Strategies for the prevention of obesity in children

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Abstract

The prevalence of obesity is increasing at an unprecedented rate in the United Kingdom, in both adults and children. Obesity is a risk factor for many chronic diseases and may also lead to psychological disorders. The long-term successful treatment of obesity is a difficult goal to achieve. Preventing obesity, particularly in children, has become a public health objective. In this thesis, two strategies for the prevention of obesity in children are presented.

The first study utilised a health promotion approach. A school-based programme, aimed at children aged 5-7 years, was developed and delivered in lunchtime clubs over four school terms (initial cohort, *n* 218). Healthy eating and/or physical activity were the focus of the learning objectives in an interactive and supportive teaching environment. Results of the intervention showed an improvement in children's knowledge and a modest increase in fruit intake, which was independent of a rise in parental consumption. Schools appear to provide an important opportunity for children to undertake physical activity. Satisfaction with the programme was high for parents and teachers. This pilot study is the first such intervention in this age group in the UK and it may provide guidance for future initiatives. The teaching materials developed are to be made available nationally.

In a second study, the effect of glycaemic index (GI) on appetite and satiety was investigated in a cohort of children aged 9-11 years (*n* 37). In this within-subject design study, all subjects received three test breakfasts, low-GI, low-GI with added sucrose or high-GI, in a random order, for three days each. This was followed by a buffet style lunch where food intake was recorded covertly. Results showed a significantly lower lunch intake after the low GI and low GI with added sucrose breakfasts when compared to both the high-GI and a trial day when habitual breakfast was eaten at home. Satiety pre-lunch was rated lower after the high-GI breakfast compared to the other two breakfasts. This is the first study to investigate the effect of low-GI meals on appetite and satiety in a group of normal and overweight children. It adds to the growing body of evidence for a role of low-GI foods in weight management.

Obesity is a complex and multifactorial condition, which must be addressed on many levels. The research undertaken in this thesis provides evidence for pursuing both a health promotion approach and dietary manipulation to decrease the GI of a diet as potential strategies for the prevention of obesity in children.

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Abbreviations

AUC	Area under the curve
BMI	Body mass index
BMR	Basal metabolic rate
BP	Blood pressure
CAT	Computer-aided tomography
CCK	Cholecystokinin
CHD	Coronary heart disease
CI	Conicity index
CNS	Central nervous system
CVD	Cardiovascular disease
DEXA	Dual-energy X-ray analysis
DIT	Diet-induced thermogenesis
DLW	Doubly labelled water
EAR	Estimated average requirement
EI	Energy intake
FFM	Fat-free mass
FFQ	Food frequency questionnaire
GI	Glycaemic index
HR	Heart rate
LDL	Low-density lipoprotein
MRI	Magnetic resonance imaging
MUAC	Mid-upper arm circumference
NDNS	National Diet and Nutrition Survey
PAL	Physical activity level
PE	Physical education
PL	Packed lunch
PSHE	Personal social and health education
RMR	Resting metabolic rate
TBW	Total body water
TEE	Total energy expenditure
UCP	Uncoupling protein
VAS	Visual analogue scale
WHR	Waist: hip ratio

Chapter 1

Strategies for the prevention of obesity in children

1.1 Introduction

There is currently a rapid increase in the prevalence of obesity in adults and children in both developed and developing countries. The causes of obesity are multifactorial and include unfavourable environmental influences, genetic predisposition and biochemical abnormalities. The consequences of obesity are an increased risk of disease, psychological stress and a sizeable economic burden to the health service. Given its complex aetiology, it is not surprising that the successful long-term treatment of obesity is a difficult goal to achieve. Therefore, interest in pursuing a preventative approach to obesity, particularly in children, is growing.

In this thesis two preventative approaches to obesity are explored: (a) primary health promotion (b) dietary intervention. In the first part of the research a school-based, family-orientated study was undertaken aimed at promoting healthy lifestyle behaviours in children aged 5 -7 years. This study is a pilot study and marks a novel public health response to obesity prevention in the United Kingdom (UK).

In a second study, the potential effect of low-glycaemic index (GI) foods on appetite, satiety, and food intake, was investigated in children aged 9 -12 years. Recent reports suggest that low-GI foods may be an effective dietary strategy for treating obese children. This study is the first to investigate the effects of variable GI meals in children of normal weight.

1.2 Literature Review

1.2.1 Definition and classification of obesity

Obesity may be defined as a condition of excessive fat accumulation to the extent that health and well-being are affected (Deurenberg and Yap, 1999). The World Health Organisation's (WHO) definitions of overweight and obesity are based on the risks of increased morbidity and mortality (WHO, 1998). Body mass index (BMI), calculated by dividing weight (kg) by height $(m)^2$, categorises weight accounting for these risks (Table 1.1).

Table 1. 1 WHO cut-off points for the classification of overweight and obesity

BMI (kg/m^2)	WHO classification	Risk of co-morbidities
<18.5	Underweight	Low (but other clinical risks)
18.5-24.9	Normal	Average
25.0-29.9	Overweight	Increased
30.0-34.9	Obese class I	Moderate
35.0-39.9	Obese class II	Severe
≥40	Obese class III	Very severe

Source: WHO (1998)

This classification is useful, as it permits surveillance of obesity within countries and allows meaningful comparisons of obesity prevalence between countries to be made. In addition, it enables individuals and groups at risk of increased morbidity and mortality to be identified, highlights priorities for intervention both at individual and community levels, and provides a reference to evaluate interventions (WHO, 1998). However, the BMI has several limitations: it does not consider the regional distribution of body fat; it does not appear to correspond to the same degree of fatness or associated health risk between different individuals or population groups (WHO, 2000); and heavily muscled athletes will have a high BMI but will not be obese (Garrow, 1999). Garrow (1983) proposed that the relationship of increasing BMI and associated body fat reaches a plateau effect and has been interpolated in Figure 1.1.

Figure 1. 1 Relationship between BMI and percentage body fat (Garrow, 1983)

1.2.2 Measurement of body fat

In Caucasian populations, the BMI cut-off point for obesity corresponds to a percentage body fat of over 25% in young adult men and 35% in young adult females (Deurenberg and Yap, 1999). The accurate measurement of total body fat requires invasive and/or expensive investigations. The three reference methods are based on different assumptions: a constant characteristic density; water content; or potassium content (Garrow, 1999). All reference methods are based on two-compartment body composition models (Ellis, 2000).

1) Body density – assumes fat has a density of 0.90 kg/l and that 'fat-free mass' (FFM), i.e. water, protein, mineral, has a density of 1.0kg/l. Therefore, if the density of the whole body is measured (classically by underwater weighing) the proportion of fat can be calculated by deduction using the equation:

   $$4.96/D - 4.50$$

   where D stands for the density of the whole body (Garrow, 1999).

   Underwater weighing is beginning to be replaced by air-displacement plethysmography; the subject is placed in a closed air-filled chamber where the pressure is increased slightly to alter the subject chamber volume. This chamber is compared throughout to a reference chamber (Garrow, 1999).

2) Total body water – assumes that FFM contains 73% water and that fat is triacylglycerol, which does not contain water. If total body water (TBW) is measured by dilution of a tracer dose of labelled water, FFM is calculated by dividing TBW by 0.73 and total body fat is calculated by subtracting FFM from body weight.

3) Total body potassium – assumes body potassium, like all potassium, contains 0.114% of a very long-lived radioactive isotope ^{40}K, which emits a high-energy gamma ray. If this emission is measured in a sensitive counter the potassium content of the body can be measured. In men the potassium content of FFM is 66mmol/kg and in women it is 60 mmol/kg, therefore FFM and then fat mass can be calculated using the appropriate factor.

Total body fat can also be measured by more sophisticated methods such as neutron activation or total body electrical conductivity and by other multi-compartment models (Ellis, 2000). Bio-electrical impedance is a relatively inexpensive method of estimating body fat. An alternating current is passed between electrodes placed on the hand and foot and the impedance of the body reflects the relative amount of conducting material (intra- and extra- cellular water) compared to insulating material (i.e. fat). The limitations of this method are due to variability in the hydration state of the body; in addition, it is not suitable for the very obese (Ellis, 2000).

A less common approach to the measurement of body fat is near-infrared reactance where monochromatic light in the near-infrared is shone into subcutaneous tissue and the reflected signal indicates the proportion of fat or lean tissue under the skin.

The distribution or patterning of body fat in adults is a risk factor for later disease, independent of the level of obesity (Power et al., 1997). It is apparent that the risk of disease is greater in individuals with abdominal fat rather than truncal fat accumulation (Lean, 1995). Body fat distribution can be accurately assessed by computer-aided tomography (CAT) or magnetic resonance imaging (MRI) scanning and by dual-energy X-ray scanning (DEXA) (Garrow, 1999). However, in clinical practice or in most research settings, these methods are clearly not feasible, therefore other proxy measures of body fat, such as BMI or waist circumference, are used.

Skinfold measures (biceps, triceps, subscapular and supra-iliac) can provide a good estimate of body fat, except in the severely obese where measurement is difficult due to handling problems of the large fat stores and is prone to error (Durnin and Rahaman, 1967).

Waist circumference is a valuable measure of abdominal fat. Reference cut-off points for disease risk have been developed for Caucasian and South Asian populations (WHO, 1998; WHO, 2000) (Table 1.2). Further research on the application of waist circumference in monitoring disease risk in different populations is ongoing. It appears from epidemiological studies that waist circumference may be a better indicator of cardiovascular risk than waist: hip ratio (WHR) (Han, 1997). However, small reductions in waist circumference do not necessarily indicate loss of intra-abdominal fat.

Table 1. 2 Gender specific cut-off points for waist circumference (cm) in Caucasian and South Asian populations

	Waist circumference (cm) cut-offs for risk of metabolic complications	
	Increased	Substantially increased
Caucasian men	≥ 94	≥ 102
Caucasian women	≥ 80	≥ 88
South Asian men	≥ 90	*
South Asian women	≥ 80	*

* not defined Source: WHO (1998, 2000)

Another measure of central fat has been suggested: the conicity index (CI). This concept was proposed in 1991 (Valdez, 1991; Valdez et al., 1993) and was based on the idea that as people accumulate fat around the waist, their body shape changes from a cylinder to a 'double cone' (two cones with a double base). Measures of the CI and WHR were compared in seven European populations and found to have a good correlation (Valdez et al., 1993). An evaluation in children, of the sensitivity of waist circumference, WHR, and CI to measure trunk fat mass compared with DEXA found that CI was less effective than waist circumference but more effective than WHR (Taylor et al., 2000). The formula of the CI is

$$CI = \text{abdominal girth}/(0.109 \sqrt{W/H})$$

where the value 0.109 is a constant that results from the conversion of units of volume and mass into units of length. The CI has no units and its predicted range is between 1.00 (perfect cylinder) and 1.73 (perfect double cone). A person with a CI of 1.25 has a waist circumference which is 1.25 times greater than the circumference of a cylinder generated with their height and weight. The CI therefore accounts for height, has a theoretical expected range and does not require hip measurements (Valdez et al., 1993). Only a limited number of studies have looked at the relationship between CI and cardiovascular risk factors. In the Framingham Heart Study CI did not predict coronary heart disease (CHD) incidence and mortality; BMI was found to be a better marker (Kim et al., 2000).

1.2.3 Prevalence of obesity

Due to disparities in study sampling and methodological approaches, comparisons of obesity rates between countries are difficult. There is no doubt, however, of the alarming rate of increase in overweight and obese people globally. Obesity is most common in

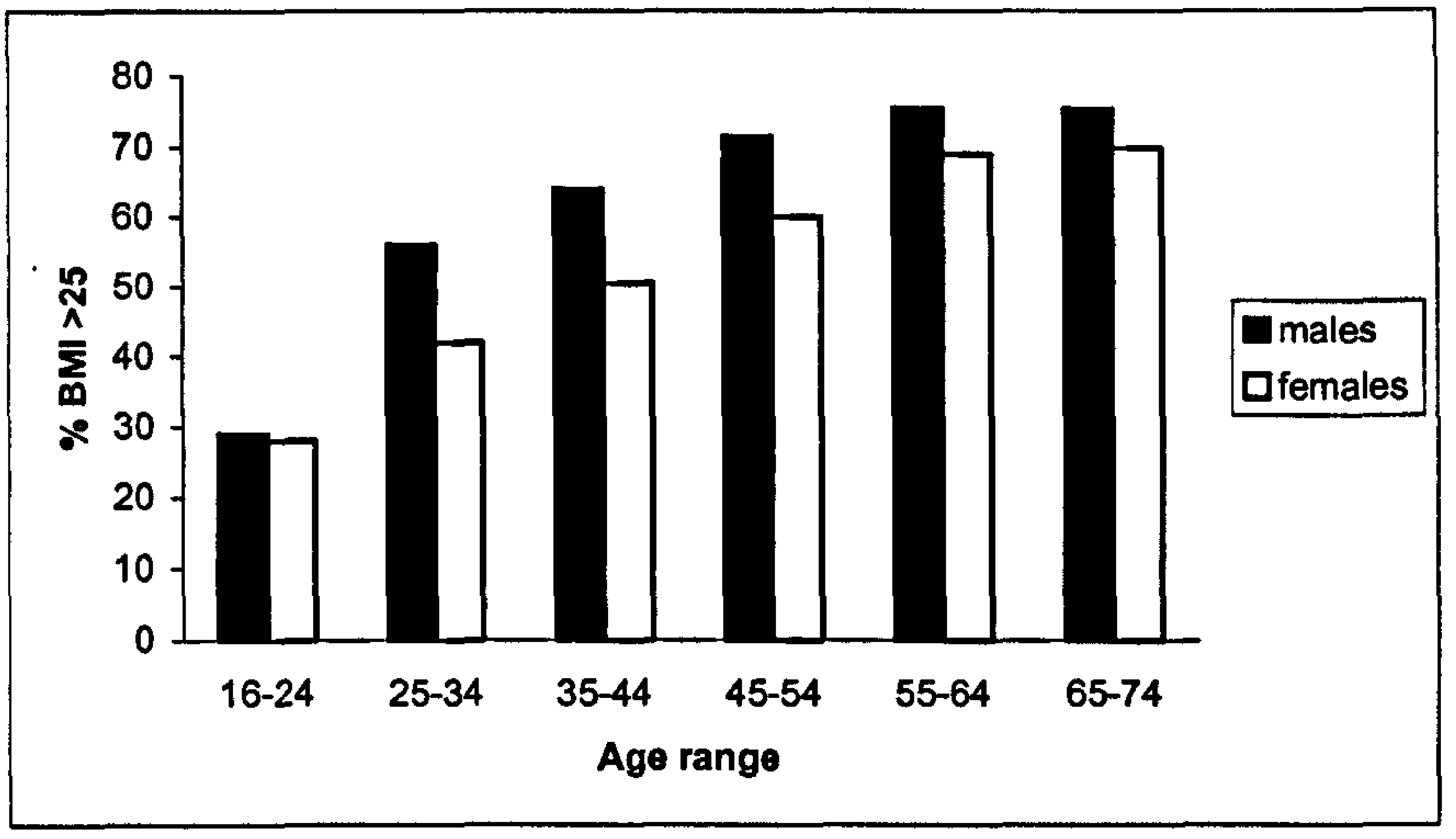
Westernized countries and within Europe is lowest in Scandinavian countries and highest in Eastern European countries (Fehily, 1999). A comparison of the male and female obesity levels in selected European countries is shown in Figure 1.2.

Figure 1. 2

In developing countries, problems of undernutrition and overnutrition may coexist such as in China, India, other South Asian countries and some African countries (WHO, 1998).

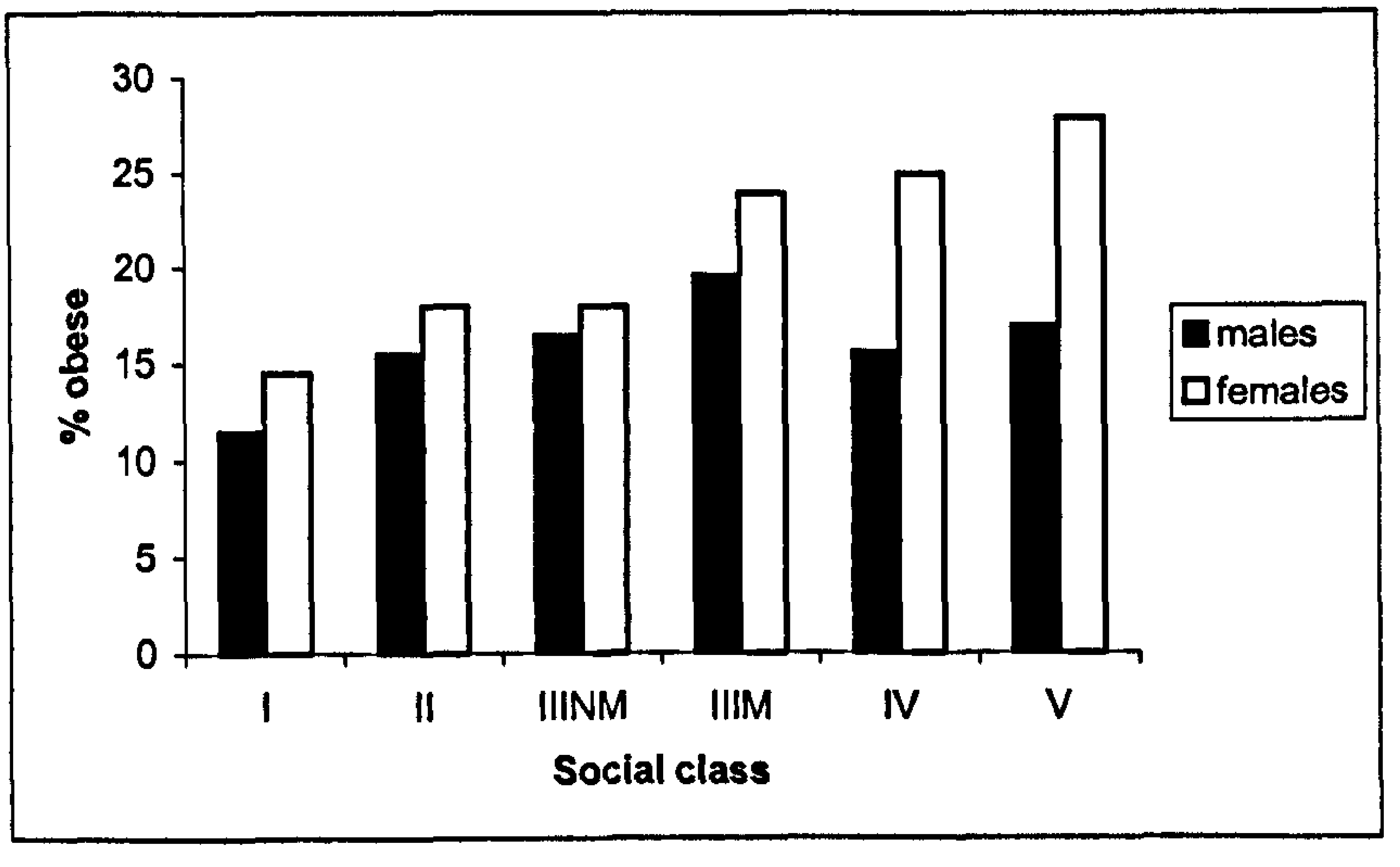
In the UK there have been successive studies which provide useful data on obesity trends and the effect of socio-economic factors. Recent UK figures (1998) estimate levels of 46% and 32% for overweight and 17% and 21% for obesity in men and women respectively (National Audit Office, 2001). Between 1980 and 1996, the prevalence of obesity more than doubled from 6-16% in men and 8-18% in women (Prescott-Clarke and Primatesta, 1998). Obesity and overweight increase with age, and this is apparent in all geographical regions of England (National Audit Office, 2001). Data from the Health Survey for England suggest that people of both sexes gain weight most rapidly in their twenties and early thirties and continue to gain weight gradually until their seventies (Figure 1.3). Gender differences are less marked for overweight than obesity. The effect of social class varies between the sexes; women in the lower social classes have a greater tendency to excessive weight gain while for men this relationship is less apparent (Fehily, 1999) (Figure 1.4). Smokers tend to have a lower BMI than non-smokers, but they have a greater degree of central adiposity. In the UK, there is a higher prevalence of obesity among certain ethnic groups, in particular among Black Caribbean and Pakistani women (National Audit Office, 2001).

Figure 1. 3 Percentage of overweight /obese men and women in 1998 by age range



Source: National Audit Office (2001) analysis of Health Survey for England data

Figure 1. 4 Prevalence of obesity in men and women for each of the six social classes measured by the Health Survey for England 1998



Source: National Audit Office (2001) analysis of Health Survey for England data

1.2.4 Consequences of obesity

The impact of obesity on morbidity and disability is higher than its impact on mortality (Visscher and Seidell, 2001). The multiple complications of obesity are well documented and include life-threatening chronic non-communicable diseases which lead to disability and death, e.g. type 2 diabetes, coronary heart disease (CHD) and some cancers (Garrow, 1988; Must et al., 1999; Kumanyika et al., 2002). In addition, a range of debilitating diseases, such as osteoarthritis, gallstones, sleep apnoea and reproductive disorders, and psychosocial problems, including depression and lowered self-esteem, are associated with obesity (Garrow, 1988; Must et al., 1999; Kumanyika et al., 2002). There is currently a campaign in the UK called the 'Forgotten Million' which aims to highlight the estimated million undiagnosed cases of type 2 diabetes; obesity and lack of physical activity are major contributory factors to this figure.

