*	*0.8*	Juice	1.9
Juice	2.1	Chips, crisps	1.5	Fish, fish dishes	2.5	Sauces	1.8
Sauces	1.9	Sauces	1.5	Sauces	2.1	*full fat*	*1.0*
full fat	*1.1*	*full fat*	*0.9*	*full fat*	*1.3*	Fish, fish dishes	1.4
Vegetables	1.1	Vegetables	1.0	Vegetables	2.0	Vegetables	1.1
Eggs, nuts, soya, legumes	0.7	Poultry, poultry dishes	0.9	Eggs, nuts, soya, legumes	1.0	Eggs, nuts, soya, legumes	0.6
Poultry, poultry dishes	0.7	Eggs, nuts, soya, legumes	0.6	Poultry, poultry dishes	0.8	Poultry, poultry dishes	0.5

Table 4.5b Proportion of protein from food groups, by age and gender

9 y				15 y			
Girls	%	Boys	%	Girls	%	Boys	%
Milk, yoghurt	24.4	Milk, yoghurt	26.6	Milk, yoghurt	22.3	Meat, meat dishes	25.6
full fat	9.0	*full fat*	*9.8*	*full fat*	*5.6*	*burgers, sausages*	*14.1*
Meat, meat dishes	23.5	Meat, meat dishes	23.7	Meat, meat dishes	19.9	Milk, yoghurt	23.7
burgers, sausages	*13.4*	*burgers, sausages*	*14.5*	*burgers, sausages*	*11.0*	*full fat*	*7.5*
Bread	9.6	Bread	9.8	Bread	10.3	Cheese	11.2
low fibre	*8.2*	*low fibre*	*8.2*	*low fibre*	*7.9*	*high fat cheese*	*9.9*
Cheese	8.2	Cheese	8.1	Cheese	10.0	Bread	10.9
high fat cheese	*7.8*	*high fat cheese*	*7.8*	*high fat cheese*	*8.5*	*low fibre*	*9.4*
Pasta, rice, potatoes	5.9	Pasta, rice, potatoes	6.4	Fish, fish dishes	6.3	Pasta, rice, potatoes	6.0
Fish, fish dishes	5.3	Fish, fish dishes	4.2	Pasta, rice, potatoes	5.9	Fish, fish dishes	3.1
Pizza, pies, pancakes	4.4	Pizza, pies, pancakes	4.1	Pizza, pies, pancakes	3.9	Pizza, pies, pancakes	2.9
Poultry, poultry dishes	2.6	Poultry, poultry dishes	2.9	Sweets, chocolate	2.7	Cereal	2.1
Cakes, biscuits	2.4	Cereal	2.5	Poultry, poultry dishes	2.6	*sweetened*	*0.7*
Cereal	1.9	*sweetened*	*0.8*	Cereal	2.3	Sweets, chocolate	2.0
sweetened	*0.4*	Cakes, biscuits	1.6	*sweetened*	*0.7*	Poultry, poultry dishes	1.5
Sweets, chocolate	1.6	Desserts, sugar, etc	1.6	Vegetables	1.9	Desserts, sugar, etc	1.4
Desserts, sugar, etc	1.4	Eggs, nuts, soya, legumes	1.1	Cakes, biscuits	1.8	Cakes, biscuits	1.3
Chips, crisps	1.2	Sweets, chocolate	1.1	Eggs, nuts, soya, legumes	1.6	Chips, crisps	1.3
Eggs, nuts, soya, legumes	1.1	Vegetables	0.8	Desserts, sugar, etc	1.4	Eggs, nuts, soya, legumes	1.0
Vegetables	1.0	Chips, crisps	0.7	Chips, crisps	1.2	Vegetables	1.0
Fruit	0.9	Sauces	0.6	Fruit	1.1	Sauces	0.7
Sauces	0.7	*full fat*	*0.3*	Juice	1.0	*full fat*	*0.3*
full fat	*0.3*	Fruit	0.6	Sauces	0.7	Juice	0.6
Juice	0.6	Juice	0.6	*full fat*	*0.3*	Spreads, oils	0.5
Spreads, oils	0.6	Spreads, oils	0.5	Spreads, oils	0.4	*high fat*	*0.0*
high fat	*0.1*	*high fat*	*0.1*	*high fat*	*0.0*	Fruit	0.5
Sweetened drinks	0.2	Sweetened drinks	0.2	Sweetened drinks	0.2	Sweetened drinks	0.2

Table 4.5c Proportion of total fat from food groups, by age and gender

9 y				15 y			
Girls	%	Boys	%	Girls	%	Boys	%
Meat, meat dishes	22.3	Meat, meat dishes	23.9	Meat, meat dishes	17.5	Meat, meat dishes	22.3
burgers, sausages	*16.6*	*burgers, sausages*	*17.7*	*burgers, sausages*	*13.1*	*burgers, sausages*	*15.8*
Milk, yoghurt	14.3	Milk, yoghurt	16.0	Milk, yoghurt	10.8	Milk, yoghurt	13.6
full fat	*7.9*	*full fat*	*9.0*	*full fat*	*4.9*	*full fat*	*7.1*
Spreads, oils	12.8	Spreads, oils	13.3	Cheese	10.4	Cheese	11.5
high fat	*8.2*	*high fat*	*8.9*	*high fat cheese*	*9.0*	*high fat cheese*	*10.7*
Cheese	8.1	Cheese	8.5	Spreads, oils	10.1	Spreads, oils	11.0
high fat cheese	*7.9*	*high fat cheese*	*8.3*	*high fat*	*6.6*	*high fat*	*6.1*
Cakes, biscuits	5.9	Pizza, pies, pancakes	5.6	Sweets, chocolate	7.7	Pizza, pies, pancakes	4.6
Pizza, pies, pancakes	5.5	Desserts, sugar, etc	5.1	Sauces	5.6	Sauces	4.6
Desserts, sugar, etc	4.7	Cakes, biscuits	4.8	*full fat*	*3.7*	*full fat*	*2.9*
Sauces	4.6	Bread	3.7	Cakes, biscuits	5.5	Sweets, chocolate	4.6
full fat	*3.1*	*low fibre*	*3.1*	Pizza, pies, pancakes	5.3	Chips, crisps	4.5
Sweets, chocolate	4.1	Sauces	3.4	Desserts, sugar, etc	4.7	Desserts, sugar, etc	4.2
Bread	3.4	*full fat*	*2.2*	Chips, crisps	4.4	Bread	4.1
low fibre	*2.9*	Sweets, chocolate	3.1	Bread	4.0	*low fibre*	*3.4*
Chips, crisps	3.4	Fish, fish dishes	2.3	*low fibre*	*3.2*	Cakes, biscuits	3.9
Fish, fish dishes	2.9	Chips, crisps	2.1	Fish, fish dishes	3.7	Fish, fish dishes	1.9
Pasta, rice, potatoes	1.3	Cereal	1.7	Eggs, nuts, soya, legumes	1.9	Cereal	1.5
Eggs, nuts, soya, legumes	1.2	*sweetened*	*0.5*	Vegetables	1.8	*sweetened*	*0.7*
Cereal	1.2	Poultry, poultry dishes	1.3	Cereal	1.4	Pasta, rice, potatoes	1.3
sweetened	*0.2*	Pasta, rice, potatoes	1.3	*sweetened*	*0.4*	Eggs, nuts, soya, legumes	1.1
Poultry, poultry dishes	0.9	Eggs, nuts, soya, legumes	1.1	Poultry, poultry dishes	1.3	Vegetables	0.8
Vegetables	0.6	Vegetables	0.7	Pasta, rice, potatoes	1.2	Poultry, poultry dishes	0.8
Fruit	0.3	Fruit	0.2	Fruit	0.4	Fruit	0.2
Juice	0.1	Sweetened drinks	0.2	Juice	0.2	Sweetened drinks	0.2
Sweetened drinks	0.1	Juice	0.1	Sweetened drinks	0.1	Juice	0.1

Table 4.5d Proportion of saturated fat from food groups, by age and gender

9 y				15 y			
Girls	%	Boys	%	Girls	%	Boys	%
Milk, yoghurt	20.1	Milk, yoghurt	22.7	Meat, meat dishes	16.3	Meat, meat dishes	20.4
full fat	*11.2*	*full fat*	*12.5*	*burgers, sausages*	*12.0*	*burgers, sausages*	*14.5*
Meat, meat dishes	20.0	Meat, meat dishes	21.1	Milk, yoghurt	16.0	Milk, yoghurt	19.6
burgers, sausages	*14.7*	*burgers, sausages*	*15.5*	*full fat*	*7.2*	*full fat*	*10.1*
Spreads, oils	12.8	Spreads, oils	13.1	Cheese	15.1	Cheese	16.4
high fat	*8.6*	*high fat*	*9.2*	*high fat cheese*	*13.1*	*high fat cheese*	*15.3*
Cheese	11.5	Cheese	12.0	Spreads, oils	9.8	Spreads, oils	10.5
high fat cheese	*11.1*	*high fat cheese*	*11.6*	*high fat*	*6.6*	*high fat*	*6.1*
Cakes, biscuits	6.0	Desserts, sugar, etc	5.1	Sweets, chocolate	9.6	Sweets, chocolate	5.3
Desserts, sugar, etc	4.7	Pizza, pies, pancakes	4.8	Cakes, biscuits	5.5	Desserts, sugar, etc	4.3
Pizza, pies, pancakes	4.6	Cakes, biscuits	4.7	Desserts, sugar, etc	5.2	Pizza, pies, pancakes	4.0
Sweets, chocolate	4.5	Sweets, chocolate	3.5	Pizza, pies, pancakes	4.6	Cakes, biscuits	3.9
Sauces	4.0	Sauces	2.6	Sauces	4.2	Sauces	3.3
full fat	*2.8*	*full fat*	*1.7*	*full fat*	*2.6*	*full fat*	*1.8*
Chips, crisps	2.3	Fish, fish dishes	1.6	Fish, fish dishes	2.8	Chips, crisps	2.6
Fish, fish dishes	2.1	Bread	1.5	Chips, crisps	2.6	Bread	1.8
Bread	1.5	*low fibre*	*1.3*	Bread	2.0	*low fibre*	*1.6*
low fibre	*1.3*	Chips, crisps	1.4	*low fibre*	*1.7*	Fish, fish dishes	1.5
Cereal	1.0	Cereal	1.2	Eggs, nuts, soya, legumes	0.9	Pasta, rice, potatoes	0.9
sweetened	*0.0*	*sweetened*	*0.1*	Vegetables	0.9	Cereal	0.6
Pasta, rice, potatoes	1.0	Poultry, poultry dishes	0.9	Cereal	0.9	*sweetened*	*0.1*
Eggs, nuts, soya, legumes	0.6	Pasta, rice, potatoes	0.9	*sweetened*	*0.1*	Eggs, nuts, soya, legumes	0.6
Poultry, poultry dishes	0.6	Eggs, nuts, soya, legumes	0.7	Poultry, poultry dishes	0.9	Poultry, poultry dishes	0.5
Vegetables	0.3	Vegetables	0.4	Pasta, rice, potatoes	0.8	Vegetables	0.4
Sweetened drinks	0.2	Sweetened drinks	0.3	Fruit	0.2	Sweetened drinks	0.2
Fruit	0.1	Fruit	0.1	Sweetened drinks	0.1	Fruit	0.1
Juice	0.0	Juice	0.0	Juice	0.0	Juice	0.0