In the UK, it is estimated that in 1998 obesity cost the National Health Service at least £0.5 billion, 18 million days of sickness absence and 40, 000 lost years of working life (National Audit Office, 2001). In Western societies the direct cost alone of obesity is estimated to range from 2 to 7% of total health costs; this is likely to be a conservative figure (James and Ralph, 1999). Furthermore, the health costs of obesity are a particular concern for developing countries with already over-strained health budgets (Kumanyika et al., 2002).

1.2.5 Treatment of obesity

Theoretically, the treatment of obesity is simple: create a negative energy balance by reducing energy (food) intake and/or increasing energy expenditure (physical activity). However, given the complex and multifactorial causes of obesity it is not surprising that the long-term successful treatment of obesity is a very difficult goal to achieve (Wadden, 1993). Traditional treatment of obesity is a combination of dietary change and an increase in physical activity. For the severely obese, pharmacological and surgical interventions may be additional treatment options (Garrow, 2000). In recent years there has been a greater emphasis on the benefits of modest long-term weight loss (5-10%) on health (James and Ralph, 1999). This may represent a more realistic goal for many obese people. In addition, there is increasing awareness of the importance of behavioural and cognitive therapy in weight reduction (Rapoport, 2001). For many obese patients their weight has been an ongoing battle for years, and a full exploration of their eating behaviour, motivation and confidence to lose weight is a pre-requisite to any lifestyle intervention.

1.2.6 Aetiology of obesity

Body weight is ultimately determined by an interaction of environmental, genetic and psycho-social factors acting through physiological mediators of energy intake and expenditure (Jebb, 1997). The body obeys the laws of thermodynamics which state that energy can neither be destroyed nor created; an excess of energy intake over energy expenditure is stored as body fat. Obesity is the result of a positive energy balance where energy intake exceeds energy expenditure for an extended period of time through:

1) increased energy intake;
2) decreased energy expenditure;
3) combination of both the above.

This relatively simple concept belies a complex condition with multifactorial origins. At one end of the spectrum obesity is the result of a genetically determined condition (e.g. Prader-Willi) and at the other end of the spectrum is purely behavioural (e.g. Sumo wrestlers). Most cases of obesity are likely to cluster between these two extremes (Prentice, 1999).

1.2.6.1 Genetic factors

The rapid rise in obesity rates globally has occurred in too short a time for there to have been any evolutionary genetic changes within populations (Kumanyika et al., 2002). Family, twin and adoption studies have provided a useful means of investigating the genetic influences in obesity. Obesity appears to be a polygenic disorder with a non-Mendelian pattern of transmission; from family, twin and adoption studies it appears a considerable proportion of the genetic variance is a major gene effect (Kopelman, 1999). Genetic influences seem to operate through susceptibility genes, but the environment determines phenotypic expression.

1.2.6.2 Endocrine and hypothalamic disorders

Endocrine and hypothalamic disorders (e.g. Cushing's syndrome) make up only a small proportion of the total cases of obesity (Jebb, 1997).

1.2.6.3 Energy expenditure

Energy expenditure has classically been divided into four major components: basal metabolic rate (BMR), thermogenesis, physical activity and growth (children and adults in certain physiological states). BMR is the minimal rate of energy expenditure compatible with life and is the largest component of energy expenditure accounting for 60-75%. An individual's BMR is measured under standard conditions: early in the morning, after an overnight fast of at least 12 hours, in a thermoneutral environment (24-26°C) and with the subject at complete rest. In practice, resting metabolic rate (RMR) is frequently measured due to the difficulties in achieving standardised conditions in most measurement situations. RMR tends to be approximately 3% higher than BMR due to subject arousal (Goran and Treuth, 2001). Energy expenditure can be measured by assessment of total heat production in the body (direct calorimetry) or by assessment of oxygen consumption and carbon dioxide production (indirect calorimetry and doubly labelled water) (Goran and Treuth, 2001).

Reports of the dietary intakes of the obese have indicated low energy intakes leading to investigations of possible defects in energy expenditure. However, it has been conclusively shown that obese individuals have a relatively raised BMR compared to lean counterparts (Prentice et al., 1996), dispelling theories of 'faulty metabolism' as a cause of obesity. Diet-induced thermogenesis (DIT) accounts for approximately 10% of energy expenditure. Studies of DIT have yielded conflicting results about a possible defect in this component of energy expenditure in the obese (Jebb, 1997). However, it is unlikely to make a significant contribution to obesity.

Physical activity is the most variable component of energy expenditure and is also the most difficult to measure objectively. The doubly-labelled water (DLW) technique provides an estimate of an individual's physical activity level (PAL) from the ratio of total energy expenditure (TEE)/BMR (Jebb, 1997). Overall, there is little evidence to support a specific defect in energy expenditure as a cause of obesity (Prentice et al., 1996). The level of physical activity in work and leisure time is falling rapidly in the modern Western world, and as a result, use of leisure time is an important determinant of energy expenditure (Livingstone et al., 1991).

1.2.6.4 Energy intake

Energy intake is determined by the interaction of both exogenous and endogenous factors (Garrow, 2000). Exogenous influences include food availability, food variety, subjective factors, religious and socio-cultural beliefs. Endogenous factors which affect energy intake include food composition and characteristics, eating experience (time to eat, speed of eating), appetite, meal frequency, satiety and energy density (Garrow, 2000).

It is not possible to pinpoint specific foods as being culprits in the rise in obesity; however, modern trends in eating such as increasing consumption of fast food are likely to be important factors. In the assessment of dietary intake, the obese and overweight are particularly prone to under-reporting their food intake which compounds investigations of the energy intake in this group (Lichtman et al., 1993). Dietary under-reporting may also partly explain the apparent paradox of a decrease in total energy intake (according to the long running National Food Survey) concurrent with increasing rates of obesity (Prentice and Jebb, 1999).

Generally, in the UK there is wide access to highly palatable, convenience and snack foods due to the revolution in food production and distribution which has occurred in the last 50 years. In addition to this, the biological system of our bodies tends to oppose the undersupply of nutrients, but permits overconsumption (Blundell and King, 1996). It is generally accepted that the macronutrients differ in their satiating effects; in descending order of effect - protein, carbohydrate, fat (Stubbs, 1999). It has been suggested that a high consumption of fat, termed 'passive overconsumption' due to its high palatability and low satiating effect, is a key contributory cause of obesity (Blundell and King, 1996; Blundell and Macdiarmid, 1997; Stubbs et al., 2001). Energy density of a food may be a more important factor than the fat content in the tendency to over-consume foods (Rolls et al., 1998; Rolls et al., 1999). Energy-dense foods tend to be highly palatable which also may lead to overconsumption (Drewnowski, 1998a).

1.2.6.5 Energy balance

When energy intake (EI) equals energy expenditure a state of energy balance exists. Positive energy balance occurs when energy input exceeds energy output and a negative energy balance results when energy output exceeds energy input. A positive energy balance may result from overconsumption of high fat foods and/or reduced energy expenditure through physical activity due to the increasingly sedentary lifestyles which are a feature of Western societies. Populations where the rates of obesity have soared over a very short time period (e.g. Western Samoa and other developing nations) have experienced concurrent changes in lifestyle, suggesting that environmental factors are key in the aetiology of obesity. A positive energy balance may also be the result of a predisposition to poor appetite control, a defect in appetite signalling or a genetic propensity to obesity.

1.2.6.6 Psycho-social influences on energy balance

A further complication in the aetiology of obesity is the potential for cognitive factors, arising from cultural, ethnic, gender or socio-economic influences, to override physiological regulatory mechanisms of food intake (Jebb, 1997). In addition, there are many complex influences on EI and energy expenditure which are a result of the political agenda including, for example, food supply, food pricing, transport policy and provision of recreation facilities. The International Obesity Taskforce (IOTF) has developed a pictorial representation of these influencing factors, entitled the 'Causal Web' (Figure 1.5) (International Obesity Taskforce, 1999). From this diagram it is apparent that the influences on food intake and energy expenditure are complex and insidious. The school/work/home column is the most common focus for intervention, but is influenced by factors further upstream.

1.3 Regulation of body weight

The regulation of body weight is intimately linked to the regulation of energy balance in the long term. Following on from the above discussion of energy balance, it is clear that the mechanisms involved in body weight regulation in humans include genetic, physiological and behavioural factors. The hypothesis that body weight is regulated in a similar manner to that of other physiological functions was first cited by Gulick (1922), who observed that the body weight of adults is remarkably constant over time, despite short-term variations in food consumption (reviewed by Henry, 1984). Subsequent longitudinal observations appear to agree with this theory; Fox (1973) and Garrow (1974) recorded a fluctuation in body weight of 5 kg range over a 19 year and 7 year time span respectively. Observations of the relative constancy of body weight have recently been made (Jequier and Tappy, 1999). To set this in context, an increase in body weight of 5kg in twenty years represents a mean energy excess of 5kcal/day which is suggestive of the regulation of body weight, considering the average adult consumes 1 million kcal per year (Albright and Stern, 1995). However the rapid increase in obesity also suggests that the mechanisms of body weight regulation are altered when food availability increases (Jequier and Tappy, 1999).

Investigation of the mechanisms responsible for food consumption and regulation of body weight involves researchers from many disciplines as eating represents a biological activity under environmental and cultural influence. An energy balance approach is primarily concerned with quantitative aspects of eating and the energy value of food (Tremblay and Blundell, 1995). In contrast, appetite research is often concerned with the qualitative aspects of eating (e.g. choice, preference, sensory aspects) together with subjective phenomena (e.g. hunger, fullness and hedonic rating) which can be considered as causal agents. Appetite studies often use short term studies investigating stimuli or manipulations to food intake, while energy balance research involves measurement of energy intake, expenditure and intermediary metabolism (Blundell, 1995). A clear division in these approaches is apparent when it comes to explaining 'abnormal' eating and its consequences for weight gain. However, appetite control may be affected by mechanisms responsible for fuel balance which indirectly influence energy balance (Blundell, 1995).

1.3.1 Hypotheses of body weight regulation

Numerous hypotheses have been postulated to explain body weight regulation. Listed below are six of the most popular models:

1. set point theory
2. adaptive thermogenesis
3. cognitive control
4. dynamic equilibrium or 'buffer' control system
5. settling point theory
6. leptin.

Set point theory

The set point theory of body weight regulation is analogous to the homeostatic control of other body parameters, such as blood pH or temperature. Early experiments indicated that the hypothalamus was the centre of feeding control and it was proposed that blood glucose, body temperature and body fat were the determining signals of feeding (Henry, 1984). The essential elements of this model were a sensing device, detector of deviation from desirable levels and a feedback mechanism which either increased or decreased intake or expenditure to restore the system back to the preferred set point (Henry, 1984).

The set point theory has been weakened substantially by subsequent studies (Drewnowski, 1998b) which have failed to show convincing evidence for the components or error signals of these models. In addition, it has been argued that set point theories are inconsistent with basic evolutionary eating related pressures, namely an inconsistent and unpredictable supply of food (Pinel, 1997). Furthermore, set point theories do not account for the influence on hunger and eating of important factors such as taste, learning and social influences (Pinel, 1997).

Adaptive thermogenesis

During the 1970s, studies in rodents suggested a defect in a physiological mechanism, termed adaptive thermogenesis, which was thought to protect against weight gain. A protein was discovered in brown adipose tissue which was capable of uncoupling oxidation and phosphorylation, the process whereby food energy can be converted to adenosine triphosphate (ATP) for use by the body (Stubbs, 1998). Although this theory was unsubstantiated in humans (Stubbs, 1998) interest has recently been reawakened when it was reported that genetic anomalies of the uncoupling protein (UCP-1) may be associated with human obesity.

The cognitive hypothesis

The cognitive hypothesis argues that, in humans there is clearly some degree of conscious control of body weight or volume through voluntary alteration of food intake and/or physical activity (Garrow, 1988).

The dynamic equilibrium model

The Payne and Dugdale model (Payne and Dugdale, 1977a) proposed that body weight and food intake are inextricably linked, and any deficit in energy supply is met by withdrawing lean and fat tissue in a fixed proportion known as the P ratio, defined as:

$$\text{P ratio} = \frac{\text{energy stored or mobilised as protein}}{\text{total energy stored or mobilised}}$$

The P ratio is constant in an individual over time and during tissue storage, as well as mobilisation (Henry, 1984). On this basis, three types of individuals were classified:

'metabolically lean' – where the lean: fat deposition ratio was 30:70, i.e. P ratio = 0.3;
'metabolically average' – where the P ratio = 0.15;
'metabolically fat' – where the P ratio = 0.03.

Thus, the model predicts that, within certain limits, changes in food intake will eventually lead to a new equilibrium body weight. The difference in P ratio explains why individuals differ in their propensity to gain weight and produce heat during overfeeding (Payne and Dugdale, 1977b). Recent work has developed this theory and hypothesised that, although the protein and fat depositioning which occurs during re-feeding after starvation is due to an individual's partitioning characteristic, a disproportionate laying down of fat occurs due a prolonged suppression of thermogenesis under adipose-specific control (Dulloo and Jacquet, 2001). Further work is required to elucidate sensors, signals and effector mechanisms (Dulloo and Jacquet, 2001).

Settling point

A recent response to the above theories is the settling point theory, which advocates that eating is not part of a system that is designed to defend a body fat set point, rather that body weight tends to drift around a natural 'settling 'point' (Pinel, 1997). This settling point model accounts for the various factors that influence body weight and provides a loose kind of homeostatic regulation by merely limiting further changes in the same direction. The essential elements of the model are:

1. food availability
2. positive incentive value of the available food
3. amount of energy consumed
4. level of body fat
5. energy expenditure
6. strength of the satiety signal

When there is an enduring change in one of these parameters that affect body weight, body weight will drift to a new settling point (Pinel, 1997).

Leptin

Leptin acts in the central nervous system where it interacts with a number of hypothalamic neuropeptide systems to regulate feeding behaviour and energy expenditure (Havel, 2000). It appears that obese adults may be resistant to the effects of endogenous leptin. Responsiveness may vary according to metabolic conditions or genetic background and further research on this variation is ongoing (Jequier and Tappy, 1999).

1.3.2 Macronutrient and energy balance regulation

Mayer (1953) proposed the glucostatic theory, which accounted for meal initiation and termination by the ebb and restoration of plasma glucose concentrations respectively. At this time, two other set point theories of energy regulation were proposed based on the crucial role of fat (Kennedy, 1953) and amino acids (Mellinkoff et al, 1956) in determining energy balance. These set point models are generally accepted to be inoperative, at least in their original format (Holt et al., 1992; Roberts, 2000). However, aspects of the glucostatic theory are still recognised as having a possible role in energy regulation through glucose induced rises in plasma insulin, which may be an important central satiety signal (Astrup et al., 2002).

Since Mayer's glucostatic theory, carbohydrate metabolism has been considered by many scientists in the field to be key in the control of appetite and energy intake. The work of JP Flatt has been particularly influential (Stubbs, 1998). Flatt proposed that carbohydrate balance is tightly controlled and people eat to maintain a certain range of glycogen stores regardless of their fat intake (Flatt, 1996a; Flatt, 1996b). Evidence for carbohydrate models of feeding is inconclusive and it appears that carbohydrate status *per se* does not exert a powerful negative feedback on feeding behaviour (Stubbs et al., 1993; Snitker et al., 1997). In the short-term, however, it appears that there may be a potent role for carbohydrate in the control of appetite (Blundell et al., 1994). This evidence has come from pre-load and carbohydrate substitution studies. Carbohydrates have a diverse chemical structure and interest is growing in the relationship between the GI of a carbohydrate and its effect on satiety. In addition, dietary fibre may modulate the satiating effect of a food.

In an extension of Mayer's original theories, Friedman (1995) proposed that eating behaviour is controlled by signals that are generated in the post-absorptive metabolism of energy-yielding substrates; the metabolism of both glucose and fat is said to provide such a signal. Evidence points to changes in hepatic adenosine triphosphate (ATP) as the source of the signal, and suggests that this information is transmitted to the brain via vagal afferent nerves. This mechanism for energy balance links energy intake, energy expenditure and storage; interactions among the components of energy balance are explained by the concept of partitioning of metabolic fuels. The mechanism of integration is unknown, but it is speculated to be a neural or biochemical process.

1.3.3 Appetite control

Eating is an episodic activity and the limits set by mechanisms of appetite are those which limit the size of eating episodes, their frequency and the selection of particular foods; satiation and satiety acting in tandem have a major role in affecting these processes (Blundell and Stubbs, 1999). Satiation is responsible for the termination of a given meal and reduced meal size; satiety delays the onset of the next meal and so reduces energy intakes in the long-term (Drewnowski, 1998b). Palatabilty and satiety appear to have opposite effects on food intake (Drewnowski, 1998a). The control of appetite has been conceptualised on three levels as part of a network of a psychobiological system (Blundell, 1999). The three levels are:

1) psychological events (hunger, cravings and hedonic sensations) and behavioural operations (meals, snacks, energy and macronutrient intake);
2) peripheral physiology and metabolic events;
3) neurotransmitter and metabolic interactions in the brain.

Recent discoveries have started to reveal how humoral factors, such as insulin and glucagons, gut-derived peptides, melatonin, leptin and cytokines, modulate hypothalamic function and hence control appetite and satiety (Prentice and Stubbs, 1999). Another important area of current research is the role of the central nervous system (CNS) in appetite control (Schwartz et al., 2000). It appears that neuropeptides (especially neuropeptide Y), in the hypothalamus, have a role in energy homeostasis; satiety signals conveyed to the hindbrain are involved in the termination of a meal and defects in their function may be a potential cause of obesity (Schwartz et al., 2000).

1.4 Childhood obesity

1.4.1 Prevalence of overweight and obesity in children

Worldwide, approximately 22 million children under 5 years of age are overweight (Kumanyika et al., 2002). Figures for the UK show that the incidence of overweight in children almost doubled from 1984 to 1994 (5-6% to 9-10% in boys and 9-10% to 13-16% in girls). In the same period, obesity reached 1.7-2.1% in boys and 2.6-3.2% in girls (Chinn and Rona, 2001). Another study looking at overweight and obesity in children aged 0-4 years in Liverpool from 1989 to 1998, reported increases from 14.7 to 23.6% and 5.4% to 9.2% in the incidence of overweight and obesity respectively (Bundred et al., 2001). Both of these studies used BMI as a means of categorising weight; the first study used recently devised 'cut-offs' (Cole et al., 2000) and the second study used the 85th and 95th percentile as cut-off points for overweight and obesity respectively.

1.4.2 Measurement of overweight and obesity in children

In children, the measurement of obesity is more difficult than in adults because of ongoing growth and natural changes in body fat (Deurenberg and Yap, 1999). It is usual for the percentage of body fat to decline between the age of 1 to 5 years and then increase again between the age of 6 to 9 years. This is known as 'adiposity rebound' (Rolland-Cachera et al., 1984). Further rises in body fat occur during adolescence.

There is disparity in the methods used to categorise overweight and obesity in children, which makes comparisons within and between populations difficult. In 1995, Cole produced BMI centile charts for the UK (Cole et al., 1995a). Definitions of 'overweight' and 'obesity' vary, but generally a BMI >85th centile is described as 'overweight' and a BMI >95th centile is described as 'obese' (Barlow and Dietz, 1998). Caution in the use of BMI in very young children is required due to the rapidly changing proportions of body fat (Cole *et al,* 2000).

A new set of standards for assessing BMI, based on international surveys of six large, nationally representative, cross sectional growth studies, has been published (Cole et al., 2000). Percentile curves were drawn that, at age 18 years, passed through the widely used cut-off points of BMI 25 and 30kg/m^2 for adult overweight and obesity respectively. The resulting curves were averaged to provide age and sex specific ranges. These standards for BMI are designed for ages 2 to 18 years and provide an international standard for interpreting BMI to enable comparisons of prevalence of overweight and obesity. The inherent methodological statistical errors, such as gaining a representative sample and the setting of arbitrary cut-off values, are acknowledged. These cut-off values are a statistical phenomenon; their relationship to obesity-related morbidity is not known (Reilly et al., 2002). It has been recommended that research is undertaken to investigate the disease risk associated with the 91st and 97.7th centiles of the BMI reference charts to confirm if these provide meaningful cut-off values for childhood obesity (Power et al., 1997). Despite its limitations, BMI remains the recommended method of defining obesity in populations (Bellizzi and Dietz, 1999).

Body fat values derived from skinfold measures were correlated in adults by Durnin and Rahaman (1967) and in children by Brook (1971). The age range was extended by comparing total body water, measured by dilution of deuterium oxide, with skinfold measures in children aged 1 to 11 years. In addition, centile charts for waist circumference in children have recently been published, which provide an additional method of assessing body fat (McCarthy et al., 2001). Skinfold measures, possibly used in conjunction with body circumferences, are likely to give a better indicator of body fat than BMI, but are not as acceptable for measurement of overweight and obesity in children because of their relative invasiveness (Power et al., 1997). Observer error is an inherent problem of skinfold measurements.

1.4.3 Lifestyle factors and childhood obesity

1.4.3.1 Physical activity

Changes in children's physical activity habits have been cited as a contributory factor to the energy imbalance which results in excessive weight gain (Trost et al., 2001). Level of physical activity has been weakly inversely related to excessive weight (Fogelholm et al., 1999). There is concern that children's leisure time is becoming increasingly sedentary and, in the UK, physical education lessons in primary and secondary schools have been reduced because of pressures on the school curriculum (Rowe and Champion, 2000). Other factors, such as safe places to play and parental fears for their children's safety ('stranger danger'), may also have a detrimental effect on the level of physical activity in children (Fox and Riddoch, 2000).

Lindquist et al. (1999) found that television was a marker of inactivity in children, however other studies have not found a relationship between television viewing and level of physical activity (Taylor and Sallis, 1997). Children's physical activity may also be influenced by psychosocial factors, such as socio-economic group, ethnic group and single/dual parent families (Taylor and Sallis, 1997). Furthermore, girls tend to be less active than boys and activity decreases with age (Sallis et al., 2000). The determinants of physical activity have been classified as: physiological/developmental, environmental and psychological/socio-demographic (Table 1.3) (Kohl and Hobbs, 1998). The relative contribution and effect of these various factors have not been clearly established (Ritchie et al., 2001).

1.4.3.2 Dietary factors

The recent National Diet and Nutrition Survey in Young People aged 4-18 years (Gregory and Lowe, 2000) did not show an increase in energy intake, at least not by the dietary assessment methodology employed. The survey did show a low level of fruit and vegetable intake while the level of saturated fat was higher than recommended (Department of Health, 1991). Food advertising aimed at children, particularly via television, has become a political issue and it appears that parents have less influence over what children eat. Snacking is also a common feature of many children's diets and has been found to make a significant contribution to energy and fat intake (Ruxton et al., 1996; Gregory and Lowe, 2000).

There is conflict in the literature about the role of dietary fat in the aetiology of obesity (McGloin et al., 2002) with some studies finding a positive relationship and other studies

Table 1. 3 Potential determinants of physical activity behaviours among children

Physiological/developmental	Growth and maturation Physical fitness Physical limitations
Environmental	Facilities/equipment access Seasonality Safety
Psychological/socio-demographic	Self-efficacy Knowledge/attitudes Parental influences Role modelling Peer influences Education/socio-economic status Gender Age

Source Kohl (1998)

failing to do so. In a cross-sectional study undertaken by these authors, fat intake was related to body fatness in childhood, but it cannot be determined if this association was casual or a post-hoc effect (McGloin et al., 2002).

Research has indicated that most young children are inherently able to regulate their food intake when challenged with a high energy preload (Birch and Fisher, 1995). However, overly restrictive feeding practices may interfere with this ability (Birch and Deysher, 1986) and be implicated in excessive food intake in adulthood. Restricting access to palatable foods has been shown to increase children's attention and desire for that food (Fisher et al., 2000). Feeding practices and parental attitudes to food, therefore, may be a contributory factor to excessive food intake in later life.

1.4.3.3 Socio-economic factors

A cross- sectional study of over 20,000 children aged 5-14 years, in a recognised area of high deprivation in the UK, showed that obesity rates were 2 ½ times greater than national averages. Further analysis showed that the rate of obesity increased with age and that there was a significant association between obesity and level of deprivation in both males and females. It was concluded that this is a further adverse influence which may affect morbidity in children in later life (Kinra et al., 2000).

1.4.4 Energy expenditure

Some studies have found lower RMR values, relative to total body mass, in obese children compared to lean children, or the children of obese parents compared to children of non-obese parents. However, there is conflict in the literature with other studies finding no differences as reviewed by Ritchie et al. (2001). Differences in stage of maturation, race, gender and insufficient subject numbers contribute to this disagreement (Goran, 2000). It remains to be proven whether lower RMR translates into elevated risk of adiposity (Ritchie et al., 2001).

1.4.5 Susceptibility to childhood obesity

Dietz (1994) defined three periods when children are most susceptible to developing obesity:

1. prenatal period;
2. period of adiposity rebound;
3. adolescence.

The actual mechanisms that make these periods "critical" are not fully understood. One example of how nutrition affects the prenatal period is gestational diabetes, where the quantity of substrate to which the foetus is exposed is altered. This may affect the glandular control in the regulation of body weight. Similarly, the capacity for fat oxidation may be established prenatally; this would promote the increased deposition of body fat (Ballew et al., 2000). High birth weight and low birth weight have both emerged as potential risk factors for overweight and development of chronic disease in adulthood (Ritchie et al., 2001). A recent review concluded that although the evidence is suggestive, it is not yet definitive that undernutrition in early life is a risk factor for subsequent overweight (Martorell et al., 2001). However, the evidence that overnutrition in early life or high birth weight is a risk factor for excess adiposity in adulthood is very conclusive (Martorell et al., 2001).

Early adiposity rebound may be a reflection of early puberty and may be predictive of BMI in young adulthood (Rolland-Cachera et al., 1984). However, it has been suggested that the strength of this relationship may be too small to be of practical significance (Gasser et al., 1995). It may be that combining the age of adiposity rebound with the value of BMI at that age may be more predictive, but further research is required (Power et al., 1997). At adolescence, the change in body composition and the redistribution of body fat show the processes that can be influenced by genetic or environmental factors (Dietz, 1994). Wisemandle *et al,* (2000) concluded that, for both males and females, adiposity rebound is likely to be an effective time in a child's development to detect and initiate prevention for childhood and early adult onset of adult overweight. Puberty seems to be a critical phase in the development of later adult onset of overweight in females; however, the effect of later onset overweight (over 25 years) needs further study. Early menarche, defined as before 11 years of age, is indicative of advanced puberty and is also associated with an increased incidence of obesity (Garn et al., 1986; Adair and Gordan-Larsen, 2001).

Obesity in one or both parents influences the risk of obesity in their offspring because of shared genes and/or environmental factors within families. It has been shown that parental obesity significantly alters the risk of obesity in adulthood for both obese and non-obese children, especially those under 10 years of age (Whitaker et al., 1997). Several large-scale family studies, in different ethnic populations, have shown a familial correlation in the degree of obesity, with a parent to offspring correlation of about 0.2 and a correlation around 0.25 for same gender siblings as reviewed by Kopelman (1999).

1.4.6 Consequences of childhood obesity

Approximately 60% of overweight 5 to 10 year old children in the US already have one associated biochemical or clinical CVD risk factor, for example hyperlipidaemia, raised blood pressure (BP), raised insulin levels, and 25% have two or more risk factors (Freedman et al., 1999). Central adiposity has been related to CVD risk factors in black and white girls and boys (Morrison et al., 1999a; Morrison et al., 1999b). Mamalakis et al., (2000) showed that in Cretan children the endurance run test (an index of physical fitness) was negatively associated with obesity indices and the sum of skinfolds positively related to serum low-density lipoprotein (LDL). Type 2 diabetes has been documented in obese children in the US, particularly in Hispanic, African-American and American Indian populations (Arslanian, 2000; Fagot-Campagna, 2000), whereas impaired glucose tolerance has been detected in severely obese children and adolescents irrespective of ethnic group (Sinha et al., 2002). The first UK paediatric case reports of Type 2 diabetes were recently documented in overweight children aged 9-16 years of South Asian origin (Ehtisham et al., 2000). Thus, Type 2 diabetes, classically a disease of adult onset, is now a diagnosis to be considered in children (Ortega-Rodriguez et al., 2001).

Another consequence of childhood obesity is psychosocial dysfunction with a decrease in self-worth, often the direct result of peer group teasing, and an increased incidence of depression. In a study of 1520 children aged 9-10 years, there were no significant differences between scholastic and self-esteem scores among obese and non-obese children (Strauss, 2000). However, when 79% of these children were followed up 4 years later, decreases in self-esteem, particularly among Hispanic and white obese females, were significantly different to their non-obese counterparts. These decreased levels of self-esteem may lead to changes in psychological well-being and increased levels of high risk behaviours, such as smoking and alcohol consumption. Thus, early adolescence appears to be a critical time for the development of self-esteem among obese boys and girls.

Few studies have examined the long-term effects of childhood and adolescent adiposity on adult morbidity or mortality (Power et al., 1997). In the longitudinal Harvard Growth Study, adolescent obesity was found to be associated with an increased disease risk in males, but not females (Must, 1996). Lauer et al. (1991) reported that raised childhood BP and BMI are powerful predictors of adult BP across both genders and all ages. However, it is unclear whether the risks of obesity vary with the age of onset, severity of obesity, its duration, or if the effects are reversed by weight loss (Barlow and Dietz, 1998). Clarification is also required about whether the links between childhood adiposity and adult disease operate primarily through continued adiposity over a lifetime (Power et al., 1997).

1.4.7 Treatment of childhood obesity

Childhood obesity, as in adults, is difficult to successfully treat in the long-term. Most weight loss studies in children and adolescents have included behaviour modification, diet and exercise, with lifestyle exercising programmes in particular showing the best long term results (Fulton et al., 2001). Recent recommendations are that any weight loss regimen should be tailored to an individual's degree of excessive weight and disease risk (Barlow and Dietz, 1998). Epstein (1996) has shown that, in order to treat childhood obesity, a family-based approach is essential and this was further confirmed by Golan et al. (1998). However, it has been noted that the decision to include parents in paediatric weight loss studies may depend on the developmental stage of the child receiving treatment (Fulton et al., 2001). A recent critical review of childhood obesity (Edmunds and Walters, 2000) described results in treatment as 'equivocal' and 'modest'. A review of school-based weight loss programmes described moderate short-term weight loss, with more success seen in younger children than in adolescents (Story, 1999). Interestingly, only one such study has been undertaken since 1985, which suggests that this approach is not favoured currently.

1.4.8 Tracking of childhood obesity

Factors in childhood which may influence the development of obesity in adulthood have been identified: parental fatness, social factors, birth weight, timing or rate of maturation, physical activity, dietary factors and other behavioural or psychological factors (Parsons et al., 1999). Due to differences in study design, definitions of obesity and analytical methods used, it is not possible to undertake a formal meta-analysis of the literature on the tracking of obesity. Serdula et al. (1993) reviewed 17 reports published (in English) between 1970 and 1992 and concluded that 26-41% of obese pre-school children and 42-63% of obese school-aged children were obese as adults. Studies in the UK and the US suggest that childhood obesity appears to account for 33% of adult obesity (Power et al., 1997; Barlow and Dietz, 1998). There is also evidence that intransigent obesity tracks with age (Guo and Chumlea, 1999) and the risks of tracking increase with the age of onset and the severity of obesity (Edmunds and Walter, 2000). A recent study did not show a relationship between childhood obesity and adult obesity using BMI, until 13 years of age. In addition, being thin in childhood was not found to offer protection against adult fatness (Wright et al., 2001).

1.4.9 Indications for a preventative approach to obesity

The IOTF concluded that the prevention of weight gain is easier, less expensive and more effective than treating obesity after it has fully developed (Basdevant et al., 1999). The prevention of obesity is an important public health strategy that must be utilised (Serdula et al., 1993; Power et al., 1997; Visscher and Seidell, 2001). Addressing the problem in children who are forming lifestyle habits offers an opportunity for successfully managing and controlling obesity, especially as most adult obesity occurs in later life. Prevention programmes can be of two types: targeting individuals at high risk (secondary prevention) or a general population approach (primary prevention) (Pate et al., 1995). On studying the effectiveness of a population versus a targeted approach, Harrell et al. (1996) concluded that the much cheaper and more feasible population approach should be considered as one means of early primary prevention of cardiovascular disease. This view has recently been substantiated by Zwiauer (2000) who argues that 'a health problem which affects the well being of a major proportion of the population is unlikely to be effectively controlled by strategies dealing with the weight status of the population. Public action therefore is needed to promote and protect the health of the population'. Another argument for a primary approach is that the factors which lead to obesity have yet to be fully elucidated.

1.5 School as a setting for health programmes

Schools provide the ideal vehicle for the delivery of interventions for childhood obesity (Sallis et al., 1995) and have been highlighted as a potential societal solution for obesity prevention (Kumanyika et al., 2002). They provide a unique combination of professional personnel, access to children, a structured and formalised education environment and physical resources. Three major components within schools have been identified as potential areas which may contribute to the prevention of obesity: the physical education syllabus, classroom health education and the school food service (Story, 1999). Previous work has concentrated on one or more of these domains. The factors within a school that may contribute to obesity or its prevention have been described by (Dietz and Gortmaker, 2001) and are outlined in Figure 1.6. There has been some concern that programmes which address overweight and eating problems may inadvertently harm the child emotionally or psychologically (Ritchie et al., 2001). It has been recommended that emphasis should be given to building self-esteem, helping children enjoy healthy eating and physical activity without developing a fear of food, rather than focusing on negative, problem-based issues (O'Dea, 2000).

1.5.1 Previous school-based studies

There is only a limited number of explicit school-based prevention of obesity studies (Hardeman et al., 2000) and therefore the efficacy of this approach has not yet been established (Story, 1999). A recent Cochrane review surmised that due to a lack of high quality data on the effectiveness of obesity prevention programs, no generalisable conclusions can be made (Campbell et al., 2002). Previous school-based health promotion studies have tended to focus on the promotion of healthy eating and/or the reduction of cardiovascular risk factors (Lister-Sharp et al., 1999). Twenty-six school-based studies carried out between 1980-1999 are reviewed below and detailed in Tables 1.4 to 1.6. This forms an integration of two reviews (Resnicow and Robinson, 1997; Rowe et al., 1997) and other studies identified through database searches (Medline, Science Citation Index, Social Science Index and CINAHL), from 1966 using both MESH headings and keywords (school(s), child(ren), obesity, overweight, nutrition, health promotion, prevention, cardiovascular risk, family, weight loss). Inclusion criteria are:

1. discrete intervention or intervention with specific aims undertaken in school or linked to school;
2. directed at students up to 16 years of age (excluding pre-school);
3. use of a comparison group;
4. promotion of healthy eating or the targeting of at least one CVD risk factor.

1.5.1.1 Study design

None of the school-based prevention studies were carried out in the UK; most were undertaken in the US with four European studies (Tell et al., 1981; Puska et al., 1982; Lionis et al., 1991; Alexandrov et al., 1992) (Table 1.4). Fifteen studies employed a cohort or a matched cohort design, one used a quasi-experimental approach and the remainder were of a randomised design. In the 'hierarchy of evidence', a randomised controlled trial is considered superior to a cohort study as it allows rigorous evaluation of a single variable and potentially eradicates bias (Greenhalgh, 1997). However, in a school setting a randomised design may not be viable due to difficulties allocating subjects to different interventions within one school. Another problem is the use of a control group as it may not be considered ethical or feasible for a group of children to miss out on a health promotion intervention. A potential way to overcome this may be randomising by school rather than by individual, but more schools will be required for this design and they should be well matched. An error seen in some previous studies is a difference in the unit of randomisation and that of analysis, for example randomisation by school but analysis by individual (Rowe et al., 1997).

Inconsistencies in randomisation and subsequent analysis, selection bias, high attrition rates, inadequate or unvalidated methods of assessment, failure to report null results and incomplete report of results are all factors which detrimentally affect the quality of the study (Rowe et al., 1997). Good study designs are seen in Domel et al. (1993) and Nader et al. (1989) for cohort studies and Lionis et al. (1991), Walter et al. (1988), Luepker et al. (1996) and Donnelly et al. (1996) for randomised procedures. In contrast, poor quality designs are evident in the cohort studies by King et al. (1988) and Parcel et al. (1989) due to high attrition rates and inadequate methods of assessing dietary intake respectively and in the randomised studies by Arbeit et al. (1992) and Hopper et al., (1992). In these randomised studies there were issues of inappropriate unit of analysis, poor quality randomisation, inadequate methods of assessment and insufficient reporting of results.

Table 1.4 Study details of school-based health promotion studies

Source Study Name	Location	Subjects		Study length		Study design	Study quality
		Age (yrs)	Number (n)	Duration	Intensity		
Tell et al. (1981)	Norway	11-15	856	2 years	20 lessons	Cohort	Moderate
Puska et al. (1982)	Finland	13-15	351	2 years	10 x 45 minute sessions	Cohort	Good
Dwyer et al. (1983)	Australia	10	Phase 1 500 Phase 2 216 (follow up)	14 weeks Follow-up 2 years later	1.25 hours/day	Cohort	Moderate
Perry et al. (1987) 'Slice of Life'	USA	14-16	173	1 term	10 sessions	Cohort	Moderate
Killen et al. (1988)	USA	15-16	1447	7 weeks	20 x 50 minute sessions	Matched Cohort	Moderate
King et al. (1988)	USA	15-16	218	3 weeks	5 x 1 hour session	Randomised	Poor
Walter et al. (1988) 'Know Your Body'	USA	8-10	3388	1 year two groups- 5 years	2 x hours /week	Randomised	Good

Source Study Name	Location	Subjects		Study length		Study design	Study quality
		Age (yrs)	Number (n)	Duration	Intensity		
Bush et al. (1989) 'Know Your Body'	USA	9-12	1041	2 years	2 x 45 minute sessions /week	Randomised	Moderate
Crockett et al. (1989) Perry et al. (1989) 'Hearty Heart'	USA	8-10	2250	5 weeks	15 sessions 5 x 2-3 hour sessions 'home group'	Randomised	Moderate
Ellison et al. (1989)	USA	15	1100	14 weeks	N/S	Cohort	Moderate
Parcel et al. (1989) 'Go for Health'	USA	8-10	700	2 years	30 minutes x 8 weeks plus 10 minute daily x 8 weeks	Cohort	Poor
Tamir et al. (1990) based on 'Know Your Body'	Israel	7	829	2 years	15-20 hours/year	Matched Cohort	Moderate
Lionis et al. (1991) based on 'Know Your Body'	Crete	13-14	171	1 year	10 x 2 hour sessions	Cohort	Good
Alexandrov et al. (1992)	Russia	11-12	1005	1 year	N/S	Cohort	Moderate

Source Study Name	Location	Subjects		Study length		Study design	Study quality
		Age (yrs)	Number (n)	Duration	Intensity		
Arbeit et al. (1992) 'Heart Smart'	USA	9-11	530	1 year	15-35 hours	Randomised	Poor
Hopper et al. (1992)	USA	11-13	132	6 weeks	60 minutes/ week 3 physical fitness classes/ week	Randomised	Poor
Nader et al. (1992)	USA	10-12	206 families 300 adults 323 children	1 year		Cohort	Good
Resnicow et al. (1992) 'Know Your Body'	USA	6-10	2973	3 years	30-45 minutes per week	Cohort	Moderate
Domel et al. (1993) 'Gimme 5'	USA	9-11	346	6 weeks	18 sessions	Cohort	Good
Vandongen et al. (1995)	Australia	10-12	1147	1 year	10 hours	Randomised	Moderate
Donnelly et al. (1996)	USA	8-11	N/S	2 years	9 lessons/ year 35 minutes x 3/week	Randomised	Good

Source Study Name	Location	Subjects		Study length		Study design	Study quality
		Age (yrs)	Number (n)	Duration	Intensity		
Harrell et al. (1996) 'CHIC'	USA	9	1274	8 weeks	16-24 sessions	Cohort	Moderate
Luepker et al. (1996) 'CATCH'	USA	8-9	5106	59 sessions	3 school years	Randomised	Good
Sallis et al. (1997) 'SPARK'	USA	9-11	955	2 years	10 x 30 minute/ week (fitness) 9 x 3 sessions/ week (skills)	Cohort	Good
Gortmaker et al. (1999) 'Eat Well and Keep Moving'	USA	9-11	2103	2 years	Intra-curriculum	Quasi Experi-mental Design	Good
Gortmaker et al. (1999) 'Planet Health'	USA	11-14	1295	2 years	Intra-curriculum	Randomised	Good

N/S-=not specified
Adapted and modified from Resnicow and Robinson (1997) and Rowe et al. (1999

1.5.1.2 Target group

There was a wide range in the number of subjects recruited for the studies. The smallest study had 132 subjects (Hopper et al., 1992) which has implications on the validity of these results as the study may not be large enough to detect significant changes. The largest study to date had over 5000 subjects (Luepker et al., 1996). A wide variation is also apparent in the duration and intensity of the interventions (where reported) from less than 15 weeks (King et al., 1988; Crockett et al., 1989a; Ellison et al., 1989; Hopper et al., 1992; Resnicow et al., 1992; Harrell et al., 1996) to 5 years (Walter et al., 1988). It does appear that studies with a higher intensity and duration and also those integrated into the school curriculum may be associated with a higher level of impact (Rowe et al., 1997). Age does not appear to affect outcomes.

Many of the United States (US) studies were carried out in populations that contained a significant proportion of subjects from ethnic minority groups. The 'Know Your Body' intervention (Walter et al., 1988) was replicated in populations of varying socio-economic status and cultural background, and in several countries (Tell et al., 1981; Puska et al., 1982; Tamir et al., 1990; Lionis et al., 1991). The 'Know Your Body' intervention has therefore demonstrated that it is generalisable, which is vital for the future dissemination and reproducibility of any programme.

1.5.1.3 Methodological issues

A theoretical basis to the research undertaken was reported in 20 studies (Table 1.5). Seventeen studies reported 'Social Cognitive (Learning) Theory' as the underlying supposition, ten of which employed other theories in tandem. Other social theories included the 'Health Belief Model' (Walter et al., 1988) and the 'PRECEDE' model (Bush et al., 1989). However, it has been noted that although social learning/cognitive theory predominates in this field, its use in children requires further investigation (Resnicow and Robinson, 1997).

Most interventions were carried out in the classroom as part of the curriculum. Diet and physical activity were the main target behaviours, most commonly in a multi-factorial intervention, but also in a combined approach or targeting only one of these aspects. Only a few studies looked at intervening in the wider school environment, such as the school meals system (Puska et al., 1982; Crockett et al., 1988; Luepker et al., 1996). The most common dietary goals measured in the studies were a reduction in dietary fat (*n* 22), a reduction in sodium intake (*n* 16) and an increase in fruit and vegetable intake (*n* 10).