Table 4.5e Proportion of carbohydrates from food groups, by age and gender

9 y				15 y			
Girls	%	Boys	%	Girls	%	Boys	%
Bread	19.3	Bread	20.5	Bread	18.7	Bread	22.1
low fibre	*16.9*	*low fibre*	*17.4*	*low fibre*	*14.6*	*low fibre*	*19.1*
Pasta, rice, potatoes	14.2	Pasta, rice, potatoes	15.4	Pasta, rice, potatoes	12.5	Pasta, rice, potatoes	13.7
Milk, yoghurt	11.3	Milk, yoghurt	12.8	Sweets, chocolate	10.9	Milk, yoghurt	11.0
full fat	*4.6*	*full fat*	*5.3*	Milk, yoghurt	9.8	*full fat*	*4.0*
Sweetened drinks	7.0	Desserts, sugar, etc	9.3	*full fat*	*3.0*	Sweetened drinks	9.9
Desserts, sugar, etc	7.0	Sweetened drinks	5.9	Sweetened drinks	7.1	Sweets, chocolate	8.0
Fruit	6.8	Fruit	5.0	Fruit	7.1	Desserts, sugar, etc	6.5
Sweets, chocolate	6.3	Cereal	4.7	Desserts, sugar, etc	6.5	Cereal	4.1
Cakes, biscuits	5.9	*sweetened*	*2.2*	Juice	5.0	*sweetened*	*1.6*
Pizza, pies, pancakes	3.8	Sweets, chocolate	4.3	Cakes, biscuits	4.2	Meat, meat dishes	3.5
Juice	3.7	Cakes, biscuits	4.2	Cereal	3.6	*burgers, sausages*	*2.7*
Cereal	3.4	Pizza, pies, pancakes	3.8	*sweetened*	*1.1*	Cakes, biscuits	3.4
sweetened	*1.1*	Juice	3.8	Pizza, pies, pancakes	2.9	Fruit	3.3
Meat, meat dishes	3.0	Meat, meat dishes	3.6	Chips, crisps	2.5	Juice	3.3
burgers, sausages	*2.0*	*burgers, sausages*	*2.3*	Meat, meat dishes	2.2	Chips, crisps	3.1
Chips, crisps	2.4	Chips, crisps	1.4	*burgers, sausages*	*1.7*	Pizza, pies, pancakes	2.3
Vegetables	1.4	Vegetables	1.2	Vegetables	2.1	Vegetables	1.2
Fish, fish dishes	0.7	Fish, fish dishes	0.6	Fish, fish dishes	0.7	Fish, fish dishes	0.5
Sauces	0.5	Sauces	0.5	Sauces	0.5	Sauces	0.5
full fat	*0.1*	*full fat*	*0.2*	*full fat*	*0.1*	*full fat*	*0.1*
Cheese	0.3	Cheese	0.3	Cheese	0.3	Cheese	0.3
high fat cheese	*0.1*	*high fat cheese*	*0.2*	*high fat cheese*	*0.1*	*high fat cheese*	*0.2*
Eggs, nuts, soya, legumes	0.2	Eggs, nuts, soya, legumes	0.1	Eggs, nuts, soya, legumes	0.3	Eggs, nuts, soya, legumes	0.1
Poultry, poultry dishes	0.0	Poultry, poultry dishes	0.0	Poultry, poultry dishes	0.1	Poultry, poultry dishes	0.0
Spreads, oils	0.0	Spreads, oils	0.0	Spreads, oils	0.0	Spreads, oils	0.0
high fat	*0.0*	*high fat*	*0.0*	*high fat*	*0.0*	*high fat*	*0.0*

Table 4.5f Proportion of sucrose from food groups, by age and gender

9 y				15 y			
Girls	%	Boys	%	Girls	%	Boys	%
Sweetened drinks	23.3	Desserts, sugar, etc	23.9	Sweets, chocolate	29.8	Sweetened drinks	32.6
Sweets, chocolate	20.2	Sweetened drinks	20.8	Sweetened drinks	22.3	Sweets, chocolate	23.5
Desserts, sugar, etc	17.7	Sweets, chocolate	15.3	Desserts, sugar, etc	14.9	Desserts, sugar, etc	15.1
Cakes, biscuits	9.2	Cakes, biscuits	7.2	Fruit	8.3	Bread	6.3
Fruit	9.2	Fruit	6.9	Cakes, biscuits	6.7	*low fibre*	*6.2*
Bread	5.8	Bread	6.7	Juice	4.8	Cakes, biscuits	5.2
low fibre	*5.7*	*low fibre*	*6.5*	Bread	3.3	Fruit	3.8
Juice	3.8	Cereal	4.5	*low fibre*	*3.1*	Juice	3.3
Milk, yoghurt	2.4	*sweetened*	*4.1*	Milk, yoghurt	2.2	Cereal	2.8
full fat	*1.9*	Juice	4.1	*full fat*	*1.4*	*sweetened*	*2.4*
Cereal	2.0	Milk, yoghurt	3.3	Cereal	1.7	Milk, yoghurt	1.8
sweetened	*1.8*	*full fat*	*3.0*	*sweetened*	*1.3*	*full fat*	*1.3*
Vegetables	1.9	Meat, meat dishes	1.5	Vegetables	1.4	Vegetables	1.0
Meat, meat dishes	0.6	*burgers, sausages*	*0.4*	Sauces	0.5	Meat, meat dishes	0.7
burgers, sausages	*0.3*	Vegetables	1.4	*full fat*	*0.1*	*burgers, sausages*	*0.3*
Pasta, rice, potatoes	0.4	Pasta, rice, potatoes	0.5	Pasta, rice, potatoes	0.4	Sauces	0.4
Sauces	0.4	Sauces	0.2	Meat, meat dishes	0.4	*full fat*	*0.0*
full fat	*0.0*	*full fat*	*0.0*	*burgers, sausages*	*0.2*	Pasta, rice, potatoes	0.4
Chips, crisps	0.2	Fish, fish dishes	0.2	Fish, fish dishes	0.2	Chips, crisps	0.2
Eggs, nuts, soya, legumes	0.2	Chips, crisps	0.1	Eggs, nuts, soya, legumes	0.2	Fish, fish dishes	0.1
Fish, fish dishes	0.2	Pizza, pies, pancakes	0.1	Chips, crisps	0.1	Eggs, nuts, soya, legumes	0.1
Pizza, pies, pancakes	0.1	Cheese	0.1	Cheese	0.1	Pizza, pies, pancakes	0.0
Cheese	0.1	*high fat cheese*	*0.0*	*high fat cheese*	*0.0*	Cheese	0.0
high fat cheese	*0.0*	Eggs, nuts, soya, legumes	0.0	Pizza, pies, pancakes	0.1	*high fat cheese*	*0.0*
Poultry, poultry dishes	0.0	Poultry, poultry dishes	0.0	Poultry, poultry dishes	0.0	Poultry, poultry dishes	0.0
Spreads, oils	0.0	Spreads, oils	0.0	Spreads, oils	0.0	Spreads, oils	0.0
high fat	*0.0*	*high fat*	*0.0*	*high fat*	*0.0*	*high fat*	*0.0*

the *desserts, jams etc.* group, *sweets and chocolate* and *cakes and biscuits* provided over 20 % of the carbohydrate intakes of 9-year-olds, and over 25 % of 15-year-olds. The main sources of sucrose in the diet were *sweetened drinks, desserts, jams etc.*, and *sweets and chocolate* (Table 4.5f). This was followed by *cakes and biscuits* and *fruit* in the 9-year-olds and older girls, and by *bread* and *cakes and biscuits* in the older boys. The four nutrient-poor food groups mentioned above accounted for 67 to 76 % of sucrose intakes.

4.4 BREAKFAST CONSUMPTION

According to the 24-hour recall, 97 % of all subjects reported consuming something for breakfast on the day recalled. *Milk, yoghurt or cheese* products were consumed for breakfast by 77 % of the subjects, *bread or cereal* products by 84 % and *fruit, juice or vegetables* by 27 %. One point was assigned to each subject if they consumed anything from each of these groups, to give a maximum score of three (deemed a "healthy breakfast"). When this score was calculated, one quarter of all subjects had consumed a healthy breakfast. The breakdown of scores by age and gender is shown in Figure 4.2. The percentage of both healthy breakfast consumers and non-breakfast consumers was higher in both genders in the older age group than in the younger group (30 % and 8 %, *vs.* 20 % and 1 %).

Of the subjects that consumed just one of the breakfast groups, 50 % consumed a *bread or cereal* product, 33 % a *milk, yoghurt or cheese* product and 17 % a *fruit, juice or vegetable* product. Of those that had a breakfast score of 2, most (91 %) lacked *fruit, juice or vegetables*, 8 % did not consume any *milk, yoghurt or cheese* and 2 % ate no *bread or cereal* product.

The composition of the breakfasts that scored from zero (those that included none of the recommended groups) to three (a "healthy breakfast") is shown in Table 4.6. Healthy breakfasts contained the most energy (both in absolute terms and as a percentage of the daily total, and protein, fat and carbohydrate amounts that were between the "fair" (2 points) and "poor" (1 point) groups. The "fair" breakfast was high in protein and fat, and low in carbohydrates. The "poor" breakfast contained appropriate proportions of fat, protein and carbohydrate, but provided just 12 % of total energy intake.