Table 1.5 Methodological details of school-based health promotion studies

Source	Theory	Focus of intervention				Outcomes measured
		Diet	Physical activity	Smoking	Chol-esterol	
Tell et al. (1981)	Social Influences	✔	✔			Anthropometry: adiposity Diet: intake Physical activity: fitness Also: health knowledge, attitudes and behaviours
Puska et al. (1982)	Social Influences	✔		✔		Anthropometry: adiposity Diet: intake Physiological: cholesterol, BP Also: smoking, health knowledge
Dwyer et al. (1983)	N/A		✔			Anthropometry: SF Physical activity: CV fitness Physiological: cholesterol, BP
Perry et al. (1987)	• Social Learning • Process Evaluation	✔				Diet: dietary change, reading food labels, healthy eating skills Physical activity: exercise behaviour Also: knowledge and intentions
Killen et al. (1988)	• Social Cognitive • Social Inoculation	✔	✔	✔	✔	Anthropometry: BMI, SF Diet: dietary change, nutrition knowledge Physical activity: exercise knowledge Physiological: heart rate, BP Also: CV risk factor knowledge

Source	Theory	Focus of intervention				Outcomes measured
		Diet	Physical activity	Smoking	Chol-esterol	
King et al. (1988)	Social Learning	✔				Diet: food choice Also: nutrition knowledge, attitudes to dietary practices, behavioural intentions
Walter et al. (1988)	• Health Belief Model/ • Social Cognitive & Development	✔	✔	✔		Anthropometry: height, weight Diet: dietary change (subsample) Physiological: cholesterol, BP
Bush et al. (1989)	• Social Learning • PRECEDE model	✔	✔	✔		Anthropometry: ponderosity index, SF Diet: dietary change Physical activity: pulse recovery rate Physiological: cholesterol, BP, serum thiocynate, Also: health attitudes
Crockett et al. (1989) Perry et al. (1989)	Social Cognitive	✔				Diet: dietary change Also: health knowledge
Ellison et al. (1989)		✔				Diet: school meal changes
Parcel et al. (1989)	• Social Learning • Organisational Change Strategy	✔	✔			Diet: dietary change, school lunch modifications Physical activity: exercise knowledge, self-reported aerobic activities Also: self-efficacy

Source	Theory	Focus of intervention				Outcomes measured
		Diet	Exercise	Smoking	Chol-esterol	
Tamir et al. (1990)	Social Learning	✔	✔	✔		Anthropometry: BMI Diet: not reported Physiological: cholesterol, BP, triglycerides
Lionis et al. (1991)	Social Learning	✔	✔	✔	✔	Anthropometry: height, weight, SF, BMI Diet: dietary change Physical activity: exercise knowledge Physiological: BP, cholesterol Also: nutrition knowledge, health knowledge and behaviour
Alexandrov et al. (1992)		✔	✔	✔		Anthropometry: BMI Physiological: cholesterol, BP Also: smoking, lifestyle habits
Arbeit et al. (1992)	Social Cognitive	✔	✔	✔		Anthropometry: weight, height Diet: intake (subgroup only), food choices Physical activity: run/walk test Physiological: CV risk factors, BP
Hopper et al. (1992)	Social Learning	✔	✔			Anthropometry: height, weight, SF Diet: dietary change Physical activity: flexibility, fitness, knowledge Also: school and home parental changes measured

Source	Theory	Focus of intervention				Outcomes measured
		Diet	Exercise	Smoking	Chol-esterol	
Nader et al. (1992)	• Social Learning • Self Management Principles	✔	✔			Anthropometry: BMI Diet: dietary change Physical activity: aerobic capacity, physical activity recall Physiological: cholesterol, BP Also: health knowledge
Resnicow et al. (1992)	• Social Learning • PRECEDE model	✔	✔	✔		Anthropometry: BMI Diet: dietary change, food group knowledge Physiological: cholesterol, BP Also: health knowledge, attitudes, self efficacy
Domel et al. (1993)	• Social Marketing • Social Learning	✔				Diet: dietary change
Vandongen et al. (1995)	N/A	✔	✔			Anthropometry: SF, BMI Diet: dietary change Physical activity: fitness Physiological: cholesterol, BP
Donnelly et al. (1996)	N/A	✔	✔			Anthropometry: % body fat Diet: intake Physical activity: fitness Physiological: blood lipids, BP Also: nutrition knowledge

Source	Theory	Focus of intervention				Outcomes measured
		Diet	Exercise	Smoking	Chol- esterol	
Harrell et al. (1996)		✔	✔	✔	✔	Anthropometry: BMI, SF Diet: dietary change Physiological: cholesterol Also: smoking, health knowledge & behaviour
Luepker et al. (1996)	• Behaviour Change Models/ • Social Cognitive/ • Process Evaluation	✔	✔	✔		Anthropometry: height, weight, BMI, SF Diet: dietary change, knowledge, intention Physical activity: physical fitness, checklist Physiological: cholesterol, heart rate, BP, apolipoprotein B Also: smoking, self-efficacy,
Sallis et al. (1997)	Self-monitoring		✔			Physical activity: levels of physical activity
Gortmaker et al. (1999)	• Social Learning • Skills Development	✔	✔			Diet: intake Physical activity: levels of physical activity, TV viewing Also: diet and physical activity knowledge
Gortmaker et al. (1999)	• Social Learning • Skills Development	✔	✔			Anthropometry: BMI, Diet: dietary change Physical activity: television viewing, activity diary

Adapted and modified from Resnicow and Robinson (1997) and Rowe et al. (1997) (SF=skinfold

Physical activity goals were more varied and included increased time spent doing physical activity (*n* 6), improved physical fitness (*n* 14) and a decrease in the time spent viewing television (*n* 2). Cholesterol levels (*n* 16), smoking prevalence (*n* 11) and health-related attitudes, knowledge and perceptions (*n* 17) were also measured.

Careful attention must be paid to the methodology of all assessments undertaken before interpreting results. Inadequate reporting of methods throws a question over any results reported. Overall, a wide range of methods were used to measure similar variables. Dietary assessment methods employed ranged from a validated diary method (Domel et al., 1993) to the use of hypothetical food choices or questions about eating habits (Puska et al., 1982; Perry et al., 1987; Harrell et al., 1996). Physical activity and fitness were assessed in a variety of ways including using television viewing as a proxy measure for physical inactivity (Gortmaker et al., 1999a; Gortmaker et al., 1999b) and using self-reports of aerobic activity (Harrell et al., 1996). Physiological measurements, such as BP and cholesterol, are likely to be more objective measures as they tend to be carried out by standard methods (Resnicow and Robinson, 1997), but this should not be assumed. The differing nature and schedule of the interventions and these methodological issues hinder comparison of results between studies.

1.5.1.4 Main findings

The main findings of each of the studies are summarised in Table 1.6. In some studies there is disparity between the measures made and results reported. For example, Hopper et al. (1992) measured a range of anthropometric, dietary, physical activity and knowledge parameters, but failed to report the results of these. Inadequate reporting of results was also apparent in other studies (Perry et al., 1987; Parcel et al., 1989).

An aspect of diet was a focus of all studies except Dwyer et al. (1983) and Sallis et al. (1997). Twelve studies reported a favourable dietary change. As previously mentioned, however, some of the dietary assessment techniques were inappropriate. For example, the use of a hypothetical snack choice (Killen et al., 1988; King et al., 1988) is not a sensitive nor reliable measure of diet which therefore calls into question the validity of any results using this measure. In three of the 12 studies, the nutrient content, in particular the sodium content, of the school lunch was successfully improved (Ellison et al., 1989; Parcel et al., 1989).

Table 1.6 Main findings of school based health promotion studies

Source	Main findings		
	Increase	Decrease	No effect
Tell et al. (1981)	• Fitness (males)	• Cholesterol	• BMI • SF
Puska et al. (1982)	• Some evidence of dietary change		• BMI • SF • Prevented increase in smoking and cholesterol
Dwyer et al. (1983)	• Fitness	• SF	• Cholesterol
Perry et al. (1987)	• Healthy eating scores (females)		
Killen et al. (1988)	• Knowledge of risk factors and nutrition • Hypothetical snack choice		• Exercise related measures
King et al. (1988)	• Knowledge scores • Hypothetical food choice		
Walter et al. (1988)		• Total fat intake • Cholesterol (middle income group)	
Bush et al. (1989)		• Cholesterol (both groups)	• Diet
Crockett et al. (1989) Perry et al. (1989)		• Fat intake (home groups) not sustained at a year	
Ellison et al. (1989)		• Sodium	
Parcel et al. (1989)	• Knowledge and skills		• Diet
Tamir et al. (1990)	• HDL	• Cholesterol	
Lionis et al. (1991)	• Changes in dietary habits suggested by one of the two dietary assessments		• Prevented increase in cholesterol and BMI
Alexandrov et al. (1992)		• Cholesterol	
Arbeit et al. (1992)			• Inadequate measure of diet • knowledge

Source	Main findings		
	Increase	Decrease	No effect
Hopper et al. (1992)			• Inadequate measure of diet • Parental involvement
Nader et al. (1992)		• Total energy and fat intake (Anglo adults) • Cholesterol in Anglo males	•Hispanic adults or children
Resnicow et al. (1992)	• Heart health food score	•Cholesterol	
Domel et al. (1993)			• Fuit and vegetable intake
Vandongen et al. (1995)	• Fitness (females)	• Fat and increase in fibre (some groups)	• Cholesterol
Donnelly et al. (1996)	• Improved school lunches • Nutrition knowledge		• BMI • Body fat
Harrell et al. (1996)	• Healthy heart knowledge • Physical activity	• Possibly SF	
Luepker et al. (1996)	• Moderate to vigorous exercise in school, • Dietary knowledge	• Fat (school lunches)	• Family component group
Sallis et al. (1997)	• Class time spent in PE		
Gortmaker et al. (1999a)	• Fruit and vegetables	• Dietary fat • TV viewing	
Gortmaker et al. (1999b)		• Obesity (females) • Energy intakes (females) • TV viewing	

Adapted and modified from Resnicow and Robinson (1997) and Rowe et al. (1997)
SF=skinfolds; HDL=high density lipoprotein; PE=physical education

One study that focused solely on physical activity (Dwyer et al., 1983) reported significant benefits in skinfolds and physical fitness in one of the intervention groups. The other study that had this sole focus (Sallis et al., 1997) achieved an increase in time spent partaking in physical activity. Five other studies reported a positive result in the area of physical activity, including Gortmaker (1999a, 1999b) who demonstrated a decrease in the time spent viewing television. Television viewing has been specifically linked to childhood obesity (Robinson, 2000). In the randomised controlled study by Gortmaker et al. (1999b), adolescents undertook a six month curriculum to decrease television, videotape and video game use. Significant decreases in BMI, other anthropometric measures, television viewing and food eaten in front of the television were seen in the intervention group. Gortmaker (1999b) also showed a decrease in the prevalence of obesity among female adolescents which, along with Dwyer et al. (1983), are the only studies which report favourable anthropometric outcomes.

Six out of 16 studies reported a beneficial effect on blood cholesterol levels and two studies reported preventing an increase in blood cholesterol. One of these studies used a tabletop method of cholesterol analysis (Vandongen et al., 1995), which may be considered an invalid method of analysis due to inherent features of the analyser (Rowe et al., 1997).

Nine out of 16 studies reported a favourable change in an aspect of health-related knowledge or attitudes. These aspects are particularly difficult to measure and it should be remembered that a lack of knowledge might not be the underlying reason for a particular behaviour. This is a salient lesson from past health promotion campaigns.

Walter et al. (1988) compared effects in populations from different social and demographic background groups and found less beneficial results in the low-income groups for both diet and cholesterol, and for diet in the black population groups. Four studies had some family involvement (Nader et al., 1989; Perry et al., 1989; Lionis et al., 1991; Luepker et al., 1996), two of which specifically tested the effect of adding a familial component (Perry et al., 1989; Luepker et al., 1996). Results did not seem to indicate a particularly beneficial effect from this approach.

The results of a UK school-based prevention of obesity study (the 'APPLES' study) have recently been published (Sahota et al., 2001a; Sahota et al., 2001b). The intervention was based on individual school action plans and varied between schools, therefore it was not included in the above review. No reduction in the incidence of obesity was detected as a result of the intervention. An increase in vegetable intake (but reduction in fruit consumption) and improvements in knowledge were seen as a result of this year long intervention.

1.5.1.5 Ongoing studies

The Pathways study is a 3-year randomised, school-based intervention for the primary prevention of obesity in American Indian school children (Davis et al., 1999). The study is being undertaken in seven American Indian communities throughout the US and is multifaceted, offering programmes for health promotion, physical education, school meals and the family. In Germany, the Kiel Obesity Prevention Study (KOPS) is a long term, 8-year study which has shown promising preliminary results with apparent reductions in overweight among intervention children (Muller et al., 2001). The study gives specific and identical behavioural and educational messages to children and their parents. In addition, a sports programme is offered to overweight children.

1.5.1.6 Conclusion

The results of these studies show that there is limited evidence for school-based prevention programmes offering a means to impact on lifestyle habits associated with obesity. However, many of the studies failed to make an impact on the variables measured and the work to date has highlighted potential problems in methodologies that must be addressed in order to ensure robust and high quality study designs. It has been noted that positive intervention effects were observed 80% of the time for studies targeting cigarette smoking in contrast to 16% for adiposity (Resnicow and Robinson, 1997). This suggests that in order to decrease or prevent obesity greater emphasis on obesity rather than other risk factor interventions may be more effective. The need for maintenance or a booster for such interventions has been highlighted in a recent report (Ritchie et al., 2001). Nevertheless, despite the limitations associated with a preventative approach, this method still offers a way forward to reduce the obesity epidemic and improve public health (Fulton et al., 2001). Lessons should be learnt from these studies and further research is needed to investigate ways of increasing the effectiveness of this population-based preventative approach. At its inception, the current research was the first UK school-based study aimed at the prevention of obesity in children. It concurred with the 'Health Promoting Schools' initiative which was gaining momentum at the time, the ethos of which targets the whole school and moves away from traditional health messages (Lister-Sharp et al., 1999). The author was not aware of the 'APPLES' study until midway through the research described in this thesis.

This literature review has provided an introduction to obesity, body weight regulation, childhood obesity and school-based interventions to prevent obesity. In chapter 6, further issues relevant to the prevention of obesity through dietary intervention will be discussed.

1.6 Research aims

1.6.1 Study 1

Aim

To develop, deliver and monitor a programme aimed at the prevention of obesity in primary school children.

Objectives

1. To develop a school-based / family-orientated intervention programme to prevent obesity in children under 10 years of age.
2. To implement an intervention programme that is acceptable and appropriate for primary school children.
3. To monitor and evaluate the programme and determine if there is an appropriate intervention(s) to prevent obesity in primary school-aged children.
4. If a successful programme(s) is identified, disseminate this at a national level.

In addition, this study provided opportunities to: (a) investigate detailed anthropometric data in children aged 5-7 years and (b) assess the ability of children of this age to provide a dietary recall of an observed lunch meal.

1.6.2 Study 2

Aim

To investigate the effect of breakfasts with variable glycaemic index (GI) on appetite and satiety on children aged 9 -11 years of age.

Objectives

1. Assess the appetite responses (i.e. satiety, appetite, hunger) to three test breakfasts of varying GI.
2. Measure ad-lib lunch intake after habitual breakfast and the three test breakfasts.

The three test breakfasts:

1. Test breakfast 1- low-GI (oats, fruit, yoghurt);
2. Test breakfast 2 - low-GI breakfast (oats, fruit, yoghurt) with 10% added sucrose;
3. Test breakfast 3 - high-GI breakfast (breakfast cereal, toast).

Chapter 2
Materials and methods

Section 1 School-based prevention of obesity study

2.1 Programme development

The intervention, known as 'Be Smart', lasted for eight weeks per term, over four school terms: weekly in term 1 and fortnightly thereafter in terms 2 - 4. The setting for the intervention was lunchtime clubs. Each lesson was designed to last for a 20-25 minute period and used an interactive approach. Three intervention programmes and one control programme were developed:

1. nutrition group ('Eat Smart');
2. physical activity group ('Play Smart');
3. combined nutrition and physical activity group ('Eat Smart Play Smart');
4. control group ('Be Smart').

The author and three trained research assistants were responsible for the delivery of the interventions. The author undertook the training of the research assistants as a quality control check to ensure the delivery of the intervention was consistent. The author and research assistants had to undergo police checks before the intervention commenced. A Latin square* design was employed for the delivery of the lessons so that each 'teacher' taught a different intervention for each of the seven groups of children, but the same children always had the same 'teacher' for continuity.

The programme developed used some American resources and material from the UK 'Give me 5' campaign (which promotes fruit and vegetables) as a basis, but was mainly original work. All materials were reviewed by experienced primary school teachers and amended on the basis of their recommendations. For all children, an activity book, which was designed for use at home, accompanied each term's lessons. Specific weekly messages were discussed with the nutrition, physical activity and combined programme children. These were reiterated through related 'homework' that parents were asked to sign when completed by the child. Parents were also targeted through a newsletter sent home at the conclusion of each term, which gave a résumé of the lessons and key messages.

* An arrangement of letters in a square array of n^2 compartments each letter appearing *n* times but never twice in the same row or column

2.1.1 Nutrition programme (Eat Smart)

The nutrition programme was developed to give specific positive messages: the promotion of fruit and vegetables and the promotion of power foods (high starch foods). By default, this encouraged a decrease in consumption of high fat, high sugar snack foods (e.g. replacing crisps with sandwiches or fruit as snack foods). The link between food and good health was also made. A summary of the lesson outlines per term is given in Appendix B.1.

2.1.2 Physical activity programme (Play Smart)

The physical activity programme was designed to promote activity in daily life rather than the promotion of specific leisure pursuits, which would not be accessible to everyone. Using insects as a theme, the concepts of energy and activity were explored. The promotion of activity in the playground and a reduction in television viewing were specifically addressed. The US recommendations for physical activity in children have been translated into an 'activity pyramid', which in a very visual way promotes cardiovascular and strength/flexibility activities with suggested frequencies of these (Frary and Johnson, 2000). This model was used in the final term of 'Play Smart'. A summary of the lesson outlines per term is given in Appendix B.2.

2.1.3 Combined programme (Eat Smart Play Smart)

Children in the combined programme received half of the nutrition and half of the physical activity programme each term. The lessons chosen were those deemed by the author to be key to the message of the overall term. In appendices B.1 and B.2 the weeks included in this combined programme have been marked with an asterisk.

2.1.4 Control programme (Be Smart)

The children in the control group were not given any guidance on nutrition or physical activity. However, it was considered very important to include an educational element in this group, and time was divided equally between interactive educational CD-ROMs and lessons. The CD-ROMS used ('My Amazing Human Body' and 'All About Me') were produced by Dorling Kingersley and were recognised educational tools. In the lessons children learned about food in a non-nutrition sense. There were no weekly messages for the children and their parents/carers, however, there was an activity book with homework for the week that the children received a lesson. A summary of the lesson outlines is given in Appendix B.3.

2.1.5 Methodological considerations

Children present with many unique issues when they are the recipients of health programmes; the most challenging is a still evolving cognitive ability. Therefore regard to developmental and health education literature was vital to develop an appropriate programme (and to employ suitable assessment techniques). One of the grandfathers of educational theory is Jean Piaget (1896-1980) and his assertion that children think differently from adults was revolutionary at the time (Shaffer, 1996). Contento (1981) carried out a study on children aged 5-11 years to investigate their thinking about food and eating based on a Piagetian model. Findings showed that children at this age relate to real world objects and events for development; ideas presented to children at this age should be perceptually based, rather than formally structured.

The influence of home, significant people, multi-environments, social settings and culture have a marked effect on a child's understandings, belief systems and view of self (Moore, 1998). From a health education perspective, interventions which reach beyond the classroom may be more effective.

It is critical that nutrition educators know how children think about nutrition and health and the relationship between them (Singleton et al., 1992). Abstract questions such as 'Why is that healthy?' appear to be suitable only for older children. With increasing age, children appear better informed about which foods and activities are publicly deemed 'healthy' and 'unhealthy', but in younger children, there is a tendency to confuse personal preferences and health issues (Backett and Alexander, 1991). Research suggests that young children (4 to 7 years) are ready to learn about food, nutrition and health and that young children can comprehend some abstract concepts and relationships if targeted appropriately (Singleton et al., 1992).

One of the biggest misconceptions in health education is the assumption that a change in knowledge will lead to a change in attitude and, subsequently, a change in behaviour (Kemm and Booth, 1992). A behaviourally focused approach to nutrition education in children has been compared and found to be superior to a knowledge-based approach (Lytle, 1995). Health messages should be relevant, credible and achievable (Naidoo and Wills, 1998) and when targeting children their social and psychological perspectives must be accounted for (Moore, 1998).

Theories which underpin health promotion act as a framework or a model rather than a rigorously tested hypothesis, as in the physical sciences Nutbeam and Harris (1998). It has been suggested that a clear theoretical basis is more important than the actual choice of theory to the likely success of nutrition education (Achterberg and Clark, 1992). As discussed in Chapter 1, Social Learning Theory (later renamed Social Cognitive Theory) is the most cited and utilised theory in school-based lifestyle interventions. Albert Bandura is attributed with the development of the theory. He defined human behaviour using Social Learning Theory as a 'continuous, reciprocal interaction between cognitive, behavioural and environmental determinants' (Bandura, 1986). The Center for Disease Control and Prevention (CDC) has based its recommendations for school health programmes on the three interacting spheres of influence outlined in Social Learning Theory: environment, personal characteristics and behavioural skills and experience (CDC, 1996).

In the current research, a programme was developed based on Social Learning Theory and incorporated the following elements:

1. Raising the value of the desired behaviour, including the short-term benefits, which are most likely to appeal to young people.
2. Providing the opportunity to taste healthy foods and undertake non-competitive physical activity.
3. Working with parents and others to overcome barriers to the desired health behaviour.
4. Providing incentives to reinforce messages, for example verbal praise and small prizes.
5. Developing practical skills and thus self-confidence in the desired behaviour.

It is recognised that there are limitations with the use of this theory in school and its extrapolation for use with school programmes. Practical constraints of school may cause a reliance on more traditional and didactic methods of teaching, rather than providing sufficient time for the rehearsal and mastery of experiences necessary to enhance self-efficacy and self-regulatory skills.

Based on the outcomes and recommendations of a comprehensive review of children's understanding of nutrition messages (Lytle et al., 1997), the health messages in the present research aimed to be:

1. developmentally appropriate;
2. specific and behaviourally focused;
3. simple and clear to enable food and activity selection;
4. positive, engendering a healthy attitude and behaviour towards food.

Another important consideration when working with children is obtaining police checks and clearance if researchers are to have direct unsupervised contact with children. The author and the research assistants who assisted in assessments and delivery of the intervention were all police checked before at the outset of this research.

2.1.6 Evaluation

Process evaluation should be an ongoing aspect to any health promotion initiative and is part of formative evaluation. Process evaluation describes the activity undertaken and informs on the effectiveness and success of an intervention (Field, 1992). Process evaluation includes answering the following questions (Hawe et al., 1995):

1. Is the programme reaching the target group?
2. Are all participants satisfied?
3. Are all activities being implemented?
4. Are all materials and components of satisfactory quality?

In this research, each 'teacher' delivering the intervention kept a regular diary of lesson evaluations. This included a record of the aspects of the lessons which worked well and those which did not. The author met with all the 'teachers' to discuss the diaries and these were then used to guide future lessons. Children were regularly asked about their satisfaction with the programme and their responses noted. In addition, throughout the intervention the author met with the head and lead teachers in each of the schools to discuss progress of the study. Telephone calls from parents were logged and acted on if appropriate.

As part of impact evaluation, parents and teachers completed a satisfaction survey at the end of the intervention (Appendix C.1 and C.2). In addition, all children in the relevant year groups in each of the three schools completed a quiz based on the intervention to assess whether the programme had been comprehensible (Appendix C.3).

2.2 Assessments

Assessments were made in three ways:

1. measurements in school;
2. postal questionnaires completed by parents about their children;
3. postal questionnaires to parents about themselves.

All assessments were made at the initial stage and at the conclusion of the intervention. Postal questionnaires were mailed as two separate sets with a two-week period between each set.

2.2.1 Anthropometry

As previously discussed (section 1.2.2), a range of anthropometric measures gives the best indicator of an individual's body composition. For this reason weight, height, skinfolds and body circumferences were measured. The author, two research assistants and the supervisor of this research who is an expert in the measurement of skinfolds undertook the anthropometric measurements. Skinfolds measurement is particularly prone to within- and between- subject error; therefore experience and expertise were essential for this assessment. All measurements were taken in school with children in minimum indoor clothes (shirt/blouse, trousers/skirt, underclothes) and bare feet. Measurements were taken three times and the mean calculated.

Height and weight

Height was measured using a stadiometer ("Seca" Somatometre 200cm x 0.1cm) with children standing straight and still, with their heads in the Frankfurt plane. Shoulder blades, buttocks and heels were touching the measurement board. Measurements were made to the nearest millimetre. Weight was measured using dial scales (Healthometer Professional Scales, 148kgs x 500g) and recorded to the nearest 0.1kg. BMI was calculated using the standard formula weight (kg)/height $(m)^2$.

Arm Span

Arm span was measured using a standard tape measure (0.1mm intervals) positioned on a flat wall, secured at 90 cm above the ground. Arms were held outstretched, straight and at shoulder height, feet were together and the head was forward. Arm span was recorded to the nearest millimetre.

Skinfold measurements were taken at five sites with Holtain skinfold calipers (0.2mm intervals) using standard procedures (Harrison et al., 1988). The five sites were as follows:

- *biceps* - measured at the thickness of a vertical fold on the front of the upper non-dominant arm, directly above the centre of the cubital fossa;
- *triceps* - measured at the midpoint of the back of the upper non-dominant arm;
- *sub-scapular* - measured just below and laterally to the angle of the non-dominant shoulder blade, with the shoulder and arm relaxed;
- *supra-iliac* - measured in the midaxillary line immediately superior to the iliac crest;
- *calf* – measured, with the foot on a box so that the knee and hip are flexed at the place of maximum circumference with a skinfold raised parallel to the long axis of the calf. Calf skinfold measures have been used in the assessment of total body fat in children (Parizkova, 1961).

Circumferences

Body circumferences were taken at four sites with a standard tape measure (0.1mm intervals) using standard procedures (Callaway et al., 1988). The four sites were:

- *waist* - taken at the narrowest point, midway between the lower margin of the last rib and the crest of the ilium, in the horizontal plane;
- *hip* - taken at the point yielding maximum circumference over the buttocks with the subject standing erect and with feet together;
- *head* - taken with the head in the Frankfurt plane using a narrow, flexible and non-stretch tape. The tape was placed just above the supra-orbital ridges covering the most prominent part of the frontal bulge and over the part of the occiput which gives the maximum circumference;
- *mid upper arm (MUAC)* - taken at the mid-point between the acromion and olecranon processes.

2.2.2 Dietary assessment

Dietary survey work is fraught with potential errors and pitfalls. This is due to a variety of inherent problems, such as reliance on memory, lack of honesty in reporting, failure to record habitual intake and non-compliance (Bingham et al., 1988; Medlin and Skinner, 1988; Thompson and Byers, 1994) In children, these problems are compounded, since a child's cognitive skills may not be sufficiently developed to permit independent reporting of their own food intake (Haraldsdottir and Hermansen, 1995; Rockett and Colditz, 1997; Livingstone and Robson, 2000). A summary of commonly used dietary assessment techniques and their associated advantages and disadvantages is shown in Appendix A.4.

When choosing an appropriate dietary assessment tool, several issues should be considered:

1. objectives of the assessment;
2. respondent burden (especially time factors);
3. level of compliance required (e.g. 7 day weighed food intake and a 24 hour recall require very different levels of compliance);
4. will the tool be sensitive enough to detect day-to-day variability?
5. practical aspects of data collection (e.g. personnel available);
6. will nutrient intakes be calculated?
7. will portion size information be collected and, if so, how?
8. has the tool been tested for reliability and validity?

Given the young age of the children in this study, parents were relied upon to provide dietary data on the children's behalf. Due to the constraints of manpower, time and budget, a 24-hour recall and a food frequency questionnaire were used to assess the children's diets. Both of these methods are suitable to administer by post, which made them practical for this research. A 24-hour recall does not provide a reliable measure of habitual intake so a food frequency questionnaire was chosen to complement the data on dietary intake.

2.2.2.1 24-hour recall

The 24-hour recall was mailed and completed by parents as part of a record of a typical 24-hour period in the life of their child during a school week (Appendix C.4). This was based on the validated 'Day in the Life Questionnaire' (Edmunds and Ziebland, 2002). The dietary information was quantified using household measures and was supplemented by a lunch observation (see Section 2.3.2.4). The recalls were analysed using 'Diet 5' (Diet 5 for Windows 1995, Robert Gordon Institute, Aberdeen) to give a full nutrient analysis.

2.2.2.2 Food frequency questionnaire (FFQ)

The FFQ selected was a 42- food item questionnaire that had been validated to rank individuals (adults) as high/low fat and high/low fibre consumers (Hammond et al., 1993) (Appendix C.5). The FFQ was mailed and completed by parents on behalf of their children. Portion size estimation and hence nutrient analysis, were not part of the remit of this questionnaire. The average frequencies of consumption of specific foods and food groups were analysed. In addition, classifications for high, medium and low fat and fibre were made, based on the criteria used by Hammond et al. (1993). Scores were assigned to fat and fibre intake based on consumption of the following foods: red meat, cheese, whole milk, crisps, cakes and biscuits for fat; vegetarian alternatives, wholemeal bread and breakfast cereal, potatoes, chips, vegetables, salads, fresh fruit and other fruits for fibre. The cumulative scores for fat and fibre were then assigned to 'high', 'medium' or 'low' bands.

Parents' diets were also assessed using this FFQ as it was felt that familiarity with the questionnaire would be advantageous. It was anticipated that, as the questionnaires were dispatched at different time intervals, confusion between the two responses would be avoided. Analysis of the parents' diets was as described above.

2.2.3 Lunch observation and recall

A lunch observation was carried out on all children who enrolled in 'Be Smart', regardless of their intervention group. The observation had two aims:

1. to supplement the 24-hour recall provided by parents;
2. to assess children's ability to perform a recall of this meal.

The research assistants involved in the delivery of the intervention assisted in the observations. The author provided training on the observation procedures, which were adapted from those described by Domel et al. (1994) and Bollella et al. (1999). Prior to lunch, it had been established which children ate a packed lunch (PL) brought from home and which children ate a school dinner (SD). Each investigator was responsible for monitoring the lunch intakes of 4 to 5 children per observation period. As the observers were known to the children, their presence in the canteen was not perceived as unusual. Consequently, the children were not aware that their lunch intakes were being observed and that subsequent recall of their intakes was planned.

For children eating PL, observers made a covert checklist of the contents of each lunch box in the morning. This was to overcome the difficulties involved with assessing the types of food covered by bags and wrappers. During the observations, progress with eating the various dietary items was recorded using the checklist. Leftovers were noted and, if required, the lunch box was checked again in the afternoon. In all cases, lunchboxes were stored in cloakrooms outside the classroom.

For children eating SD, observers were positioned at the serving point in the canteen or school hall and recorded the content of each child's meal at this initial stage. The investigator then moved to the tables where progress with the meal was recorded covertly. Any leftover food destined to be discarded was noted. Swapping of food/drinks between children was closely monitored and recorded by all observers.

A recall interview was carried out with each child within two hours of finishing the lunchtime meal. The interviews lasted for approximately 10-15 minutes and were conducted in the library or other quiet place. Firstly, each child was asked to provide a recall of his/her lunch without any prompting. When it was apparent that the child had finished the recall, non-directive prompts were used to assess if the child was able to remember anything else. Questions, such as 'is that everything?' and 'did you eat anything else?' were used as prompts. Each child was asked specifically about leftovers at the end of the interview. This was omitted in children who were unable to provide any recall of the lunchtime meal.

The foods recalled were classified as matches (observed as eaten and reported as eaten), omissions (observed as eaten but not reported as eaten) or phantoms (not observed eaten but reported as eaten), as described by Baxter et al. (1999). For each child, additional information was noted, such as the order in which foods had been recalled, if further information had been gained by using prompts and if reports of leftover food were given spontaneously or after prompting.

2.2.4 Physical activity

The measurement of habitual physical activity is problematic, particularly in children due to their immature cognitive development if relying on self-report measures (Koo and Rohan, 1999). Methods of measuring physical activity have been comprehensively reviewed and fall into one of the following categories: (Saris, 1985; Sirard and Pate, 2001):

1. direct observation;
2. heart rate (HR) or motion sensors;
3. self-report measures.

Each of these techniques has relative benefits and deficiencies. Direct observation requires a high level of researcher manpower and is not a feasible option for large-scale projects. The use of HR or motion sensors is relatively inexpensive for small to moderate scale studies, but provide varying degrees of accuracy (Sirard and Pate, 2001). Self-report measures are appropriate for epidemiological studies and a wide range of validated questionnaires are available (Kriska and Caspersen, 1997).

2.2.4.1 Measurement of children's physical activity

In the present study, children were asked basic questions about their school day during a short face-to-face interview (approximately 10 minutes) during school time. The interviews were held in a quiet room in the school, such as the library or first aid room. Children were asked about their mode of transport to and from school, activities at break-times, attendance of after-school clubs and television viewing. Children were not asked to quantify their television viewing due to its relative cognitive complexity. Pictures were used to help elicit responses (Appendix C.6).

Parents completed a two-part postal activity questionnaire on their child's habitual activity (Appendix C.7). This was based on the 'Day in the Life Questionnaire' (Edmunds and Ziebland, 2002) and concentrated on typical school days in the first section and typical weekend days in the second section. Mode of transport to and from school, children's activities before and after school and typical weekday television viewing and computer usage were assessed. The weekend was divided into daily sections (morning, afternoon and evening) and typical activities reported for each section. In addition, average television viewing for portions of each day was assessed. The segmented day method of recall has been used in past studies and is a way of reducing error (Cale, 1994).

From the questionnaire, average daily television viewing and weekday computer usage per child was calculated. Reported activities at the weekend were classified as being of low (e.g. reading), moderate (walking) or high physical intensity (running, cycling) and the frequency of each was calculated. The categorising of activities into intensity levels was adapted from those used in the National Diet and Nutrition Survey (NDNS) for Young People aged 4-18 years (Gregory and Lowe, 2000).

The physical activity questionnaire was supplemented with information about activity undertaken in a typical day during the week from the 24-hour recall of diet and activity, completed by parents/carers.

2.2.4.2 Measurement of parents' physical activity

Parental physical activity was assessed using the Baecke Activity Questionnaire (Baecke et al., 1982) for work-related activity and the Godin Leisure Time Questionnaire (Godin and Shephard, 1985) for activity outside work (Appendix C.8). The questionnaires assessed activities in the work place and the intensity of activity over a seven-day period. Subjects reported the number of times in an average week that they spent more than 15 minutes in activities that were classified as mild, moderate or strenuous. These 15 minute bouts of exercise were totalled for each individual. Examples of activities in each category were provided on the self-administered form.

2.2.5 Nutrition knowledge

In a comprehensive review on the selection of an assessment tool for the measurement of nutrition knowledge by researchers, Parmenter and Wardle (2000a) recommended, where possible, the use of an existing tool. This tool may need to be modified for a different population or abbreviated to suit the purposes of the research. No 'gold standard' for the assessment of nutrition knowledge exists and, given the breadth of the subject, such a standard is unlikely. This means that any new tool must be rigorously tested for validity and reliability, which is a long and intensive process. (Parmenter and Wardle, 2000) have identified the key criteria that a questionnaire must satisfy: internal reliability, test-retest reliability, construct validity and content validity.

2.2.5.1 Nutrition knowledge measurement in children

A literature search on paediatric nutrition knowledge questionnaires showed a dearth of valid and reliable tools, especially in children less than 7 years of age. Many existing instruments in the US concentrate on knowledge and skills rather than the affective domain (i.e. attitudes) (Contento, 1991). In addition, many existing assessment tools have been designed to evaluate specific interventions rather than serve as population surveys.

The tool selected for this research was developed by Calfas et al. (1991) for use in children aged 4 to 8 years. In this assessment, children are shown a series of matched photographs of food and asked to select the healthiest food. In the development of the tool, validity and test-retest reliability testing were undertaken. Results showed that the nutrition knowledge had an alpha coefficient of 0.75, which indicated good internal consistency. Test-retest reliability, calculated by Pearson's correlation, was 0.72 ($p<0.001$). The matched photographs used in the original research are shown in Table 2.1. The tool is quick to administer (10 minutes approximately), which was an important factor as this assessment was being carried out in class time. In the present study, changes were made to the original foods to ensure all foods would be familiar to children in the UK (Table 2.2).

Table 2. 1 Matched pairs of photographs used in the original nutrition knowledge questionnaire (Calfas et al., 1991)

More healthy food	Less healthy food
Rice	French fries
Raisins	Chocolate candy
Cheerios	Fruitloops
Orange juice	Cola
Yoghurt	Ice cream
Rice cakes	Potato chips
Peanuts	Popcorn
Tuna sandwich	Hot dog

Table 2. 2 Matched pairs of photographs used in the 'Be Smart' nutrition knowledge questionnaire

More healthy food	Less healthy food
Rice	French fries
Raisins	Chocolate
Cornflakes	Doughnut
Orange juice	Cola
Yoghurt	Ice cream
Crumpet	Potato crisps
Banana	Cake
Tuna sandwich	Hot dog

In addition, children were asked informally and at random to explain the answers that they had given. Children were interviewed immediately after the short physical activity questionnaire (Section 2.3.3.1), under the same conditions.

2.2.5.2 Nutrition knowledge measurement in adults

The questionnaire selected to assess nutrition knowledge in adults was developed by Parmenter and Wardle (1999) and had been previously validated. This questionnaire has four sections (Appendix C.9):

1. understanding of current recommendations;

2. understanding of foods which provide the nutrients referred to in the recommendations;
3. ability to choose healthiest food option;
4. knowledge of the link between diet and disease.

The nutrition intervention of 'Be Smart' specifically addressed aspects of this questionnaire: the recommendation for the daily intake of fruit and vegetables; the promotion and explanation of starchy based foods; the choice of lower fat snacks; and the specific health benefits of fruit, vegetables and starchy based foods. Therefore, it was anticipated that, by using this questionnaire, it may have been possible to detect an increase in nutrition knowledge in those parents whose children were randomized to either the 'Eat Smart' or 'Eat Smart Play Smart' groups. It was not considered necessary to adapt the questionnaire to suit the population being assessed, therefore permission was sought and granted to use the questionnaire in its original format, as a postal questionnaire.

2.2.6 Social and medical history

Details of parental age, educational attainment, profession and ethnicity were elicited via a postal questionnaire. Parents were asked to give details of any heart/circulation problems, hypertension, diabetes, allergy and medication. Smoking status and a self-reported height and weight were also obtained. Parents were asked to give details of their child's medical history, noting previous visits to a specialist doctor, details of any chronic illness and current medication. Details of any allergy, special diet and problems with appetite were also obtained. A copy of the questionnaire is given in Appendix C.10.

2.3 Subjects and recruitment

Statistical advice, sought at the proposal application phase, advised that 50 children per intervention cell (i.e. 200 children) would have sufficient statistical power to detect any intervention effect. Recruitment began in January 2000 and was undertaken in three phases as described in the time line. Children in Years 1 and 2 (aged 5 to 7 years) from three primary schools in Headington, Oxford were targeted. The schools selected already had established links with the Nutrition and Food Science Department at Oxford Brookes University. They served a catchment area with a bias towards children of a higher socio-economic status and a low ethnic population. These schools are therefore not representative of the general population. Children were told about the study in school assemblies and invited to join. Concurrently, parents/carers were sent an invitation letter with a tear-off consent slip and a fact sheet. Posters were placed strategically in the schools advertising the study. Canvassing in the school playground during mornings and afternoons was a successful means of enhancing recruitment, along with meetings for parents held in the schools. Use of the university gym at weekends was offered as an incentive to parents to participate in the study. A total of 218 children were recruited in the three phases and were randomly allocated to one of the intervention or control groups.

January 2000	March 2000	September 2000
Targeted children in Years 1 and 2 in two local schools	Targeted children in Years 1 and 2 in a third local school	Targeted children in Year 1 in original two schools

2.4 *Ethical approval*

Ethical approval for the study was obtained from The Applied and Qualitative Research Ethics Committee for the Oxford Radcliffe Hospitals, Oxford. Parents signed consent forms on behalf of their children.

2.5 *Statistical analysis*

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS 10.0.5; SPSS Inc., Chicago.IL,USA,1999). Data are presented as frequencies, means and standard deviations. Prior to statistical analysis, the normality of the data was tested using the Kolmogorov-Smirnov statistic with a Lilliefors significance level. Between group comparisons were made using ANOVA. The independent sample t-test and paired t-test were used to investigate differences between males and females and between baseline and final data respectively. The one-sample t-test was used to compare nutrient intakes with data from the NDNS for Young People (Gregory and Lowe, 2000). The Pearson correlation was used to determine associations between selected variables, e.g. weight and television viewing and parents' and children's diets. Statistical significance was set at $P<0.05$.

Section 2 Glycaemic index study

2.6 Recruitment and ethical approval

Recruitment was undertaken during October 2001 in an East Oxford middle school which had just started to run a breakfast club. All years were targeted with special emphasis on recruiting children in Years 5 and 6 (aged 9 to 11 years). Children were told about the study in a school assembly and parents were told briefly about the study in a school newsletter. Interested parents/children then requested a more detailed information sheet and returned the consent form to the school office. Children who had a food allergy, followed a special diet for medical reasons, or who did not habitually eat breakfast were excluded from the study.

Ethical approval for the study was obtained from The Ethics Committee for the School of Biological and Molecular Science Oxford Brookes University. Written consent was obtained from both parents and children.

2.7 Study design

A within-subject study design was employed, with subjects acting as their own control. Children were divided into groups and a rolling programme devised whereby, week by week, each group would randomly receive one of the three test breakfasts for three consecutive days. The study ran on a Tuesday, Wednesday and Thursday. On the Monday preceding a group's first test day, a 'trial' lunch was undertaken in which children consumed habitual breakfast at home and were then provided with lunch at school. The inclusion of a 'trial' day as a control, allowed the effect of a buffet style lunch to be monitored. After each test breakfast, children were instructed not to eat or drink anything until lunchtime, except water and a small piece of fruit, supplying approximately 10g carbohydrate, which was provided for breaktime.

2.7.1 Baseline assessments

Anthropometric measures were made at baseline (weight, height, waist circumference, MUAC, skinfolds at four sites) as described in section 2.3.1. Children were asked to provide a 24-hour recall using a food atlas and household measures to quantify portion sizes. Further detailed questions were asked about breakfast consumption to elicit habitual intake. The recalls were analysed using 'Diet 5' (Diet 5 for Windows 1995, Robert Gordon Institute, Aberdeen) to give a full nutrient analysis. Children also completed a food preference questionnaire based on the food options for the test breakfasts and buffet lunch.