Table 4.6 Composition of breakfasts, by quality score

Breakfast score	N (%)	Protein (%)	Fat (%)	Carbohydrates (%)	Energy (MJ)	Of total energy (%)
0	57 (5)	5.8	39.0	54.5	0.22	2.5
1	114 (10)	11.9	26.2	61.4	1.09	12.0
2	668 (60)	16.3	32.1	51.2	1.87	20.1
3	282 (25)	15.0	27.3	57.2	2.39	23.7

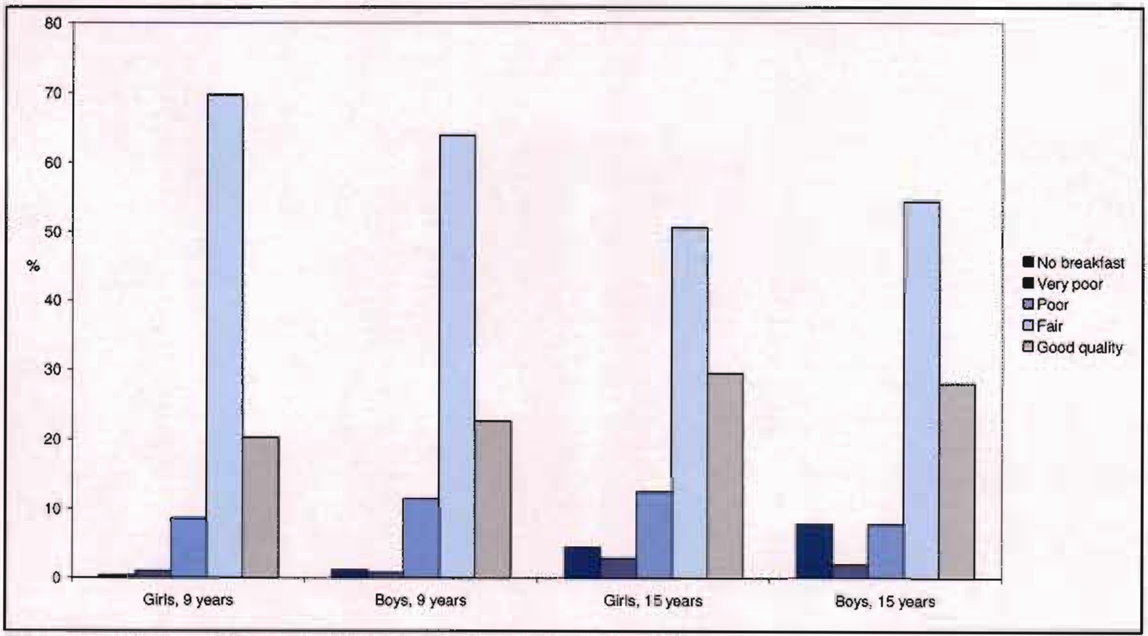

Figure 4.2 Breakfast quality score, by age and gender

4.5 ENERGY DENSITY

Energy density tertiles were created based on the cut-offs presented in Table 4.7. At both age groups, boys consumed more food (g) and more energy (kJ) than girls, and, at 15 years of age, also consumed diets of higher energy density. Cut-offs for the lower and higher tertiles were therefore similar in the younger age group, but different in the older group.

A χ-squared analysis between tertiles of energy density and tertiles of food group intakes found associations between high energy dense diets and many food groups, shown in the far left column of Table 4.8. A positive association was found for *spreads* (high and low fat), *cheese* (high fat), *bread* (low fibre), *sweetened drinks*, *pizzas, pies and pancakes*, *chips and crisps*, *sweets and chocolate* and *cakes and biscuits*. Negative associations were found for *low fat cheese*, *milk and yoghurt*, *vegetables*, *fruit*, *meat*, *fish*, and *pasta, rice and potatoes*. Even after conservative adjustment for multiple testing, many of these remained significant. Most associations were quite weak, with the highest tau-β values found for *fruit* (-.325), *pasta, rice and potatoes* (-.260), *vegetables* (-.258) and *sweets and chocolate* (.211). As the energy density calculated for the diet was already age and gender specific, these associations were calculated for the group as a whole. The actual mean intakes of these food groups at each energy density tertile and in all age and gender groups are shown in the remainder of Table 4.8.

With the exception of 9-year-old girls, energy intake increased significantly across diets of increasing energy density (Table 4.9). The macronutrient profile of those in the lowest energy density tertile most closely matched nutritional recommendations. The percentage of energy from fat and saturated fat increased across low to high energy dense diets, while protein decreased. The percentage of energy from sucrose increased (although not linearly

Table 4.7 Population specific cut-offs to define low, moderate and high energy density (ED) diets

			Food only, no beverages		
			ED (kJ/g)	Energy (MJ)	Food (g)
9 y					
Girls	Mean		6.86	6.77	1032
n = 287	SD	±	1.62	1.86	336
	Percentile	33rd	6.02	5.88	863
		66th	7.27	7.40	1157
Boys	Mean		6.77	7.36 ##	1131 ##
n = 265	SD	±	1.64	2.05	358
	Percentile	33rd	5.95	6.43	956
		66th	7.30	8.28	1252
15 y					
Girls	Mean		6.97	7.20 *	1089
n = 312	SD	±	1.90	2.41	413
	Percentile	33rd	5.91	6.06	902
		66th	7.45	7.90	1181
Boys	Mean		7.47 **,##	10.15 **,##	1426 **,##
n = 257	SD	±	1.75	3.34	552
	Percentile	33rd	6.57	8.57	1163
		66th	8.13	11.49	1604

* Age difference, $P < 0.05$

** Age difference, $P < 0.01$

\# Gender difference, $P < 0.05$

\## Gender difference, $P < 0.01$

Table 4.8 Association between energy density (ED) and food groups (all subjects), and intakes of food groups at different ED levels (by age and gender)

	All subjects		9 y Girls			Boys		
	Energy density		Low	Middle	High	Low	Middle	High
Food group			n = 97	n = 97	n = 97	n = 87	n = 87	n = 87
	K Tau-b	Sig	Mean (g) SD	Mean (g) SD	Mean (g) SD	Mean (g) SD	Mean (g) SD	Mean (g) SD
Spreads	0.166	0.000	13 ± 11	16 ± 15	19 ± 17	12 ± 11	17 ± 15	23 ± 19
high fat spreads	0.097	0.000	*7 ± 10*	*7 ± 9*	*9 ± 13*	*7 ± 9*	*8 ± 10*	*12 ± 18*
low fat spreads	0.077	ns	*7 ± 9*	*9 ± 14*	*10 ± 15*	*5 ± 9*	*10 ± 14*	*11 ± 15*
Cheese	0.084	0.002	17 ± 29	27 ± 44	23 ± 38	10 ± 21	30 ± 40	36 ± 52
low fat cheese	-0.059	ns	*2 ± 9*	*2 ± 8*	*1 ± 5*	*1 ± 5*	*4 ± 12*	*1 ± 5*
high fat cheese	0.117	0.000	*15 ± 29*	*25 ± 43*	*22 ± 37*	*9 ± 21*	*26 ± 39*	*35 ± 53*
Milk, yoghurt	-0.105	0.000	560 ± 339	490 ± 302	509 ± 308	737 ± 412	711 ± 399	480 ± 294
full fat milk, yoghurt	-0.137	0.000	*267 ± 312*	*158 ± 241*	*160 ± 221*	*329 ± 343*	*245 ± 270*	*146 ± 201*
low fat milk, yoghurt	-0.001	ns	*293 ± 271*	*332 ± 273*	*350 ± 305*	*408 ± 394*	*466 ± 412*	*334 ± 297*
Bread	0.175	0.000	69 ± 46	96 ± 76	115 ± 77	74 ± 56	110 ± 84	140 ± 80
high fibre bread	-0.038	ns	*11 ± 23*	*9 ± 19*	*14 ± 36*	*14 ± 24*	*18 ± 32*	*16 ± 37*
low fibre bread	0.202	0.000	*57 ± 45*	*87 ± 78*	*100 ± 77*	*60 ± 57*	*92 ± 80*	*124 ± 81*
Vegetables	-0.258	0.000	92 ± 96	55 ± 62	39 ± 38	69 ± 85	69 ± 92	29 ± 46
Fruit	-0.325	0.000	230 ± 195	117 ± 124	62 ± 86	169 ± 165	86 ± 100	56 ± 76
Fruit juice	-0.039	ns	99 ± 166	114 ± 174	67 ± 134	110 ± 215	89 ± 180	103 ± 208
Cereal	-0.178	0.000	48 ± 97	31 ± 77	17 ± 52	50 ± 95	55 ± 107	42 ± 90
Pasta, rice, potatoes	-0.260	0.000	214 ± 167	201 ± 153	122 ± 108	257 ± 176	225 ± 172	127 ± 117
Pizzas, pies, pancakes	0.111	0.000	29 ± 76	40 ± 89	54 ± 99	27 ± 72	40 ± 95	66 ± 111
Meat, dishes	-0.053	ns	143 ± 145	141 ± 112	115 ± 101	167 ± 155	152 ± 117	148 ± 117
burgers, sausages	-0.048	ns	*87 ± 118*	*101 ± 105*	*67 ± 80*	*102 ± 111*	*104 ± 108*	*94 ± 105*
Fish, dishes	-0.060	ns	41 ± 76	25 ± 47	19 ± 41	26 ± 51	29 ± 65	18 ± 58
Poultry, dishes	0.011	ns	12 ± 41	7 ± 26	10 ± 39	15 ± 45	12 ± 44	15 ± 75
Chips, crisps	0.134	0.000	19 ± 62	26 ± 77	28 ± 63	9 ± 35	20 ± 55	15 ± 40
Sauces	-0.066	ns	30 ± 54	26 ± 46	23 ± 39	40 ± 60	30 ± 45	17 ± 33
high fat sauces	0.044	ns	*5 ± 23*	*8 ± 26*	*9 ± 22*	*12 ± 36*	*10 ± 30*	*5 ± 17*
reduced fat sauces	-0.094	0.001	*24 ± 50*	*18 ± 40*	*14 ± 31*	*28 ± 52*	*19 ± 39*	*11 ± 29*
Desserts, ice-cream, jam, added sugar	0.016	ns	63 ± 103	66 ± 93	51 ± 70	100 ± 139	78 ± 127	82 ± 94
Sweets, chocolate	0.211	0.000	14 ± 32	18 ± 24	35 ± 43	7 ± 10	17 ± 24	25 ± 40
Cakes, biscuits	0.067	ns	25 ± 43	28 ± 40	33 ± 48	18 ± 33	18 ± 34	29 ± 46
Sweetened drinks	0.158	0.000	117 ± 183	195 ± 283	217 ± 244	153 ± 216	124 ± 212	213 ± 283