2.7.2 Test breakfasts

The three test breakfasts were devised to match energy and nutritional content of an individual's habitual breakfast as closely as possible. Any outliers, either a very high or low reported energy intake, were amended so that every child's breakfasts were within a 200-500kcal (800-2100 kJ) range. The three test breakfasts are outlined below. Pure fruit juice was included in each breakfast, and for every breakfast each child received a constant amount of juice. Milk provided for the cereal was either semi-skimmed or whole milk.

1. Low-GI - choice of All Bran, non-Swiss style toasted muesli, traditional porridge or soya and linseed bread. The GI values of these foods were estimated from the international GI tables (Foster-Powell and Miller, 1995) and manufacturers information. The GI of all the foods was estimated to be below 45-50.
2. Low-GI and added sucrose - the choice of food was as described above. Sucrose was added to provide an additional 10% energy, therefore a breakfast of 200kcal had 5g (20kcal) sucrose added. Sucrose has a GI of 60, but this level of addition would not adversely effect the overall low-GI of the breakfasts which was estimated to be below 55.
3. High-GI - choice of cornflakes, coco-pops, rice krispies or white bread. The GI values were estimated to be between 80 and 100.

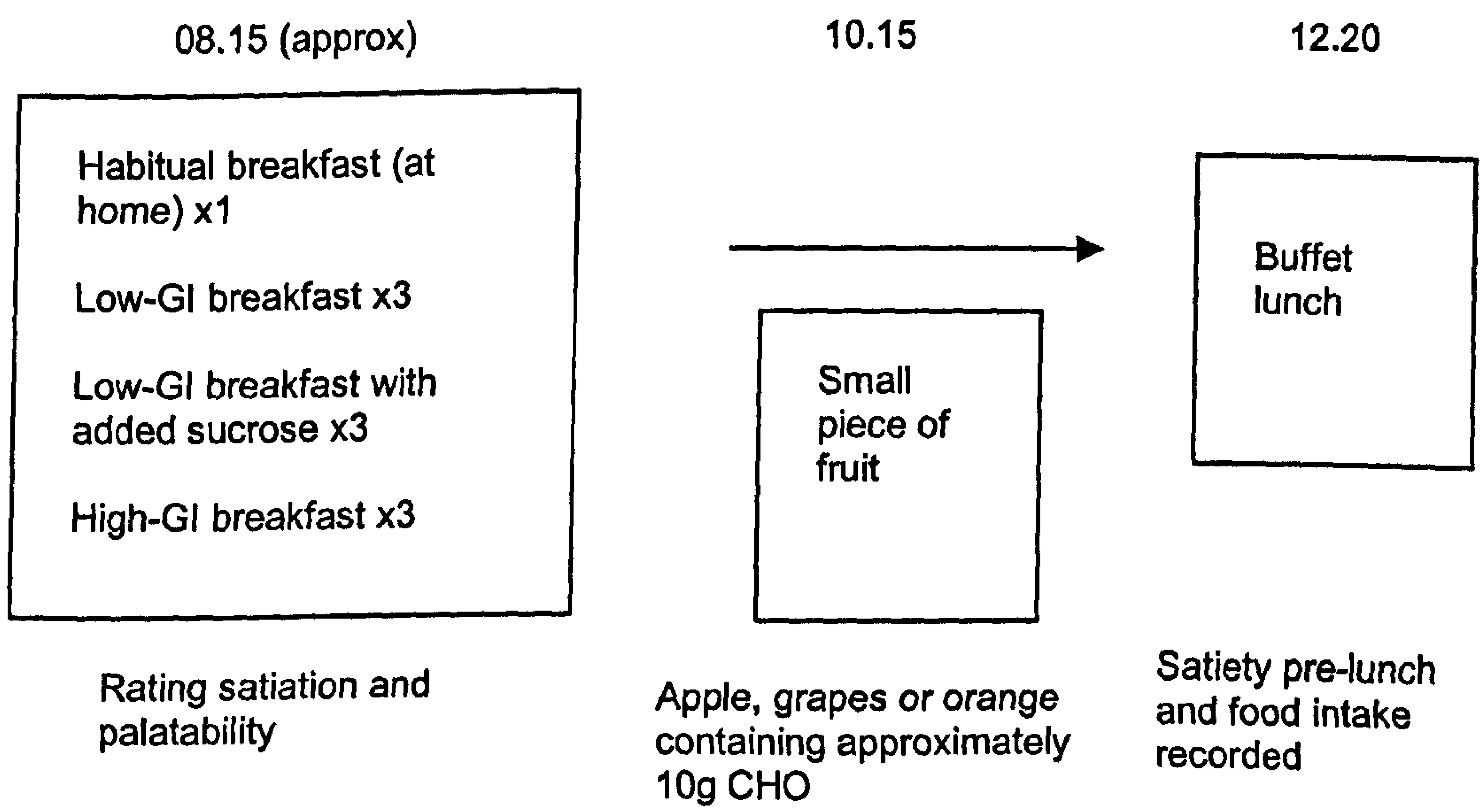
2.7.3 Buffet lunch

All groups received similar food choices at lunchtime and, for each individual group, the food choice was virtually identical for each of their test weeks. Children were provided with a choice of sandwiches (accounting for stated preferences), pizza, salad garnish (if a stated preference), crisps, biscuits, small cake, fresh fruit, yoghurt, fromage frais, squash and water. Lunch was served adjacent to the school meals area. Children sat around a large table with named seating and their lunch intake was unobtrusively observed and recorded (Appendix D.1). Undergraduate students in nutrition assisted the author in the observation process and each observer typically observed 3 or 4 children per lunchtime meal. The observations were analysed using 'Diet 5' (Diet 5 for Windows 1995, Robert Gordon Institute, Aberdeen) or manufacturer's nutritional information to give macronutrient content.

2.7.4 Rating scales

After breakfast, satiation and palatability were measured and, immediately before lunch, satiety was measured. Hunger and satiety are not absolute values, but indicate the extent of change in the sensation when recorded over a period of time (Holt and Miller, 1995). Currently, there is no standard questionnaire for the assessment of hunger or satiety, but rating scales or visual analogue scales (VAS) are commonly used. It was felt that in children, rating scales might be less cognitively demanding than a VAS due to the provision of worded ratings for children to select. The wording printed on the scale to describe the relevant sensations, or at the extremes of the scale, may be more important than the type of scale used (Holt and Miller, 1995). It has also been suggested that a rating scale may lead to reduced inter-subject differences due to increased comprehension compared to a VAS (Holt et al., 1992). The rating scale used to assess satiety has been shown by the authors to have greater test-retest reliability than VAS according to unpublished results (Holt and Miller, 1995). The palatability, satiation and satiety scales were based on previously used tools (Holt et al., 1992; Holt and Miller, 1994; Holt et al., 2001) and asked: 'How much did you like your breakfast?' (palatability rated from hated to loved breakfast), 'How full do you feel?' (satiation rated from extremely empty to extremely full stomach) and 'How hungry are you?' (satiety rated from extremely hungry to extremely full) (Appendices D.2 – D.4). An overview of the study is outlined in Figure 2.2.

Figure 2. 1 Overview of GI study



2.8 *Statistical analysis*

The study design employed was a randomised block design in which each subject provided a block of responses (i.e. 10 lunch energy intakes). This has the advantage of using the same subjects for each intervention which may reduce between subject variation and requires fewer subjects. A repeated measures ANOVA would often be used as an analysis tool for this type of study, however this has two major disadvantages in this particular study:

a. a conventional repeated measures ANOVA could only compare individual days rather than grouping days according to the type of breakfast consumed;

b. a repeated measures ANOVA does not account for missing data, therefore if a child had missed one of their three test days on only one occasion all their results would be discounted. In the present study, using a repeated measures ANOVA meant that the data from only 30 children would be analysed as 7 children had data missing for one (or more) days; this represents a 19% loss of data.

A statistician was consulted for advice on how to analyse the data. A multilevel modelling approach using the software package MLwiN was suggested (Rasbash et al., 2000). The benefits of using this approach are that the longitudinal (repeated measures) structure of the data is taken into account and individuals whose data is not complete are included with no difficulties (Goldstein, 1995). The use of the multilevel modelling approach also allows variation between individuals or between occasions to be defined as a function of the independent variables.

For descriptive purposes, data are presented as means, standard deviations and ranges for the group as a whole and for the normal weight and overweight/obese children. Differences in rating scales measures were assessed using Friedman's test and significant differences assessed by Wilcoxon's test using the Statistical Package for Social Sciences (SPSS 10.0.5; SPSS Inc., Chicago.IL, USA,1999). Statistical significance was set at $P<0.05$.

Chapter 3
School-based prevention of obesity study

In this chapter the results of the school-based prevention study as outlined in chapter 2 will be presented. As discussed, this is a pilot study and the first UK study of its kind in the age group targeted. In order to maintain cohesion, the diverse aspects of the study - anthropometry, diet, physical activity and nutrition knowledge assessment - will be presented separately, firstly for the children and then for the parents.

3.1 Recruitment and compliance

A total of 218 children (111 males and 107 females) aged 5-7 years were recruited from three first schools in Headington, Oxford, each serving a similar catchment area. Recruitment was undertaken in three phases from January 2000 to September 2001. In total seven groups were targeted over the two school years. Children were randomly allocated, on the basis of BMI, to one of the three intervention groups or the control group (Table 3.1).

Table 3. 1 Subject characteristics at baseline (mean ± SD)

	All Groups	Eat Smart	Play Smart	E/P Smart	Be Smart
N	218	56	54	54	54
M:F	111:107	31:25	27:27	24:30	29:25
Age (y)	6.1 ± 0.7	6.1 ± 0.6	6.2 ± 0.6	6.2 ± 0.7	6.1 ± 0.6
BMI	15.9 ± 2.1	16.1 ± 2.7	16.0 ± 2.0	15.8 ± 2.0	15.5 ± 1.6

The withdrawal rate during the study was 17% (*n* 37), which made the final number of subjects in the study 181. Of the 37 subjects who left the study, 43% (*n* 16) left school, 6% (*n* 2) were discounted because of chronic illness and 51% (*n* 19) withdrew from the study. There was no gender bias in the withdrawals and the rate was similar between the four intervention groups. The response rate for the postal questionnaires was approximately 70% at baseline and 45% at the final stage. The fall in returns may be indicative of respondent fatigue.

3.2 Anthropometry

Anthropometric data was obtained for 212 children (6 children missing) at the initial stage. Using the recent international cut-off values for BMI (Cole et al., 2000), the percentage and number of children who were classified as overweight and obese was calculated for all children and per intervention group (Table 3.2). More females than males were overweight and obese in all groups. There were no significant differences in BMI between groups at baseline.

Table 3. 2 Percentage (number) of children classified as overweight or obese at baseline

		Total	Male	Female
All children	overweight	8 (16)	6 (6)	10 (10)
(*n* 212)	obese	4 (11)	1 (1)	7 (10)
Eat Smart	overweight	9 (5)	6 (2)	12 (3)
(*n* 56)	obese	7 (4)	3 (1)	12 (3)
Play Smart	overweight	11 (6)	7 (2)	15 (4)
(*n* 54)	obese	6 (3)	0 (0)	11 (3)
Eat/Play Smart	overweight	2 (1)	4 (1)	0 (0)
(*n* 52)	obese	6 (3)	0 (0)	10 (3)
Be Smart	overweight	8 (4)	3 (1)	12 (3)
(*n* 50)	obese	2 (1)	0 (0)	4 (1)

At the end of the intervention, anthropometric data was obtained for 172 children. Table 3.3 shows the percentage and number of children classified as overweight or obese at the final stage; prevalence is similar to the initial stage. Small changes in the numbers of overweight in some of the groups were observed, but subject numbers were too small for statistical analysis.

Withdrawals from the study (*n* 37) further depleted the number of overweight and obese children in the intervention. This group was studied to investigate if a disproportionate number of obese or overweight children left the study, which would have caused a selective bias in the remaining children. Initial anthropometric data were available for 35 of the 37 children in this group. The proportion of obese and overweight in the withdrawals was similar to the baseline cohort: 6% (*n* 2) and 9% (*n* 3) respectively, which suggests that the intervention did not adversely affect the compliance of overweight and obese children.

Table 3. 3 Percentage (number) of children classified as overweight or obese at final stage

		Total	Male	Female
All children	overweight	8 (14)	5 (4)	13 (10)
(*n* 172)	obese	3 (5)	1 (1)	5 (4)
Eat Smart	overweight	14 (5)	5 (1)	19 (4)
(*n* 42)	obese	7 (3)	5 (1)	10 (2)
Play Smart	overweight	11 (5)	4 (1)	18 (4)
(*n* 46)	obese	2 (1)	0 (0)	5 (1)
Eat/Play Smart	overweight	2 (1)	6 (1)	0 (0)
(*n* 42)	obese	2 (1)	0 (0)	4 (1)
Be Smart	overweight	7 (3)	5 (1)	10 (2)
(*n* 42)	obese	0 (0)	0 (0)	0 (0)

Average baseline and final weight and monthly weight gain per group were calculated and the results are shown in Table 3.4. The calculation of monthly weight gain allows an accurate comparison of growth and accounts for seasonal changes in growth. There were no significant differences in any of the average measures between the groups.

Table 3. 4 Baseline and final weight and monthly weight gain per intervention group (mean ± SD)

Group	Baseline average weight (kg)	Final average weight (kg)	Average monthly weight gain (kg)
Be Smart (*n* 37)	21.1 ± 2.8	24.6 ± 6.0	0.20 ± 0.12
Eat Smart (*n* 40)	22.0 ± 4.7	25.0 ± 5.6	0.25 ± 0.20
Play Smart (*n* 42)	22.2 ± 4.4	24.4 ± 5.0	0.20 ± 0.13
Eat/Play Smart (*n* 37)	21.4 ± 5.9	24.1 ± 4.3	0.23 ± 0.14

The mean monthly weight gain of the overweight children was 0.30 kg ±0.25 (range – 0.37 to 0.57 kg) and for the obese children it was 0.23 kg± 0.23 (range –0.11 to 0.56 kg). This compares with a mean monthly weight gain in the other children of 0.21 kg ± 0.10 (range 0.0 to 0.67 kg).

3.2.1 Discussion

The prevalence of overweight and obesity at baseline and final stage, was lower than recent national reports (Reilly and Dorosty, 1999; Chinn and Rona, 2001; Rudolf et al., 2001). Given the relatively small number of children involved in the present study and the short time span (four school terms) of the intervention, it is not surprising that the prevalence of overweight and obesity were unchanged. Using anthropometric parameters as measurement outcomes necessitates a study design of sufficient duration and adequate follow-up.

Few previous school-based interventions have reported favourable changes in anthropometry. Of the studies reviewed by Rowe et al. 1997 and Resnicow and Robinson (1997) only one showed such a change. Dwyer et al. (1983) undertook an intervention which focused on physical activity and found a decrease in skinfold measures. In addition, one subsequent study has reported a decrease in obesity in adolescent females (Gortmaker et al., 1999a). However, many of these studies had longer periods of intervention than this current research.

It was beyond the scope of this research to compare the experience of participating in the programme between children who were overweight/obese with those who were of a normal weight. Collection of qualitative data would be a possible way of addressing this aspect in future research.

3.3 Dietary assessments

3.3.1 Food frequency questionnaire

A 32-question FFQ was used as a dietary assessment. The aim was to assign individuals to high or low consumers of fat and fibre and investigate habitual intake of selected foods, rather than provide a nutritional analysis. There was no significant difference in fat and fibre scores between the groups at baseline or final stage. The scoring system for fat and fibre was described in Chapter 2. In addition, gender differences in fat or fibre scores were not apparent at either baseline or final stage. Taking each group from baseline to the final stage:

Eat Smart - fat score reduced and fibre score increased but the changes were not significant;

Play Smart - fat score reduced and fibre score remained virtually the same; none of the changes were significant;

Eat Smart Play Smart - fat scores reduced and fibre scores increased but the changes were not significant;

Be Smart - fat and fibre scores increased but the increase was not significant.

A change in the desired direction for both fat and fibre scores was seen in the Eat Smart and Eat Smart Play Smart groups. Details of the fat and fibre categories at baseline and final stage are shown, per group, in Table 3.5. At both stages, children had scores which were predominately in the low or medium range for fat and the medium to high range for fibre.

Table 3. 5 Percentage of children in high, medium or low bands for fat and fibre categories at baseline and final stage

	Eat Smart		Play Smart		Eat/Play Smart		Be Smart	
	base (*n* 48)	final (*n* 20)	base (*n* 33)	final (*n* 23)	initial (*n* 38)	final (*n* 21)	initial (*n* 39)	final (*n* 22)
High fat	10	5	21	13	11	10	6	18
Medium fat	58	35	40	48	57	57	44	32
Low fat	32	60	39	39	32	33	50	50
Low fibre	27	15	23	31	33	24	27	14
Medium fibre	51	45	42	39	49	48	46	41
High fibre	22	40	35	30	18	28	27	46

The consumption of all vegetables, salads, fresh fruit, other fruit (tinned, frozen and cooked fruit), confectionery and crisps at baseline and final stage are reported as average frequency of consumption per week (Table 3.6). Overall, there was a significant increase in the consumption of vegetables ($p<0.05$) and fruit ($p<0.01$). In males, there was a significant increase in fresh fruit consumption ($p<0.01$). When analysing per group, a significant increase in fruit consumption in the Eat Smart ($p<0.05$) and Be Smart ($p<0.05$) groups was observed.

Table 3. 6 Mean weekly consumption of selected foods per intervention group at baseline and final stage

	Eat Smart		Play Smart		Eat/Play Smart		Be Smart	
	base (*n* 48)	final (*n* 20)	base (*n* 33)	final (*n* 23)	base (*n* 38)	final (*n* 21)	base (*n* 39)	final (*n* 22)
Vegetables	4.4	5.3	5.3	5.5	4.5	5.0	5.2	5.3
Salads	2.1	2.6	1.6	2.0	1.9	2.2	1.3	2.6
Fresh fruit	5.9	6.6*	5.9	6.1	5.3	5.9	5.1	6.6*
Other fruit[†]	0.7	1.1	0.7	1.1	0.6	1.0	0.6	1.1
Confectionery	3.8	3.4	3.2	3.2	3.6	3.5	3.6	3.4
Crisps	4.0	3.5	4.4	4.0	4.1	4.1	3.7	3.5

[†]other fruit included tinned, frozen and cooked fruit

* value was significantly higher than at baseline: *p<0.05

3.3.2 24-hour recall

To complement the dietary information obtained from the FFQ, a 24-hour recall was carried out. Overall, at baseline there were no significant differences in energy and nutrient intake between the groups, although the Be Smart group had a significantly lower ($p<0.05$) fat intake than the Play Smart group. At baseline and final stage, there were no significant differences in energy and nutrient intake between males and females.

In Table 3.7, the initial intakes of all subjects are compared to the NDNS (Gregory and Lowe, 2000). The range of intakes per selected nutrient from the 24-hour recall is also shown. The apparent wide range of intakes suggests caution is required in the interpretation of the 24-hour recall, but also demonstrates the wide diversity between individuals' dietary intakes.

For both males and females, energy and fat intakes were significantly higher than the values reported in the NDNS for Young People ($P<0.01$ and $p<0.001$ respectively). In females, the intakes of protein and vitamin C were also significantly higher than in the NDNS ($p<0.001$ and $p<0.05$ respectively. No significant changes in the intake of any of the selected nutrients between baseline and the final stage were found; this was the case when the cohort was taken as a whole and when analysed at a group level (Table 3.8).

Table 3. 7 Mean and range of nutrient intakes of the Oxford cohort (BS) of children at baseline compared to the NDNS

Mean daily	Males		Females		Range
intake	BS (*n* 80)	NDNS	BS (*n* 67)	NDNS	BS study
Energy (MJ)	6.93**	6.4	6.50**	5.9	3.2 – 13.3
Fat (g)	70***	60.1	64***	55.9	28.7 - 148.2
% energy fat	38**	35.5	37*	35.9	19.2 - 50.8
Protein (g)	51	49.0	50***	44.5	25.6-92.5
% energy protein	12	12.9	13	12.7	7.4-22.0
% energy CHO	50	51.6	50	51.4	32.6-72.3
Vitamin C (mg)	84	74	85*	67	7 - 337
Calcium (mg)	712	706	678	657	210– 1774
Iron (mg)	8	8.3	8	8.2	2.8 - 28.3

Mean values were significantly higher than those of the NDNS: *p<0.05, **p<0.01, ***p<0.001

Table 3. 8 Comparison of mean 24-hour dietary intake at baseline and final stage by group

Group	Point of measure	Energy MJ	%E Fat	%E CHO*	%E Protein	Vit C mg	Ca mg	Iron mg
All children	Baseline (*n* 147)	6.76	37.6	49.7	12.7	84	699	8.3
	Final (*n* 79)	*7.14*	*37.5*	*49.3*	*13.2*	*86*	*783*	*8.3*
Eat Smart	Baseline (*n 35*)	6.75	37.1	49.5	13.4	89	730	7.7
	Final (*n* 16)	*6.42*	*37.3*	*48.7*	*13.9*	*84*	*795*	*7.3*
Play Smart	Baseline (*n 35*)	6.86	39.2	49.0	11.8	72	696	8.4
	Final (*n* 21)	*7.49*	*36.8*	*50.2*	*13.0*	*84*	*804*	*8.7*
Eat Smart	Baseline (*n* 48)	6.95	38.3	49.4	12.1	90	671	9.1
Play Smart	*Final* (*n* 21)	*7.65*	*38.0*	*48.6*	*13.4*	*90*	*839*	*8.5*
Be Smart	Baseline (*n* 39)	6.28	35.9	50.8	13.3	83	697	7.5
	Final (*n* 21)	*6.86*	*37.8*	*49.5*	*12.7*	*86*	*698*	*8.3*

*CHO - carbohydrate

3.3.3 Association between body weight and dietary intake

At baseline there was a weak, positive relationship between body weight and crisp consumption (r 0.157). No other associations between body weight and specific foods were seen at baseline or final stage. There was a significant relationship between energy intake and children's BMI at baseline (r 0.219, $p<0.01$), in boys (r 0.289, $p<0.01$) and in girls (r 0.249, $p<0.05$).