Table 4.8 continued

	15 y Girls			Boys		
Energy density	Low	Middle	High	Low	Middle	High
Food group	n = 104 Mean (g) SD	n = 104 Mean (g) SD	n = 104 Mean (g) SD	n = 85 Mean (g) SD	n = 86 Mean (g) SD	n = 86 Mean (g) SD
Spreads	10 ± 10	12 ± 10	15 ± 15	15 ± 15	20 ± 17	29 ± 38
high fat spreads	*5 ± 8*	*6 ± 9*	*8 ± 11*	*6 ± 13*	*9 ± 13*	*11 ± 14*
low fat spreads	*5 ± 8*	*6 ± 7*	*8 ± 11*	*9 ± 12*	*12 ± 16*	*18 ± 39*
Cheese	25 ± 33	23 ± 32	41 ± 52	37 ± 50	49 ± 64	56 ± 73
low fat cheese	*9 ± 24*	*3 ± 11*	*8 ± 28*	*11 ± 37*	*4 ± 21*	*6 ± 25*
high fat cheese	*16 ± 26*	*20 ± 30*	*33 ± 47*	*26 ± 41*	*45 ± 63*	*50 ± 71*
Milk, yoghurt	527 ± 433	508 ± 355	408 ± 310	865 ± 466	782 ± 549	706 ± 516
full fat milk, yoghurt	*144 ± 222*	*132 ± 235*	*93 ± 182*	*301 ± 408*	*309 ± 413*	*158 ± 296*
low fat milk, yoghurt	*382 ± 368*	*376 ± 327*	*315 ± 300*	*564 ± 454*	*472 ± 422*	*548 ± 507*
Bread	88 ± 64	102 ± 68	112 ± 81	148 ± 125	163 ± 121	192 ± 124
high fibre bread	*31 ± 56*	*19 ± 32*	*17 ± 33*	*25 ± 50*	*22 ± 47*	*22 ± 43*
low fibre bread	*57 ± 54*	*83 ± 66*	*95 ± 81*	*123 ± 129*	*141 ± 123*	*170 ± 129*
Vegetables	163 ± 132	103 ± 99	57 ± 68	124 ± 136	75 ± 67	49 ± 64
Fruit	255 ± 257	124 ± 139	56 ± 110	149 ± 197	75 ± 119	39 ± 74
Fruit juice	144 ± 244	136 ± 219	136 ± 248	134 ± 250	141 ± 263	119 ± 224
Cereal	42 ± 93	26 ± 60	17 ± 43	89 ± 160	31 ± 72	22 ± 67
Pasta, rice, potatoes	202 ± 155	168 ± 122	103 ± 111	368 ± 248	244 ± 187	137 ± 158
Pizzas, pies, pancakes	16 ± 55	52 ± 99	38 ± 90	45 ± 181	35 ± 95	53 ± 114
Meat, dishes	111 ± 109	122 ± 100	103 ± 105	223 ± 179	265 ± 179	168 ± 167
burgers, sausages	*74 ± 99*	*80 ± 90*	*63 ± 91*	*130 ± 151*	*175 ± 179*	*106 ± 142*
Fish, dishes	36 ± 91	34 ± 55	21 ± 61	35 ± 74	33 ± 89	15 ± 45
Poultry, dishes	7 ± 28	14 ± 61	16 ± 48	15 ± 73	5 ± 29	7 ± 34
Chips, crisps	10 ± 35	25 ± 62	39 ± 69	29 ± 72	47 ± 81	47 ± 93
Sauces	32 ± 44	24 ± 37	17 ± 36	37 ± 58	47 ± 76	21 ± 42
high fat sauces	*10 ± 27*	*10 ± 24*	*5 ± 17*	*5 ± 25*	*16 ± 45*	*10 ± 27*
reduced fat sauces	*22 ± 39*	*14 ± 29*	*12 ± 34*	*32 ± 55*	*31 ± 67*	*11 ± 31*
Desserts, ice-cream, jam, added sugar	67 ± 109	66 ± 120	56 ± 100	71 ± 144	125 ± 184	46 ± 70
Sweets, chocolate	21 ± 31	31 ± 40	71 ± 73	27 ± 40	39 ± 56	60 ± 85
Cakes, biscuits	14 ± 30	24 ± 48	30 ± 49	14 ± 39	30 ± 53	30 ± 51
Sweetened drinks	108 ± 194	208 ± 288	262 ± 282	208 ± 272	445 ± 486	511 ± 547

Table 4.9 Macronutrient intakes by energy density level, by age and gender

	9 y Girls			Boys		
Energy density	Low	Middle	High	Low	Middle	High
	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD
Energy (MJ)	7.87 ± 1.89	8.24 ± 2.01	8.51 ± 2.12	8.33 ± 2.27^{a}	9.18 ± 2.24^{b,c}	9.45 ± 2.26^{c}
Protein (g)	75 ± 22	73 ± 22	72 ± 23	81 ± 25	88 ± 28	81 ± 26
% protein	16.1 ± 3.3^{a}	15.0 ± 3.0$^{b, c}$	14.2 ± 2.8^{c}	16.4 ± 3.1^{a}	16.1 ± 3.1$^{a, b}$	14.4 ± 3.3^{c}
Fat (g)	66 ± 22	72 ± 24	81 ± 27	67 ± 22	82 ± 27	89 ± 29
% fat	31.3 ± 6.0^{a}	33.0 ± 6.5$^{a, b}$	35.5 ± 6.9^{b}	30.1 ± 4.7^{a}	33.6 ± 5.8$^{b, c}$	35.4 ± 6.8^{c}
Carbohydrates (g)	246 ± 64	255 ± 71	253 ± 69	263 ± 79	273 ± 70	281 ± 77
% carbohydrates	52.3 ± 6.9	51.9 ± 7.3	50.0 ± 7.6	52.9 ± 5.3^{a}	50.1 ± 6.7$^{b, c}$	50.0 ± 8.0^{c}
Saturated fat (g)	31 ± 11	33 ± 12	36 ± 13	31 ± 10	38 ± 13	41 ± 15
% saturated fat	14.6 ± 3.0^{a}	14.9 ± 3.4$^{a, b}$	16.0 ± 4.1^{b}	13.9 ± 2.4^{a}	15.3 ± 2.8$^{b, c}$	16.2 ± 3.8^{c}
Sucrose (g)	47 ± 28	54 ± 30	61 ± 33	51 ± 30	52 ± 25	65 ± 37
% sucrose	10.0 ± 5.3^{a}	10.9 ± 5.1$^{a, b}$	11.9 ± 5.7^{b}	10.1 ± 4.9	9.6 ± 4.3	11.3 ± 5.7
Fibre (g)	16 ± 6	14 ± 6	13 ± 5	16 ± 6	15 ± 6	14 ± 5

	15 y Girls			Boys		
Energy density	Low	Middle	High	Low	Middle	High
	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD	Mean SD
Energy (MJ)	7.89 ± 2.37^{a}	8.64 ± 2.54^{a,b}	9.28 ± 3.05^{b}	11.61 ± 3.77^{a}	13.31 ± 3.70^{b}	12.41 ± 3.73^{a,b}
Protein (g)	73 ± 29	77 ± 24	75 ± 29	116 ± 45	121 ± 41	106 ± 42
% protein	15.5 ± 3.4^{a}	15.1 ± 3.0$^{a, b}$	13.6 ± 3.7^{c}	16.8 ± 3.5	15.3 ± 3.4	14.2 ± 3.1
Fat (g)	59 ± 23	73 ± 26	85 ± 36	88 ± 34	117 ± 43	113 ± 40
% fat	27.7 ± 6.4^{a}	31.8 ± 5.7^{b}	33.9 ± 7.1^{c}	28.4 ± 5.9^{a}	32.8 ± 6.4$^{a, b}$	34.3 ± 7.0$^{b, c}$
Carbohydrates (g)	264 ± 79	272 ± 91	286 ± 100	376 ± 131	407 ± 121	380 ± 126
% carbohydrates	56.3 ± 7.4^{a}	52.8 ± 6.2$^{b, c}$	52.1 ± 8.3^{c}	54.4 ± 6.9^{a}	51.4 ± 7.3$^{a, b}$	51.2 ± 8.1$^{b, c}$
Saturated fat (g)	26 ± 12	32 ± 11	39 ± 18	41 ± 18	53 ± 21	51 ± 21
% saturated fat	12.2 ± 3.6^{a}	13.8 ± 2.9^{b}	15.4 ± 4.0^{c}	13.1 ± 3.5^{a}	14.8 ± 3.5$^{a, b}$	15.3 ± 3.7$^{b, c}$
Sucrose (g)	50 ± 26	63 ± 40	80 ± 44	63 ± 40	100 ± 58	100 ± 64
% sucrose	10.8 ± 5.0^{a}	12.0 ± 5.3$^{a, b}$	14.8 ± 7.5^{c}	9.2 ± 4.8^{a}	12.6 ± 6.4$^{b, c}$	13.3 ± 7.0^{b}
Fibre (g)	19 ± 9	16 ± 7	14 ± 7	23 ± 10	20 ± 9	18 ± 7

$^{a, b, c}$ Figures with different superscripts are significantly different, $P < 0.05$.

in 9-year-old boys), but the percentage of energy contributed by total carbohydrates decreased (not significant in 9-year-old girls). Fibre intakes decreased as the energy density of the diet increased.

Dietary energy density did not differ between subjects who were normal/under-weight and those who were overweight or obese. From the logistic regression performed to see if dietary energy density could predict the likelihood of a child or adolescent being overweight, neither it, nor gender, age, or maternal education were associated with overweight in this population.

4.6 SOCIOECONOMIC STATUS AND DIET

Data on maternal education was missing for 63 subjects. Of the remainder, 31 % of 9-year-old boys and girls had mothers with a university level education. The proportion of highly educated mothers was higher in the 15-year-olds, at 40 % of girls and 36 % of boys.

Children of different maternal education levels did not differ overall in the percentage of protein, fat (including saturated fat) or carbohydrates (including sucrose) in their diets. The only exception was in 15-year-old boys, whose percentage intake of sucrose was higher in the low- educated maternal group (12 % *vs.* 10 %, $P = 0.039$).

The proportion of subjects consuming a healthy breakfast differed by maternal education level (Figure 4.3). For the whole sample, of those with mothers whose education level was classed as low, 22 % reported eating a healthy breakfast, compared to 31 % of those with more educated mothers (Pearson χ^2 10.251, $P = 0.002$, df = 1). This effect was more pronounced in the younger age group: 29 % of 9-year-olds with highly educated mothers consumed a healthy breakfast compared to 19 % of those with low-educated mothers ($P < 0.01$). The comparable figures for 15-year-olds were 33 % *vs.* 27 % ($P < 0.05$).

A logistic regression was performed to predict the consumption of a healthy breakfast from maternal education, adjusting for age and gender. As age was a significant predictor in the model ($B = 0.059$, $P = 0.013$), but gender was not, the subjects were split by age. Maternal education was found to be a significant predictor of healthy breakfast consumption in 9-year-olds ($B = 0.607$, $P = 0.005$). Calculated as an odds ratio, the odds of consuming a healthy breakfast was 1.8 (95 % CI 1.2-2.8) for those 9-year-olds with highly educated mothers compared to those without. No effect of gender or maternal education was found in the 15-year-olds.

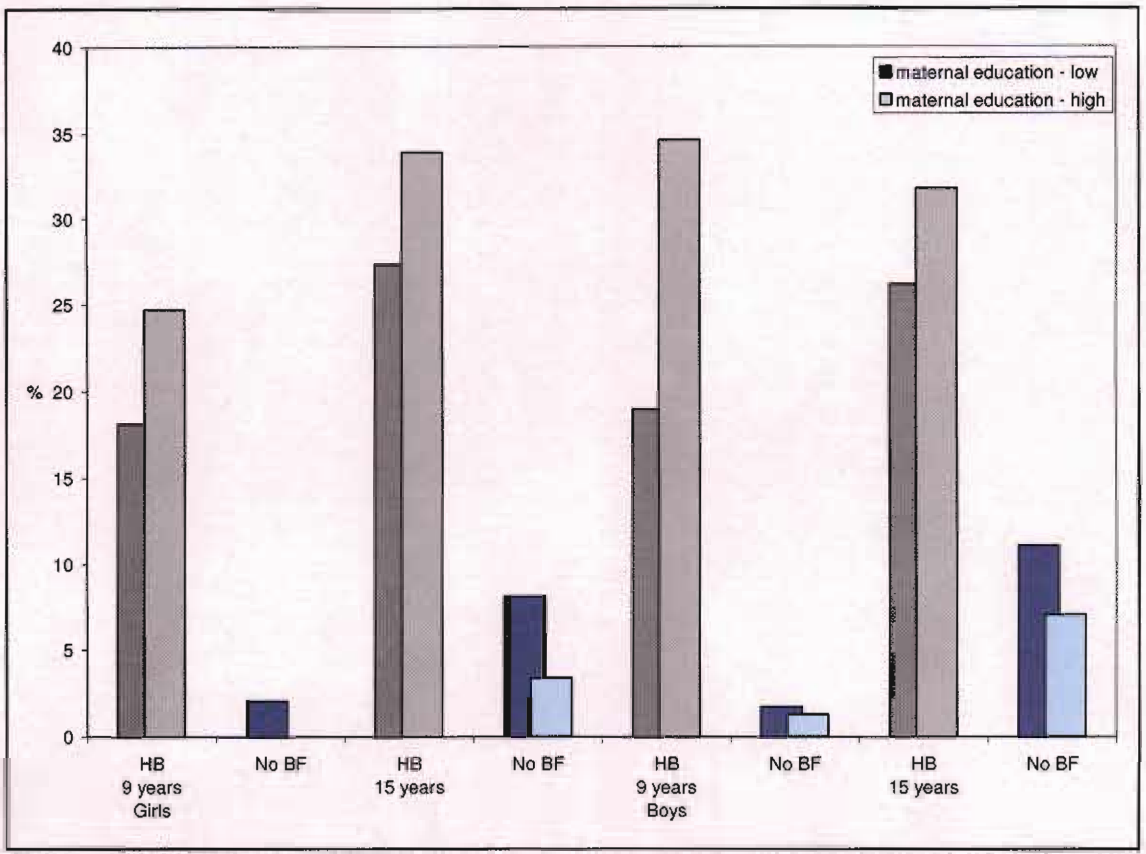

Figure 4.3 Healthy breakfast (HB) consumption and breakfast (BF) skipping, by age, gender and maternal education level. Lighter coloured bars within the HB or No BF groups represent subjects whose mothers had higher education

Boys and girls, at both 9 and 15, whose mothers had a high education level had lower total dietary energy density values than those whose mothers had a low education. This difference was significant only in 9-year-old boys. In 9-year-old girls, a negative association was seen between higher maternal education and overweight status – 22 % of girls with low-educated mothers were overweight, compared to 10 % of those with highly educated mothers (*P* = 0.009, Pearsons χ^2 5.926, df = 1). For all other age and gender groups, no such differences were seen.

4.7 ENERGY REPORTING

The group bias in energy reporting was assessed using the Goldberg equation. The factors used in the equation, and their sources, are presented in Table 3.3. The PAL values assigned, and the tertile cut-offs for designating activity levels are detailed in Table 4.10. With regard to energy reporting, the groups evaluated were: the whole sample, girls and boys, 9-year-olds and 15-year-olds, and normal weight and overweight subjects.

Table 4.10 Activity data, by age and gender showing tertile cut-offs and PALs used

		Activity level	CPM cut-offs	Mean CPM	PAL
9 y	Girls	Low	< 562	472	1.48
		Mod	-	643	1.68
	n = 229	High	> 718	874	1.88
	Boys	Low	< 680	549	1.54
		Mod	-	779	1.75
	n = 197	High	> 878	1082	1.96
15 y	Girls	Low	< 412	335	1.46
		Mod	-	469	1.66
	n = 200	High	> 535	663	1.86
	Boys	Low	< 445	352	1.60
	n = 155	Mod	-	526	1.82
		High	> 603	784	2.04

CPM - Counts per minute, recorded by accelerometer
PAL values are age, gender and activity level specific (FAO/WHO/UNU, 1985)
Missing accelerometer data, n = 319

Table 4.11 shows that in all of the groups examined, mean energy intake to BMR ratio (EI:BMR) fell below the lower 95 % CI of the expected value, but the difference varied considerably. The male and normal weight groups reported intakes that were just below the cut-offs, while girls, 15-year-olds and overweight and obese groups were well below the limit. Age, gender and activity level specific cut-offs were also calculated to briefly assess the proportion of subjects that would be classified as under- or over-reporting at the individual level (Table 4.12). Again, the subgroups with the highest percentage of under-reporting are girls, particularly aged 15 y. Subjects in the lowest activity category report intakes within the estimated ranges, but as the activity level increases, the percentage identified as under-reporting increases.

Table 4.11 Goldberg cut-offs to establish 95 % CI limits

	EI:BMR	95 % CI		PAL
	Mean ± SD	Lower	Upper	Mean
ALL *n =781*	1.54 ± 0.47	1.75	1.69	1.72
9 y *n = 428*	1.63 ± 0.41	1.67	1.76	1.71
15 y *n = 356*	1.42 ± 0.51	1.68	1.78	1.73
Girls *n = 431*	1.40 ± 0.43	1.63	1.72	1.67
Boys *n = 353*	1.70 ± 0.47	1.73	1.84	1.78
Normal weight *n = 665*	1.57 ± 0.47	1.69	1.77	1.73
Overweight *n = 116*	1.32 ± 0.41	1.60	1.77	1.68

Missing accelerometer data, n = 319
Missing BMI data, n = 4

Table 4.12 Age, gender and activity specific cut-offs, and proportion of subjects under-, adequately and over-reporting

		Activity level	Lower cut-off	EIrep:BMRest Mean ± SD	Upper cut-off	UR %	AR %	OR %
9 y	Girls	Low	1.39	1.52 ± 0.40	1.58	39	18	42
		Mod	1.58	1.53 ± 0.32	1.79	56	23	21
	n = 229	High	1.77	1.60 ± 0.42	2.00	64	13	22
	Boys	Low	1.44	1.65 ± 0.37	1.65	25	25	51
		Mod	1.63	1.73 ± 0.52	1.88	42	26	32
	n = 197	High	1.83	1.78 ± 0.39	2.10	56	23	21
15 y	Girls	Low	1.36	1.15 ± 0.38	1.57	70	19	10
		Mod	1.55	1.26 ± 0.39	1.78	73	18	9
	n = 200	High	1.74	1.27 ± 0.47	1.99	83	9	8
	Boys	Low	1.49	1.56 ± 0.43	1.72	45	20	35
	n = 155	Mod	1.69	1.65 ± 0.48	1.96	58	13	29
		High	1.90	1.80 ± 0.60	2.20	62	13	25

UR = Under-reporters (EI:BMR below lower cut-off limit)
AR = Adequate reporters (EI:BMR between cut-off limits)
OR = Over-reporters (EI:BMR above upper cut-off limit)

Missing accelerometer data, n = 319
Missing BMI data, n = 4

5 DISCUSSION

5.1 STUDY STRENGTHS AND LIMITATIONS

5.1.1 Participation

The European Youth Heart Study (EYHS) is an international study with the aim of studying cardiovascular disease risk factors and their development in children and adolescents in Europe. As a multi-centre, multidisciplinary study, the EYHS study design was carefully developed by experts in epidemiology and dietary, physical activity and physical fitness assessment (Riddoch *et al.*, 2005). A detailed protocol was drawn up to ensure standardised, comparable data between study centres. A study such as EYHS asks a lot of its participants. The more data that is collected in a study, the greater the burden on subjects, and the greater the likelihood that people will decline to participate. Non-participation is therefore an almost inevitable part of any large study. While non-differential response (*i.e.* where all age groups, genders, socioeconomic status or other potentially important determinants of study outcomes are equally likely as not to participate) will only have the effect of reducing power, a differential response (*i.e.* where some groups are under-represented) can lead to bias. The sampling frame can be designed to ensure that the study sample is representative of the general population, but the eventual study sample recruited cannot be guaranteed. The relatively low participation rate of EYHS (49 %) prompted a detailed non-participation study in order to establish if the sample was representative. The results of this suggest that children of highly educated mothers may have been over-represented (Wennlöf *et al.*, 2003). This has been found before in other Swedish dietary studies on children. Berg *et al.* (1998) reported lower participation rates from those from more disadvantaged social groups. Conclusions about the effect of socio-economic status and diet must be drawn that are mindful of this.

5.1.2 Physical activity

The method of assessment used to estimate physical activity levels – accelerometry – was objective. This is a major strength of EYHS, as subjective, self-reports of physical activity are more commonly used in studies of this size. Physical activity, like diet, is difficult to report accurately. Duration, intensity and frequency are all important components of total physical activity, but the subjective nature of intensity, combined with general issues with recalling "usual" behaviour make self-reported data of limited value (Trost *et al.*, 2005). Although accelerometers also have certain limitations, they are not affected by the issues of self-reported methods and have been found to be appropriate for measuring child and adolescent activity. In EYHS, accelerometers were worn for a minimum of 4 days, which has been determined as an adequate length of time to reflect 'usual' physical activity patterns (Trost *et al.*, 2005). However, it must be acknowledged that it does not measure energy expenditure, which is the real variable of interest when evaluating energy intakes, but it is a feasible measure of total activity. In using physical activity data at individual level, one of the recommendations for the evaluation of under-reporting is met (Black, 2000a).

5.1.3 Dietary data

As discussed in Section 1.4, every dietary assessment method is prone to shortcomings and limitations. Since the sample to be studied was relatively large, for reasons of logistics and budget considerations, and for its ability to provide valid information at group level, a single interviewer-mediated 24-hour recall was chosen as the dietary assessment method. A validation study, using the gold-standard, doubly-labelled water method of energy requirement estimation, was conducted before commencement of the main data collection and confirmed the suitability of a 24-hour recall for assessing the dietary intakes of groups of children of these ages in this study (Poortvliet *et al.*, unpublished results). A repeated assessment in a subsample of participants in the main study would have strengthened the dietary data further, by providing a means of calculating the intra-individual variation, but this unfortunately was not possible. Although children above 8 years are deemed able to provide information on their diets (Livingstone & Robson, 2000), a one-day food record was kept by the parents of the 9-year-olds for the day preceding the interview (*i.e.* for the day of intake being recalled) as a precaution against problems that some of the younger children may have had with the task of dietary recall.