3.3.4 Discussion

The modest rise in fruit and vegetable consumption seen in the group overall and specifically in the Eat Smart and Be Smart groups is encouraging, especially as this occurred independently of a rise in parental consumption (see section 3.9.1). This suggests that the increase might not be the result of a seasonal effect. Furthermore, the food frequency data were collected in varying months for the different phases of recruitment: January-February, April-May and September-October for baseline data and April-June for final stage data. The rise in the control group (Be Smart) may be the result of contamination between groups (i.e. discussion between children in different groups). Other programmes that have targeted an increase in fruit consumption have found similar levels of increase, approximately 0.5 portions per day (Niklas et al., 1998; Baranowski et al., 2000; Reynolds et al., 2000).

From the 24-hour recall it was apparent that this cohort had significantly higher intakes of energy, fat and in girls vitamin C and protein, compared with those found in the NDNS.(Gregory and Lowe, 2000). However, this may be due to the different methods used in both surveys. The relatively high intake of fruit and vegetables may account for the higher reported intake of vitamin C. The moderate relationship between body weight and reported energy intake provides reliability to the data as it suggests that under-reporting of food intake did not occur.

3.4 Physical activity

3.4.1 Children's questionnaire

As discussed in chapter 2, the measurement of habitual physical activity is difficult. Children were asked only simple and limited questions about their activity on weekdays while parents were relied on to provide more detailed information. Most children reported walking to and from school. A surprisingly high proportion of children reported travelling to school by car (32%-50%), given that these children tended to live within a relatively small radius of their school. At final stage, there were small increases in the number of children walking to and from school in all groups (Figures 3.1 and 3.2).

Figure 3. 1 Baseline transport to school per group (%)

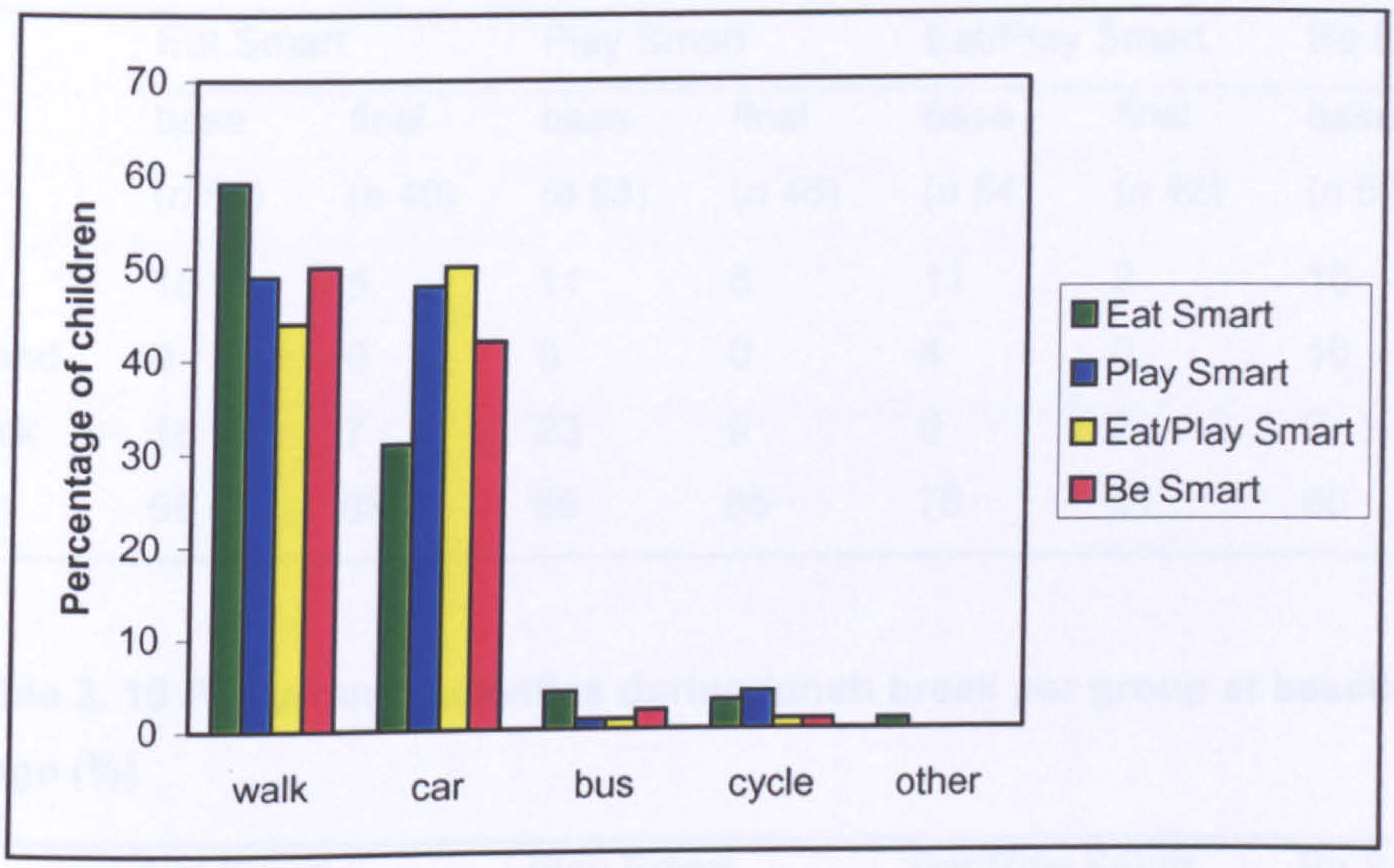
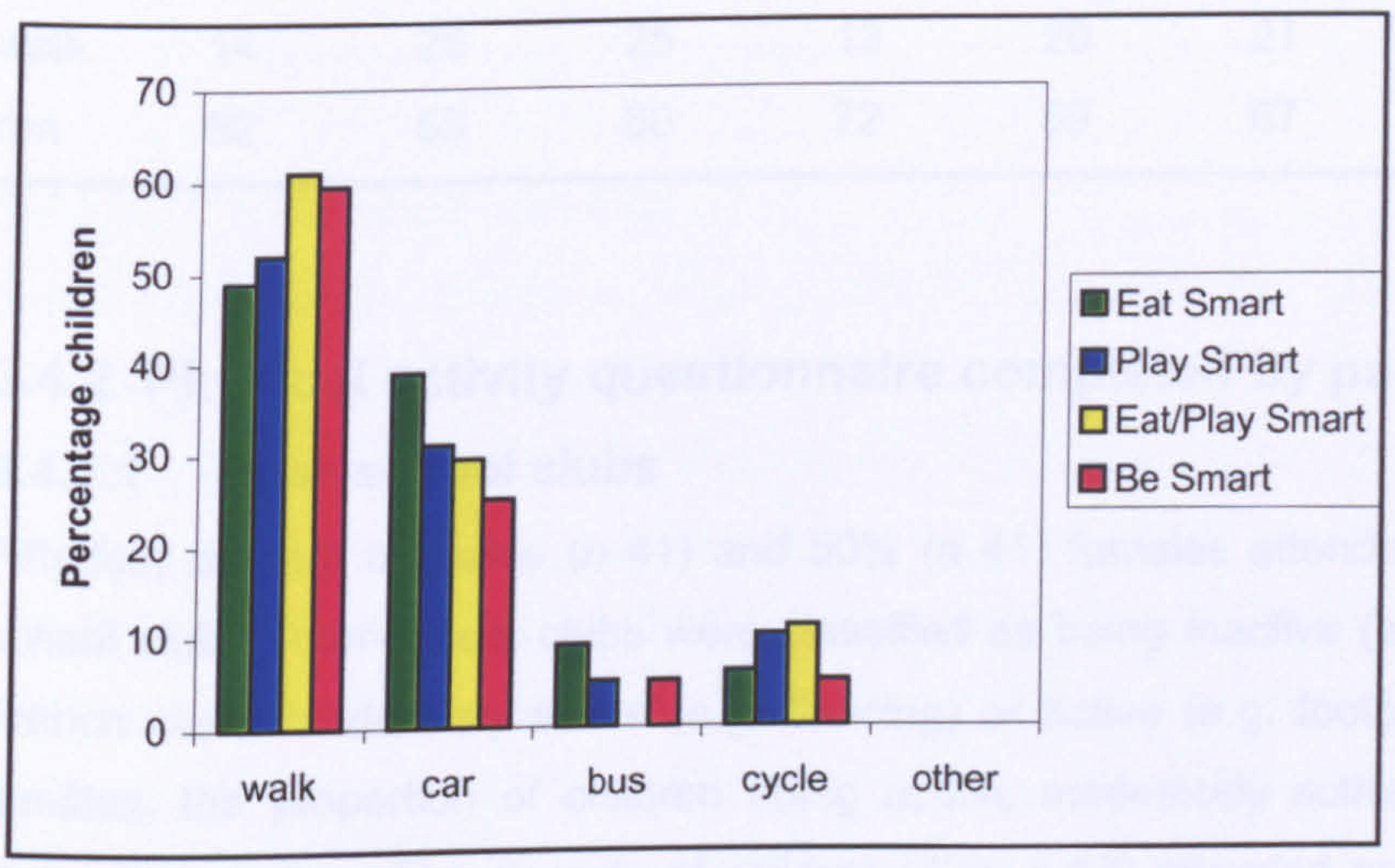


Figure 3. 2 Final stage transport to school per group (%)



An increase in activity in the playground at morning break was reported in all groups and was higher in all intervention groups compared to the control group (Table 3.9). Children were generally less active during the lunchtime break than the morning break, but an increase in activity at lunchtime was apparent in the Play Smart and Eat Smart Play Smart groups; this was not seen in the other two groups (Table 3.10). Overall, there was no detectable difference in the playground activities of boys and girls at either baseline or the final stage.

Table 3. 9 Playground activities during morning break per group at baseline and final stage (%)

	Eat Smart		Play Smart		Eat/Play Smart		Be Smart	
	base (*n* 56)	final (*n* 40)	base (*n* 53)	final (*n* 46)	base (*n* 54)	final (*n* 42)	base (*n* 50)	final (*n* 44)
sit	16	5	11	6	11	2	10	0
stand	0	0	0	0	4	0	10	2
walk	16	7	23	9	9	7	0	8
run	68	88	66	85	76	91	80	90

Table 3. 10 Playground activities during lunch break per group at baseline and final stage (%)

	Eat Smart		Play Smart		Eat/Play Smart		Be Smart	
	base (*n* 56)	final (*n* 40)	base (*n* 53)	final (*n* 46)	base (*n* 54)	final (*n* 42)	base (*n* 50)	final (*n* 44)
sit	20	16	11	15	13	10	12	12
stand	4	5	2	0	7	2	2	0
walk	14	26	25	13	20	21	16	22
run	62	53	60	72	59	67	70	66

3.4.2 Physical activity questionnaire completed by parents

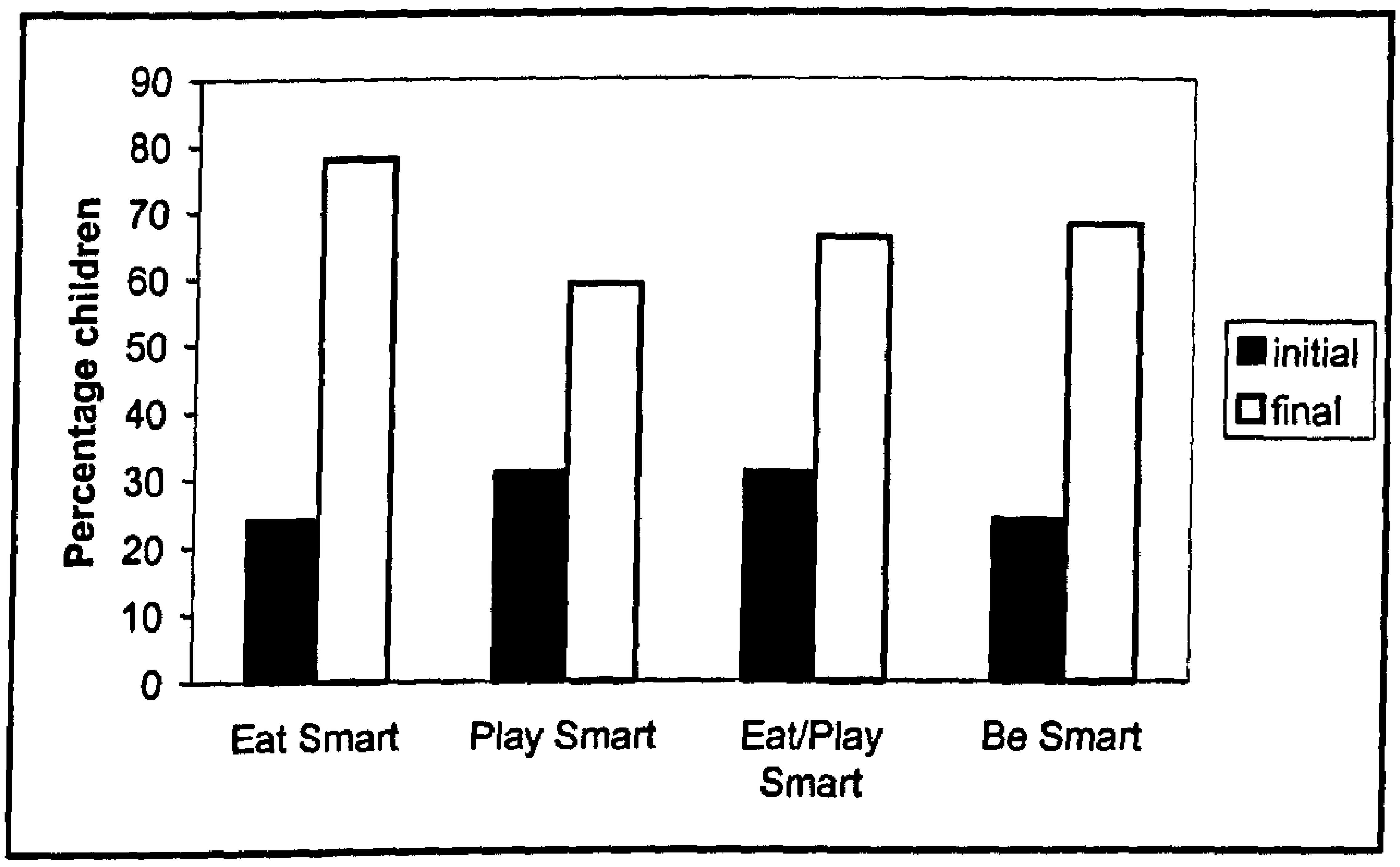
3.4.2.1 After-school clubs

Fifty-four percent of males (*n* 41) and 50% (*n* 41) females attended at least one after-school club. After-school clubs were classified as being inactive (e.g. after-school club, French club), moderately active (e.g. dancing) or active (e.g. football). For males and females, the proportion of children doing active, moderately active clubs and inactive clubs was similar. The majority of children (70% *n* 57) attended an active club, 15% (*n* 12) attended a moderately active club and 41% (*n* 34) attended an inactive club. Some children attended more than one type of after-school club. Thirty-six percent of active after-school clubs lasted 0-15 minutes, while a third lasted 15-30 minutes. The remaining duration of these clubs was 30-45 minutes (25%) and 45-60 minutes (6%). The moderate clubs tended to last for longer, 60% lasted for 30-45 minutes. There were no differences in attendance at after-school clubs between the groups or between baseline and the final stage of the intervention.

3.4.2.2 Weekday outdoor play

Weekday outdoor play after school was reported in 27% (*n* 43) of children. There were no gender differences apparent in the report of outdoor play. There was an increase in reported outdoor play during the week in all groups between baseline and final stage. Figure 3.3 shows the percentage of outdoor play at baseline and final stage per group; the greatest increase was seen in the Eat Smart children.

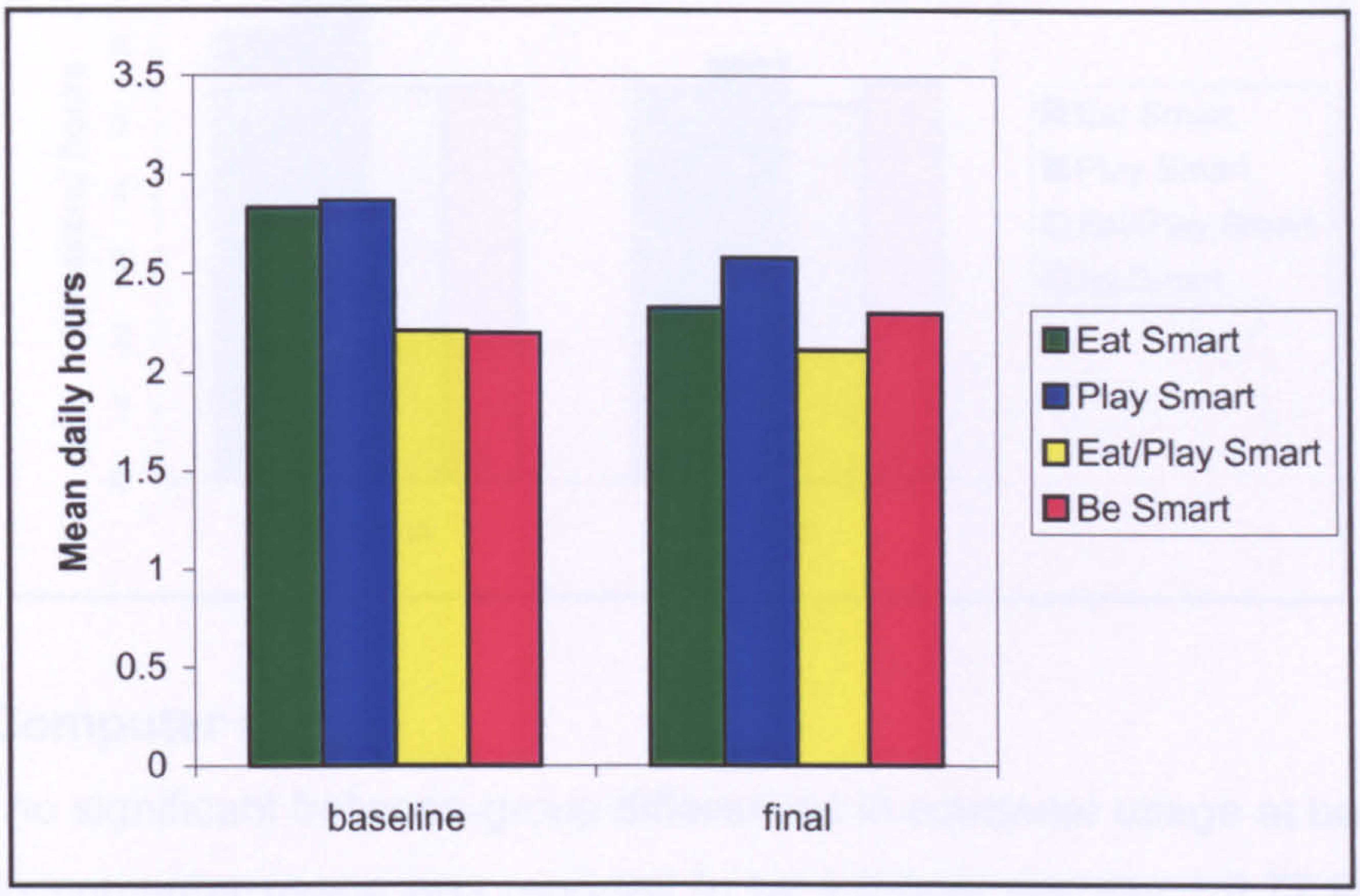
Figure 3. 3 Percentage of outdoor play at baseline and final stage per group



3.4.2.3 Television viewing

The average daily television viewing, which accounted for weekday and weekend television, was calculated to be 2.5 ±1.10 hours per day for the group as a whole at baseline, which fell to 2.3 ± 0.98 hours at the final stage. At baseline, the children in Eat Smart and Play Smart watched significantly more television than Eat Smart Play Smart and Be Smart ($p<0.05$ and $p<0.05$ for both respectively). These differences were not apparent at the final stage. At final stage there was a decrease in average daily television viewing in all intervention groups but not in Be Smart; in all cases the reductions were not significant (Figure 3.4).

Figure 3. 4 Average daily television viewing per group at baseline and final stage



Television viewing was similar in males and females: the average daily television viewing at baseline was 2.6 hours ± 1.14 for males and 2.5 ±1.08 hours for females. At the final stage the figures were 2.3 ± 0.95 and 2.3 ± 1.03 hours respectively.