5.1.4 Dietary data treatment

In order to create more informative and well-defined food groups, the pre-existing ones in the Swedish database were revised. The limits used to define the new groups were set based on obvious differences (*e.g.* 1.5 % and 3 % fat milk), on the description of the food in the database, and on *a priori* assumptions about nutrients/food components and health, with the intention of creating subgroups that could be interpreted as "healthier" and "less healthy". For example, breads with the highest fibre content, or breads that had lower levels of fibre but which were wholegrain, were classed as *high fibre* (*i.e.* they were intended to reflect "healthier" choices of bread). This inevitably involved some subjective judgements and is acknowledged as a potential source of systematic error. For clarity, the cut-offs used are provided (Table 3.1). Both the old and new food groups are presented in Appendix D.

5.1.5 Energy density calculation

The decision to include and exclude certain beverage groups when calculating total dietary energy density remains somewhat arbitrary. Currently, not enough is known about the effect on satiety and dietary composition of all foods and beverages to justify their exclusion. Beverage intake is particularly prone to large intra-individual variation. The method used here was based on the most current recommendations (Cox & Mela, 2000; Ledikwe *et al.*, 2005)

5.1.6 Dietary data analysis

As discussed in Section 1.4.2, the appropriate use of dietary data collected is essential. For this reason, only group intakes are presented here, and only population goals are referred to (as opposed to RDIs). For the calculation of food sources of intakes, the population proportion method was used instead of the mean proportion method (see Section 3.4.4.2). This method, proposed by Krebs-Smith *et al.* (1989) is a way of calculating proportions in groups where only one day of data is available. It is intended to overcome the otherwise distorting effects of unusual excessively high or low intakes and of large variance in the dataset. This method has been used by others when presenting data on group level (Subar *et al.*, 1998; Royo-Bordonada *et al.*, 2003; Matthys *et al.*, 2006). Not all studies provide full details of how the proportions they report are calculated, a practice that can hinder comparisons between studies and possible future meta-analyses.

5.2 MAIN FINDINGS

5.2.1 The diets of Swedish children and adolescents did not meet population guidelines

5.2.1.1 Nutritional guidelines

The nutrition guidelines set by Swedish health authorities (and based on Nordic and WHO recommendations) state the recommended levels of, among other nutrients, dietary energy that should come from fat, protein and carbohydrate, saturated fat and sucrose at population level (see Table 4.2). These recommendations are based on expert consultations and are intended to help populations maintain optimal (diet-related) health.

While the overall macronutrient profile is reasonably close to the recommended amounts of percent of dietary energy from macronutrients, certain discrepancies are seen. The percentage of energy from saturated fat and sucrose are higher in all age and gender groups than the upper limits set (10 % E). This is very unlikely to be a chance finding, as these mirror closely the results of the most recent Swedish National Children's survey (SLV, 2006)). In this, children aged 4, 8 and 11 y kept a 4-day (estimated) food diary. The distribution of protein, fat and carbohydrates in the diet was 14-16 %, 31-32 % and 53-54 % of energy, respectively. Intakes of sugar and saturated fat, were found to be high: sugar provided 12-14 % of energy, and saturated fat 14 %. High sugar intakes have been found even in pre-school children in Sweden, where two-thirds had sucrose intakes in excess of recommended levels (Garemo *et al.*, 2007).

5.2.1.2 Food based dietary guidelines (FBDGs)

Neither gender reached the guideline of 500 g of fruits and vegetables per day. Girls consumed more fruit than boys at both ages, findings similar to both the European ProChildren study (Yngve *et al.*, 2005) and the international HBSC study (Currie *et al.*, 2004). While approximately three-quarters reported vegetable consumption, the description of a consumer (ate any amount of that food group) may have made this figure deceptively high - intakes among consumers ranged from 61 – 79 g in 9-year-olds, to 83 – 132 g in 15-year-olds. The strategy for increasing vegetable intakes in children and adolescents might therefore be to increase portion sizes. In contrast, due to the relatively low number of consumers, increasing fruit intakes will require a bigger change of habits in adolescents, from non-consumption to consumption, particular among boys.

Fish consumption prevalence was between 20 and 30 %. If the recommendation to eat fish 3 times a week was being complied with, then on any one day, then approximately 40 % of the sample would be expected to report it. Furthermore, while the recommendation implies whole fish, the definition of the fish food group here included *kaviar* - fish eggs, usually from cod, eaten commonly as a sandwich spread. Hence the relatively small mean amount of fish reported, even among those classified as consumers, and the likelihood that whole fish consumption is actually even lower than indicated here. Wholegrain or high-fibre bread, also mentioned in the FBDG, was not consumed by many children and adolescents and contributed far less to energy or carbohydrate intakes than low-fibre bread did.

5.2.2 Intakes of energy dense food groups were high

Bread; *pasta, rice and potatoes, vegetables*, *meat*, *milk and yoghurt,* and *spreads and oils* remain the traditional staple foods in Sweden. However, more than half of all subjects also consumed *sweets and chocolate*, *desserts*, *ice-cream*, *jam and sugars, sweetened beverages.* As mentioned in the previous section, the definition of consumers is rather generous, which means that intakes of sweet foods, while common, may not always be high. Considering the *total* group (not just consumers), the mean intakes of 9-year-old girls included 61 g of *desserts*, *ice-cream*, *jam and sugars*, 28 g of *cakes and biscuits*, 24 g of *chips and crisps*, 22 g of *sweets and chocolate*, and 178 g of *sweetened beverages.* For 15-year-old boys, the figures were 83 g, 25 g, 41 g, 42 g, and 389 g, respectively. These are foods that are high in sugar and/or fat and which do not contribute greatly to micronutrient intakes.

Between one fifth and one quarter of all dietary energy reported by these children and adolescents was contributed by food groups considered to be energy-dense, nutrient-poor, and suitable only for occasional consumption: *sweetened beverages*; *sweets and chocolate*; *cakes and biscuits*; *desserts, ice-cream, jams, sugars*; *chips and crisps.* These food groups accounted approximately three-quarters of all sucrose intakes, and almost a fifth of saturated fat. These findings again confirm the results of the SLV survey, and also show that the problem areas highlighted in children's diets in Sweden are present in adolescents too. In the SLV study, more than 500 ml of soft drinks were consumed daily in 10 % of the children, and together with sweets, crisps, cakes and biscuits, ice cream and desserts, these foods provided 25 % of daily energy intakes (SLV, 2006). Despite the differences in methodology between this study and the SLV study, the findings presented here were quite similar to theirs, and importantly, they suggest that a pattern similar to that found in children also exists in adolescents. One of the conclusions drawn by SLV about the results of their survey was that the Swedish FBDGs drawn up for adults were equally applicable to children. The findings from this study strongly support those conclusions.

To understand the persistent high intakes of saturated fat and sucrose, it might be necessary to look to features of the so-called "obesogenic" environment for an explanation (Swinburn & Egger, 2004). Cereal, fat and sugar are cheap food commodities that with little processing quickly increase in commercial added-value and palatability (Nestle, 2002). These foods are widely available, they are often cheap, they are easy to consume/require little preparation, and most importantly, appeal to most people. Thus, attempts to change the consumption patterns of these foods face severe challenges. Achieving the population goal of less than 10 % of energy from sucrose will require an alteration of eating habits of one or more of these popular food groups, which poses a huge challenge to public health nutritionists. Modification of foods using food technology is one option, such as the use of sweeteners in soft drinks. The now-accepted link between saturated fat and cardiovascular disease risk factors has resulted in the development of low-fat versions of a huge range of foods. What the long term effects of high, chronic intakes of these in young children would be is unclear, and whether it is desirable to accept as an inevitable fact that these foods will be consumed frequently, in large amounts, is also open to debate.

Furthermore, as food balance sheets from the 1970's through to the 1990's demonstrated, despite an increased awareness of the diet-health link, and the popularity during the same period for low-fat foods, the availability of total fat in the food supply remained stable (Brege, 1997). When low-fat products are produced, the fat that is removed does not automatically leave the food chain, but novel and innovative uses are found for it. For example, US food balance data shows a decline in milk (especially whole milk) since the

1950's, but this has been more than matched by the increase in cheese, frozen dairy products and cream (Putnum, 1999). The legacy of the distorted and unbalanced Common Agricultural Policy (CAP) of the EU has been to foster a system that still results in the production of milk and dairy products that is surplus to requirements (Faculty of Public Health, 2007), and the EU is legally bound to dispose of all excess dairy fat and milk. What is not exported is redirected back into the food chain in two ways: *hidden* methods, where subsidies encourage the food industry to use "cheap" dairy fats in manufactured pies, pastries, cakes and biscuits: and *direct* methods where milk and butter are subsidised for use by the not-for-profit sector, *e.g.* schools and hospitals (Faculty of Public Health, 2007). Data from the school milk programme in Sweden suggests that in schools accepting the EU's subsidised, full-fat, school milk, each child consumes on average 1.5 kg extra of saturated fat, per year, compared to what they would consume if they drank skimmed milk (Elinder, 2005). It is clear that long-term, sustainable changes to the food supply so that diets are more in line with recommendations will, in addition to issues of nutrition education and personal responsibility, undoubtedly require reforms of current food production and supply chains and agricultural policies (Lobstein, 2004; Faculty of Public Health, 2007).

5.2.3 Markers of dietary quality

5.2.3.1 Breakfast

Only a quarter of the sample consumed a "healthy" breakfast, although the percentage that didn't consume anything at all was very small. Although low, an increase in skipping breakfast was found with increasing age, as seen in the international HBSC study (Currie *et al.*, 2004). Skipping in this study meant someone who did not consume a breakfast on the day of recall. The definition of a breakfast skipper varies between other studies, from someone who consumes a breakfast on "all school days" (Currie *et al.*, 2004), to those that missed a breakfast on most days of a food record (Rampersaud *et al.*, 2005). Breakfast in another Swedish study of 15- and 16-year-olds was defined as a cereal component and at least a milk product, or a fruit/juice or a meat/fish/egg product (Sjöberg *et al.*, 2003), and regular breakfast consumption (all school days) was reported by 88 % of boys and 76 % of girls.

The easiest way for this population to improve their breakfast quality would be to include some fruit, vegetables or juice, as this was the food group missing from most breakfasts. Large cultural differences in the typical composition of breakfast is seen between countries (*e.g.* the frequent consumption of ready-to-eat cereals in the US, Britain and Ireland, pastries in Spain and France, sandwiches in Scandinavia). The importance of ready-to-eat fortified breakfast cereals is often considered as important to the contribution of breakfast to overall nutritional intakes and health in the countries in which this has been studied (Nicklas *et al.*, 2004), and these relationships may not be generalisable to all countries. However, even in countries where ready-to-eat cereal consumption is not as common, a positive relationship between breakfast habits and dietary intakes have been found (Matthys *et al.*, 2007).

5.2.3.2 Dietary energy density was associated with overall dietary quality

Not all foods with high energy density are "unhealthy", *e.g.* crisp bread, and conversely, not all with low energy density are "healthy", *e.g.* soft drinks. As such, the concept of energy density may be a difficult one to convey to the public, but the identification of dietary energy density as a useful marker of overall dietary quality could be quite useful to nutritional epidemiologists. The lack of a standard definition can make comparisons of results across studies difficult, especially where the method used is not explicitly stated, and the presence of under-reporting may affect overall energy density if it is foods that are high in energy density which are more likely to under-reported. Once the method of calculation is clear, energy density is easy to calculate and enables comparison across studies and populations. In contrast, data driven methods such as cluster or factor analysis are population- and dataset-specific and involve subjective interpretations.

The energy density of Swedish child and adolescent diets is presented here for the first time. It is perhaps not surprising that intakes of foods known to be high in energy density would be associated with increasing dietary energy density, and *vice versa.* However, the fact that this association was also seen for sweetened beverages, another nutrient-poor foodstuff but which was not included in the dietary energy density calculation, would seem to suggest that what is seen is a dietary pattern – *i.e.* that diets high in energy density are indeed characterised by lower *fruit* and *vegetable* intakes, and higher consumption of *full fat cheese, high fat spreads and oils, low fibre bread, desserts, cakes and biscuits, sweets and chocolate* and *sweetened drinks.* The distribution of energy from macronutrients was also closest to recommendations in the lowest energy density groups in all age and gender groups. This suggests that if population goals are to be met, the energy density of the diet will somehow have to be lowered.

Limited work has been done on the area of energy density and dietary quality, and particularly in children and adolescents, but low energy density has been associated with higher micronutrient and fruit and vegetable intakes, and higher diet quality in US adults

(Kant & Graubard, 2005; Ledikwe *et al.*, 2006), and children (Kant, 2003). Although a review by Drewnowski *et al.* (2004) found an inconclusive relationship between energy density and body weight, a more recent large-scale cross-sectional study of almost 10,000 adults in the US found an independent and significant association between energy density and BMI in women, between energy density and waist circumference in both men and women and with fasting insulin and the presence of the metabolic syndrome (Mendoza *et al.*, 2007). In children it has been found to correlate with predictors of obesity (Mendoza *et al.*, 2006).

Taking the results presented here to be in support of the theory that energy density is a marker of dietary quality, the next step will be to see if diets low in energy density are associated with healthier cardiovascular/metabolic risk profiles in these children and adolescents. It is acknowledged that subjects were ranked and assigned to a category of energy density. Arguments have been made against using dietary data in such a way (Freudenheim *et al.*, 1988) and so it is possible that some misclassification of subjects can have occurred, and any future use of energy density in a correlation/regression model may identify some of the problems with this method. Further work to validate and test this concept is needed. Another important consideration is to see whether, if it is a marker of a behaviour or lifestyle, this tracks over time - if the children with low energy densities continue to eat low energy dense diets, relative to their peers, when they are older.

5.2.3.3 Association between dietary quality and socioeconomic status

High maternal education was positively associated with healthy breakfast consumption. After adjustment for age, children with more educated mothers were found to be almost twice as likely to consume a healthy breakfast than those with mothers with lower education, and no effect was seen in the older age group. Attempts to promote healthy breakfast habits in children may need to consider those from different socioeconomic status groups separately. The mealtimes of children are more likely to be supervised than those of adolescents. One of the ways socioeconomic status is thought to influence child health is through better modelling by parental actions (Bradley & Corwyn, 2002) and perhaps this accounts for the influence on the younger age group only, although this requires further exploration to explain fully.

Dietary energy density was lower in children and adolescents of mothers with low education, but this association reached significance only in the younger boys. The subject of energy density and cost has been explored by in both a US and a European setting. It has been shown that more energy-dense diets are relatively cheap, whereas low-energy-density diets cost substantially more. The relationship between energy density and cost ($/MJ) in the US was investigated by Drewnowski and Specter (2004). The largest differences were noted between added fats and sugars and fresh fruits and vegetables. For example, the energy cost of soft drinks was, on average, 30 cents/MJ (3.66 MJ/$), whereas that of orange juice from concentrate was 143 cents/MJ (0.71 MJ/$). A simulation of cost constraints on a typical French diet found that food selection was influenced in a way that decreased the nutrient density of the diet (Darmon *et al.*, 2002). This is an area of interest that, given rising levels of obesity and persistent high intakes of fats and sugars, perhaps deserves exploration in many more countries.

5.2.4 Differences between ages and genders

Between the 9- and 15-year-olds, some food consumption patterns differed. Although a temporal trend is impossible to rule out, the relatively short time period (6 years) suggests that the differences seen in consumption frequency and intakes may be ones of true differences between childhood and adolescence.

Boys ate more at both ages than girls, and although the absolute intakes of macronutrients increased in boys between 9 and 15 years, they did not in girls. This was also found in a large review of children and adolescent intakes across Europe (Lambert *et al.*, 2004). As mentioned previously, more girls than boys consumed fruits and vegetables at both ages, and less consumed meat. Slightly more girls than boys reported consuming sweet food groups like *cakes and biscuits*, *desserts etc.*, and *sweets and chocolate*, although this difference was more pronounced in the younger age group. This may explain the slightly higher energy density of the diets of the 9-year-old girls, compared to the boys. By age 15, this had reversed and the difference was much greater. Adolescent boys are not only eating more food and more energy, but the energy density has also increased. However, the possibility of bias due to under-reporting by the adolescent girls cannot be overlooked (see Section 5.2.5).

The biggest differences seen between children and adolescents were for *milk and yoghurt* and *cheese*, the consumption prevalence of which decreased and increased, respectively. Milk is considered an important part of children's diets in Sweden, as it is in many northern European countries, and intakes are quite high in childhood. Although absolute intakes are higher in adolescence, the percentage of consumers decreases and the contribution to energy and fat intakes decreases, although an increasing consumption of low-fat milk and yoghurt products may explain this latter finding. A decrease in intakes with age as more "adult" drinks such as more coffee and tea are consumed is to be expected. A longitudinal study in Sweden from adolescence to adulthood suggests that this trend continues with increasing age (Von Post-Skagegard *et al.*, 2002). The increase in sweetened beverages seen between boys aged 9 and 15 y may also have replaced some milk consumption.

Slightly less saturated fat (as a % of energy), and slightly more sucrose, was reported by the older subjects. The major sources of sucrose identified did not differ markedly between age groups, with the exception of sweetened beverages among boys, where it increased. Meat, a major source of fat, decreased among girls only. The incidence of under-reporting appeared to be higher in the adolescent group (see next section).

5.2.5 Under-reporting is common among certain subgroups

It is likely that under-reporting is a significant issue in this sample. Despite the best precautions taken in the study design and data collection, the likelihood of energy under-reporting, common to all dietary studies, cannot be ignored. Although no validation with doubly-labelled water was possible, the use of statistical methods to compare intakes to probable requirements suggests that under-reporting is present, and is differentially affecting subgroups of the population. Older subjects (adolescents), females and overweight and obese groups all reported energy intakes (when expressed as EI_{rep}:BMR_{est}) that were further below their predicted values than did their younger, male or normal weight peers, respectively. These are trends similar to those found in children and adolescents, and with regard to weight and gender, also in adults (Livingstone & Robson, 2000). An increased awareness of "healthy" and "unhealthy" foods in these groups may have resulted in some conscious under-reporting of certain foods in order to project a favourable impression of their diet. It is possible that the under-reporting was lower in the 9-year-olds because the keeping of a food record may have helped them to remember and recall the foods they ate more accurately. As individuals that under-report cannot be identified with certainty, it is not realistic to delete all subjects that are believed to underreport. Instead, future analysis with this dataset should identify a subgroup of "low energy reporters" and run analysis separately on this group to identify if they differ from the others in any other respects (Black, 2000a). Although awareness of the issue of under-reporting has increased in recent times, a suitable solution to this problem is lacking, and more work to understand the statistical implications of it (Black, 2000a), as well as the psychosocial reasons behind it (Blundell, 2000) are needed.

5.3 FUTURE AREAS OF RESEARCH AND CONCLUSIONS

The availability of follow-up dietary data on these subjects, together with biochemical and physiological data, means that a re-examination of the data from a multi-disciplinary and longitudinal perspective will be possible, providing valuable information on the behaviour of these children and adolescents as they grow older. The use of energy density as a marker can be evaluated with regard to biological markers either cross-sectionally or longitudinally. The follow-up data will allow the comparisons of 15-year-olds at both time points (temporal effects) and of the same subjects when both 9- and 15-years old. This way it can be seen if the differences between the age groups shown here were the result of an age effect or a temporal effect. It will be possible to investigate if children and adolescents who already have different metabolic risk profiles, or very different activity patterns, also differ in terms of dietary intake. And importantly, whether these relationships progress over time in these age groups.

This study adds valuable information on children's and adolescents' diets in Sweden. In particular, the different choices that children and adolescents make and the quality of their diets have been examined. Several unhealthy practices are evident in this population group, namely high saturated fat and sugar intakes, and low fruit and vegetable intakes. The identification of the food group sources of these nutrients will be useful to public health policy makers in Sweden and could be used to develop FBDGs specific to this population. Maternal education can affect the diets of children and should be considered a factor in health promotion strategies. The use of energy density as a dietary marker has been applied in this population, to the best of our knowledge, for the first time. These findings will be re-evaluated from a longitudinal and multi-disciplinary perspective in the near future.

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APPENDIX A Tools to promote public health nutrition used by SLV

1. The Keyhole symbol (Nyckelhålet)

This is a voluntary, front-of-pack labelling system, which has been in use in Sweden for many years, and has a high level of recognition among the public. Foods in a given category may display the keyhole (Figure 1) if they contain better levels of fat, sugar, fibre and salt than other, comparable, foods. The criteria are therefore different for different food groups. The public is advised to consume foods with the keyhole symbol in one of the Swedish food-based dietary guidelines (see Table 1.1). The symbol was chosen as a fusion of the circle previously in use in Sweden, and the pyramid (triangle) popular in other countries as a tool to promote healthy eating (*e.g.* MyPyramid in the US).

Figure 1. The Keyhole symbol

2. The Food Circle (Matcirkeln)

Sweden has traditionally used a circle (Figure 2) to promote the consumption of a varied diet. Foods are divided into 7 food groups, each assigned an equal portion of the circle, with similar nutritional content. It does not advise on portion size or frequency, but is designed to encourage people to choose foods from all groups every day.

> " Nutritional needs are meet easily if the diet is varied and includes foods from the following 7 food groups every day:
>
> - vegetables
> - potatoes and root vegetables
> - meat, fish and eggs
> - fruits and berries
> - milk and cheese
> - bread and other cereal products
> - oils and spreads. "

3. The Plate model (Tallriksmodellen)

This is a guide designed to show how the various components of meals should be balanced (Figure 3).

> " The plate has three portions:
> One big portion is for potatoes, rice, pasta and bread
> A second big portion is for vegetables and fruit
> The third, and smallest, is for meat, fish, eggs or vegetarian alternatives
> Complete the meal with bread and a piece of fruit. "

Figure 2. The Food Circle

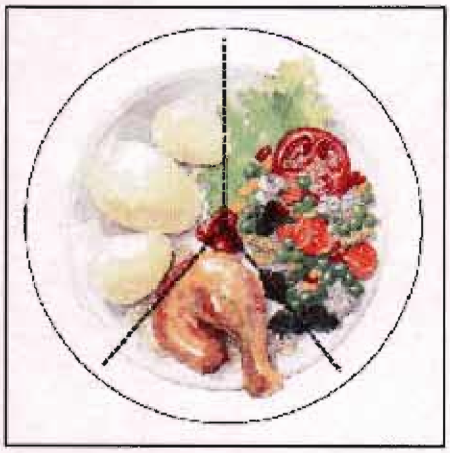


Figure 3. The Plate model

Source: Svenska Livsmedelsverket (SLV) [Swedish National Food Administration] http://www.slv.se

APPENDIX B Sweden

Capital: Stockholm
Population: 9,127,058 (2007 estimate)
Languages: Swedish

Form of government: Constitutional monarchy, parliamentary democracy
Accession to the European Union: January 1, 1995

Longest north-south distance: 1,574 km (978 mi.)
Longest east-west distance: 499 km (310 mi.)
Area: 450,000 km² (174,000 sq. mi.), third largest country in Western Europe

Average life expectancy: men 78 years, women 82 years

Hours of daylight:

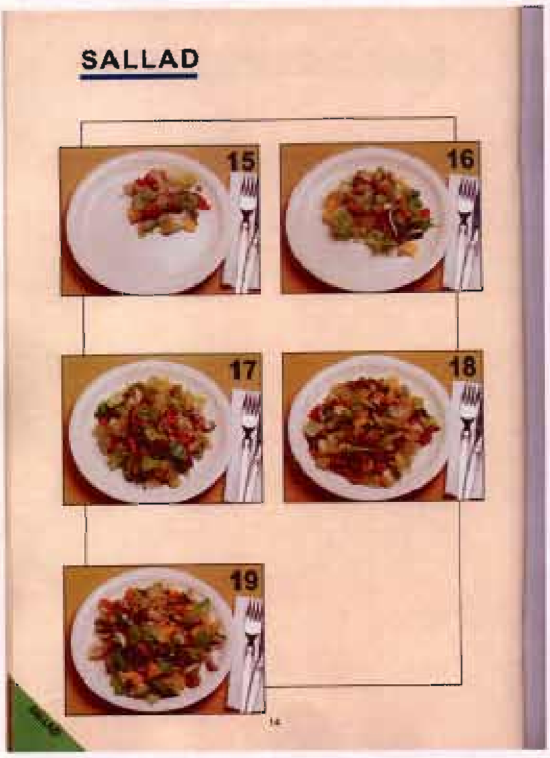
	1st January	1st July
Malmö	7 hours	17 hours
Stockholm	6 hours	18 hours
Kiruna	0 hours	24 hours

Average temperatures:

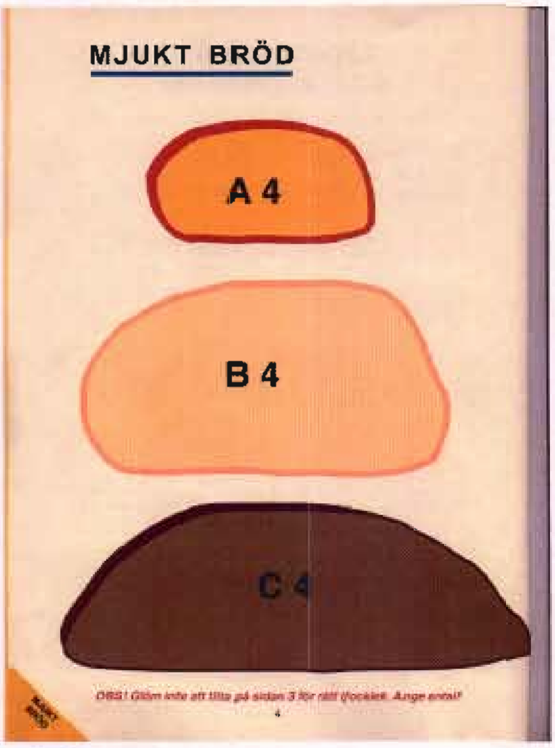
	January	July
Malmö	- 0.2° C	+ 16.8° C
Stockholm	- 2.8° C	+ 17.2° C
Kiruna	-16.0° C	+ 12.8° C

Sites of data collection for EYHS

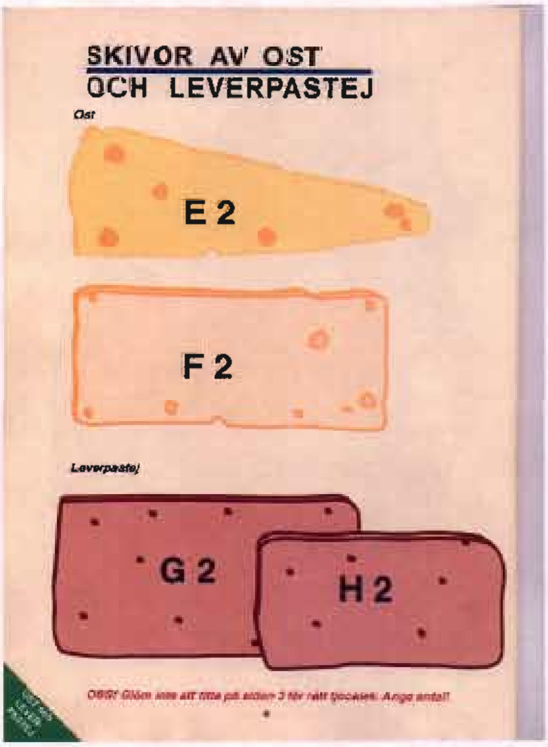
APPENDIX C Examples of portion size guides used



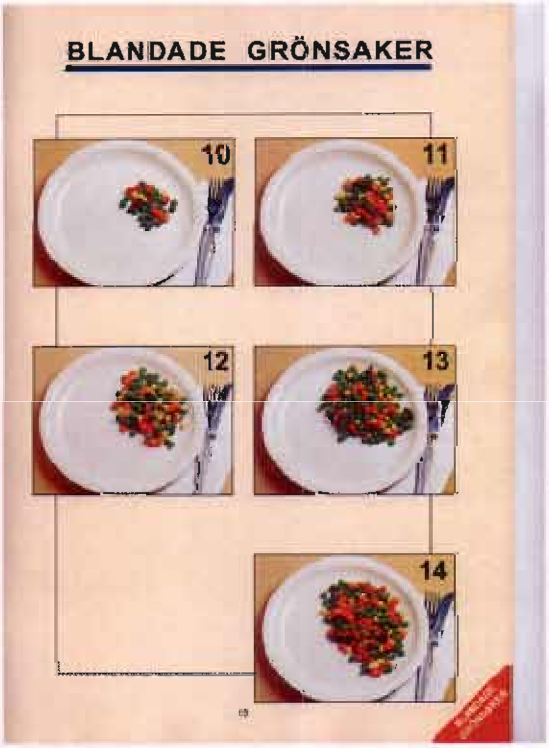
Salad



Soft bread



Slices of cheese and liver paste



Mixed vegetables

APPENDIX D List of old and new food groups

Food group (*n = 37*)
Fats and oils
Cheese
Milk and yoghurt
Bread
Potatoes
Roots and tubers
Vegetables
Fruits
Fruit juice
Porridge
Breakfast cereals
Pancakes, waffles
Pizza, pie, pastry
Rice and grains
Pasta
Beans
Meat and poultry
Eggs
Fish and shellfish
Blood pudding
Organs and offal
Sausages
Nuts, seeds, chips
Buns, cakes, cookies
Ice-cream
Cream
Sweet soups and desserts
Marmalade and jam
Soft drinks and sorbets
Sweets and chocolate
Sugar, honey, syrup
Beer, wine, spirits
Flours, starch
Coffee, tea, water
Spices, mustard, vinegar
Sauces
Sports food

New subgroups (*n = 57*)	**New food groups (*n = 23*)**
High fat spreads	**Spreads**
Lowfat spreads	
High fat cheese	**Cheese**
Low fat cheese	
Full fat milk and yoghurt	**Milk, Yoghurt**
Reduced fat milk and yoghurt	
High fibre bread	**Bread**
Low fibre bread	
Full fat sauces	**Sauces**
Reduced fat sauces	
Root vegetables	**Vegetables**
Other vegetables	
Fruit	**Fruit**
Fruit juice	**Fruit Juice**
Unsweetened cereal	**Cereal**
Sweetened cereal	
Porridge	
Pasta	**Pasta, rice and potatoes**
Rice	
Potatoes	
Potatoes cooked with oil	**Chips and crisps**
Snacks	
Pies savoury	**Pizza, pies, pancakes**
Pancakes	
Red meat	**Meat and meat dishes**
Meat dishes	
Burgers	
Offal	
Sausages	
Poultry	**Poultry and poultry dishes**
Poultry dishes	
Nuts	**Nuts, soya, legumes, eggs**
Soya, tofu	
Legumes	
Eggs	
White fish	**Fish and fish dishes**
Oily fish	
Fish dishes	
Seafood, caviar	
Cakes, biscuits	**Cakes, biscuits**
Desserts	**Desserts, ice cream, jam, sweet sauces, added sugar**
Ice cream	
Jams	
Sweet soups, sauces	
Sugar, honey	
Sweets, chocolate	**Sweets, chocolate**
Regular beverages	**Beverages (regular)**
Light/diet beverages	**Beverages (other)**
Alcoholic beverages	**Beverages (alcoholic)**
Vegetable dishes	**Miscellaneous**
Legume dishes	
Pasta dishes	
Coffee, tea	
Ketchup	
Sports foods	
Miscellaneous	