The average weekday and weekend television viewing per group at baseline and final stage are shown in Figures 3.5 and 3.6

Figure 3. 5 Mean weekday television viewing per group at baseline and final stage

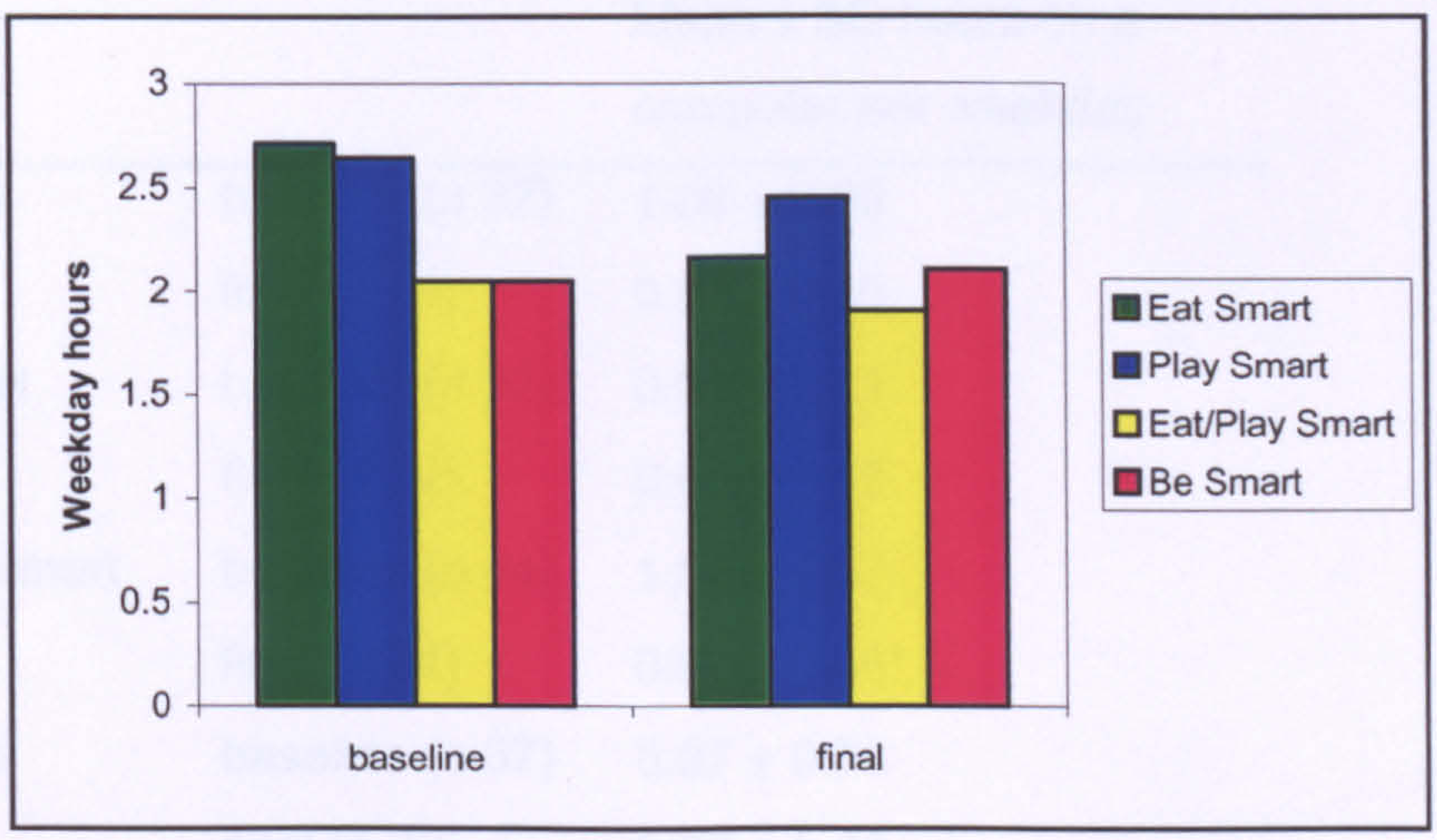
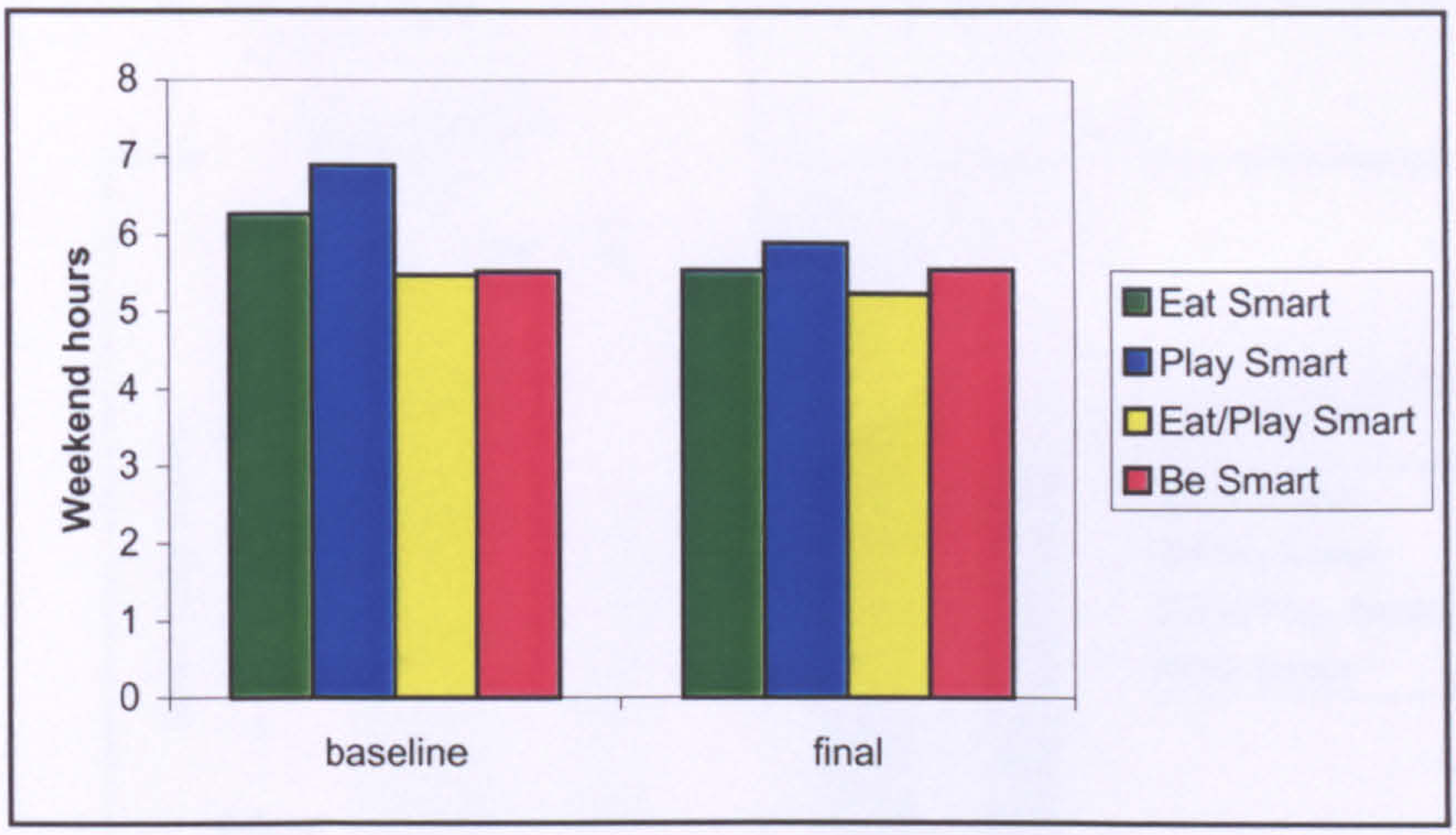


Figure 3. 6 Mean weekend television viewing per group at baseline and final stage



3.4.2.4 Computer usage

There were no significant between-group differences in computer usage at baseline. The average daily computer usage was reported to be 1.0 hour per day ± 0.77 for the group as a whole at baseline, which fell to 0.75 hours ± 0.58 at the final stage (Table 3.11). There was a decrease in average computer usage in all groups and the reduction was significant ($p<0.05$) in Eat Smart Play Smart. At baseline, computer usage was similar in males and females, however at final stage, males were using computers significantly more than females ($p<0.05$). The average daily computer usage at baseline was 1.09 (± 0.78) hours for males and 0.93 ± 0.75 hours for females; at the final stage the figures were 0.87 ± 0.54 and 0.61 ± 0.59 hours respectively.

Table 3. 11 Mean ± SD weekday computer usage at baseline and final stage

		Mean ± SD hours on a computer per weekday
Eat Smart	baseline (*n* 37)	1.08 ± 0.89
	final (*n* 19)	0.84 ± 0.60
Play Smart	baseline (*n* 32)	0.94 ± 0.91
	final (*n* 22)	0.68 ± 0.65
Eat/Play Smart	baseline (*n* 44)	1.05 ± 0.57
	final (*n* 21)	0.67 ± 0.48*
Be Smart	baseline (*n* 37)	0.97 ± 0.73
	final (*n* 22)	0.82 ± 0.59

* Mean value was significantly lower than that at baseline $p<0.05$

3.4.2.5 Reported weekend activities

Of all activities reported over the weekend at baseline, 12% were active, 26% were moderately active and 62% were inactive. Thirty-three percent (*n* 52) of children were inactive all weekend. At baseline and final stage, there were no significant differences in the reported number of moderate /active activities during the weekend, between groups or between males and females. Tables 3.12 to 3.14 show the percentage of children who reported active, moderately active and inactive activities at baseline and final stage. There was no change in the proportion of children who reported no active activities during the weekend in the Be Smart group; the proportion of children fell in the Eat Smart and Play Smart groups and increased in the Eat Smart Play Smart group. The level of inactivity was similar (32%, *n* 23) at baseline and final stage in each group.

Table 3. 12 Percentage of active activities reported per group at baseline and final stage

	Eat Smart		Play Smart		Eat /Play Smart		Be Smart	
No*.	base (*n* 31)	final (*n* 14)	base (*n* 32)	final (*n* 19)	base (*n* 41)	final (*n* 20)	base (*n* 35)	final (*n* 20)
0	49	36	47	21	27	40	31	30
1	19	50	28	52	40	10	20	35
2	19	14	16	11	24	25	40	15
3	10	0	6	5	2	15	9	20
4	0	0	3	11	2	5	0	0
5	0	0	0	0	5	5	0	0
6	1	0	0	0	0	0	0	0

* number activities reported over the weekend

Table 3. 13 Percentage of moderately active activities reported per group at baseline and final stage

	Eat Smart		Play Smart		Eat /Play Smart		Be Smart	
No*.	base (*n* 31)	final (*n* 14)	base (*n* 32)	final (*n* 19)	base (*n* 41)	final (*n* 20)	base (*n* 35)	final (*n* 20)
0	13	0	16	16	15	5	11	5
1	29	29	22	21	22	15	28	30
2	42	28	28	11	39	25	26	20
3	16	29	31	26	10	30	26	30
4	0	7	0	21	7	10	9	10
5	0	7	3	5	2	10	0	5
6	0	0	0	0	5	5	0	0

* number activities reported over the weekend

Table 3. 14 Percentage of inactive activities reported per group at baseline and final stage

	Eat Smart		Play Smart		Eat /Play Smart		Be Smart	
No*.	base (*n* 31)	final (*n* 14)	base (*n* 32)	final (*n* 19)	base (*n* 41)	final (*n* 20)	base (*n* 35)	final (*n* 20)
0	0	0	3	0	5	0	0	0
1	0	0	0	0	2	10	0	0
2	3	0	0	5	12	5	9	5
3	9	7	6	21	15	20	20	15
4	28	29	22	11	15	25	19	20
5	22	64	16	42	19	15	23	45
6	38	0	53	21	32	25	29	15

* number activities reported over the weekend

3.4.2.6 Children's weight and physical activity

At baseline there was no association between weekday television viewing and children's weight (r 0.074). There was a positive trend with weekend television viewing but this was a weak relationship (r 0.119). At final stage there was a positive association in both weekday television viewing (r 0.224) and average daily television viewing (r 0.243) with body weight. There was no apparent effect of body weight on playground activities.

3.4.3 Discussion

There is concern that children's leisure time is becoming increasingly sedentary (Fogelholm et al., 1999). In the UK, physical education lessons at school have been reduced due to pressures on the school curriculum (Rowe and Champion, 2000). Other factors, such as safe places to play and parental fears for their children's safety ('stranger danger'), may also have a detrimental effect on the level of physical activity in children (Fox and Riddoch, 2000). In particular, girls, older adolescents and minority ethnic groups have been identified as subgroups at risk of being inactive (Sallis et al., 2000). Variables that are consistently associated with children's physical activity are gender, parental weight status, physical activity preferences and intentions, perceived barriers (inverse), previous physical activity, healthy diet, access and time spent outdoors.

It is likely that physical activity has beneficial effects on children's wider health and well-being, but the evidence is less clear than in adults due to lack of research (Cavill et al., 2001). Currently, there is no consensus as to the optimum amount and type of physical activity which should be recommended for children. It has been suggested that in order to optimize current and future health, all young people should participate in physical activity of at least moderate intensity for 1 hour per day and that those already participating in activity should increase their current level by at least half an hour per day (Cavill et al., 2001).

The present study was unlikely to affect issues such as transportation and given the problems of measuring physical activity it is not surprising that no intervention effects on physical activity levels were seen. Evidence of sedentary behaviours was seen in the level of car usage as a mode of transport to and from school. The baseline figure of approximately 45% is similar to the national average reported in the Census at School (Nottingham Trent University and Office of Statistics, 2001). It has been suggested that promoting walking to school is a viable way of increasing physical activity (Tudor-Locke et al., 2001) as it is clear that the increase in car journeys has led to a decreased opportunity for activity in children. Schemes, such as a 'walking bus', have been suggested as a means of decreasing car usage whilst recognising the associated safety issues of walking to school.

School assumes importance in providing opportunities for children to be physically active, both through break-times and after-school clubs. The high incidence of activity reported at break times in this study is consistent with observational studies of primary school children which have shown that children's activity at this age is characterised by short bursts rather than sustained bouts of activity (Sleap and Warburton, 1996). The National Survey of Young People and Sport (Rowe and Champion, 2000) found that in lower primary school the proportion of children spending, on average, 2 hours or more per week in physical education (PE) declined from 32% in 1994 to 11% in 1999. Furthermore, a third of 6-8 year olds were doing less than an hour a week of PE. In a study of older children, PE was the only exercise undertaken by a third of the pupils (Riddoch et al., 1991). If these trends continue, opportunities for children's activity are likely to be seriously compromised. This is particularly topical given the concerns in the UK that school playing fields are being sold to property developers. School PE has been shown to have a long-term positive effect on adult activity level (Trudeau et al., 1999), however it has also been shown that forcing a child to exercise at school has a detrimental effect on later activity levels (Taylor et al., 1999).

In the present study, there was a high attendance at after-school clubs which may not be representative of the general population. The schools were in a relatively affluent area and were fully staffed; it is likely that the provision of after-school clubs may be lower in schools in more deprived areas and where there are teacher shortages. After-school clubs appear to provide an important opportunity to be active, especially as a low level of outdoor play outside of school was reported. A relationship between time spent on outdoor play and subsequent physical activity levels has been suggested (Taylor and Sallis, 1997).

The average daily television viewing of 2.5 hours and 2.3 hours at baseline and final stage respectively is similar to other reports in this age group (Livingstone and Bovill, 1999), although it is higher than the weekly average of 11.4 hours (including video watching) reported in the National Survey of Young People and Sport (Rowe and Champion, 2000). It has been suggested that television viewing may be linked to obesity (Robinson et al., 1999) and it has been used as a marker of inactivity (Gortmaker et al., 1999a; Gortmaker et al., 1999b). A speculative observation from this research is children of higher body weight may have increased levels of television viewing.

There is evidence that young primary school children are spending increasing amounts of time using a computer. The Census at School (Nottingham Trent University and Office of Statistics, 2001) revealed that 78% of primary school children have access to a computer at home and 54% have access to the internet at home. In the South East of England, these figures were higher, 83% and 61% respectively. The average computer usage (1 hour daily) in this cohort of children would therefore seem to be representative of current trends. A recent study in Irish children aged 7-9 years showed that children spent between one and four hours in front of a screen (Hussey et al., 2001). Television viewing and computer usage, which feature heavily in children's leisure-time, may result in a decrease in energy expenditure and subsequently contribute to increasing levels of overweight and obesity.

At weekends, most children did not appear to be active and the proportion of children who failed to do an activity classified as active over the weekend (range 21%-49%) is a cause for concern. However, it must be recognised that sedentary behaviours may be the result of environmental and social factors including the lack of safe places to play and walk to school and parents' fears for their children's safety. Therefore, addressing these issues requires changes at policymaking level using a multi-disciplinary team.

Although this present study did not observe any gender differences in physical activity, this has been documented in the literature, with reports of boys even at this young age being more active (Armstrong and Bray, 1991; Armstrong, 1998). It may be that the methods employed in this present study to assess physical activity levels may not have been sensitive enough to detect a bias, if present.

It is acknowledged that the methods employed in this study are unable to estimate levels of activity in this cohort, rather they provided an indication of patterns in physical activity. This study mainly relied on parental report of children's activity and is therefore subject to the errors of recall, which are inherent in this method (Welk et al., 2000). The segmented day method of recall has been used in past studies and is a way of reducing error (Cale, 1994). Although the population studied is not representative of the UK population, it is likely that similar trends in physical activity would be apparent in other social and ethnic groups in the UK.

3.5 Nutrition knowledge

Nutrition knowledge was assessed by selection of the healthiest food options from a series of photographs. Mean nutrition knowledge scores per group improved between baseline and final stage. No significant differences in the scores for males and females were detected. Table 3.15 shows the details of the scores pre- and post-intervention.

The increases in nutrition knowledge were significant in Play Smart and Be Smart and highly significant in Eat Smart and Eat Smart Play Smart.

Table 3. 15 Nutrition scores at baseline and final stage per intervention group

Total	Eat Smart		Play Smart		Eat/Play Smart		Be Smart	
Scores	base (*n* 56)	final (*n* 40)	base (*n* 53)	final (*n* 45)	base (*n* 53)	final (*n* 42)	base (*n* 51)	final (*n* 42)
Average	6.4	7.7***	6.2	7.3**	6.2	7.4***	5.9	7.3**
SD	1.95	1.00	2.05	0.95	1.97	0.96	2.26	1.33
Min	1	2	2	5	1	5	1	3
Max	8	8	8	8	8	8	8	8

Mean values at final stage were significantly higher than those at baseline: **$p<0.01$, ***$p<0.001$

The questions concerning fruit or fruit juice were consistently better answered by all children. When children were asked to explain their answers they often were unable to do so. In some cases, parental influence on children's views and knowledge of food appeared to be strong. Children seemed very aware of the sugar content of fizzy drinks and chocolate and generally viewed fruit as healthy. A minority of children had a good knowledge of food that contained certain types of fat and vitamins which indicates parental instruction.

3.5.1 Discussion

The measurement of nutrition knowledge has been a feature of many of the past intervention programmes in children. It is important to establish, however, that an individual's knowledge, attitudes and behaviours may or may not be consistent with each other. There is increasing evidence that changes in knowledge do not necessarily translate to behavioural change (Axelson et al., 1985; Parmenter and Wardle, 1999). This is a salient point for any health promotion initiative. One possible explanation is that the tools used to measure nutrition knowledge are not sensitive or reliable (Parmenter and Wardle, 1999).

Scores for the children's nutrition knowledge were high, suggesting a 'ceiling' effect whereby it may not be possible to distinguish between children whose knowledge was significantly better (or worse) than others. This phenomenon was noted in the original research among older children (Calfas et al., 1991). The tool may not be sensitive enough to measure the real change in children's nutrition knowledge as a result of the 'Be

Smart' intervention. Additional questioning of the children's answers showed that parental influence on some children's nutrition knowledge is strong. This may be due to the high number of well-educated parents involved in this research.

Results of parents' assessments

3.6 Dietary assessment

3.6.1 Food frequency questionnaire

Parents' diets were assessed with the same FFQ used for the children; analysis was undertaken in a similar manner. There was no significant difference in the fat and fibre scores overall or between the groups at baseline or final stage. Details of the fat and fibre categories at baseline and final stage are shown in Table 3.16. At all stages, parents had scores which were predominately in the low range for fat and the medium to high range for fibre.

Table 3. 16 Percentage of parents in high, medium or low bands for fat and fibre categories at baseline and final stage

	Eat Smart		Play Smart		Eat/Play Smart		Be Smart	
	base (*n* 20)	final (*n* 19)	base (*n* 19)	final (*n* 16)	base (*n* 25)	final (*n* 20)	base (*n* 19)	final (*n* 20)
High fat	0	5	23	0	0	0	5	0
Medium fat	14	0	18	31	25	15	26	16
Low fat	86	95	59	69	75	85	69	84
Low fibre	10	16	35	19	25	5	37	16
Medium fibre	52	42	24	37	48	55	32	37
High fibre	38	42	41	44	27	40	31	47

The consumption of all vegetables, salads, fresh fruit, other fruit (tinned, frozen and cooked fruit), confectionery and crisps at baseline and final stage are reported as average frequency of consumption per week in Table 3.17. There was no difference in the reported consumption of these foods between groups at baseline and at the final stage. When analysing per group, a significant decrease in crisp consumption ($p<0.05$) was seen in Play Smart parents and a significant increase in salad consumption in the Eat Smart Play Smart parents ($p<0.05$).

Table 3. 17 Mean weekly consumption of selected foods per intervention group at baseline and final stage

	Eat Smart		Play Smart		Eat/Play Smart		Be Smart	
	base (*n* 20)	final (*n* 19)	base (*n* 19)	final (*n* 16)	base (*n* 25)	final (*n* 20)	base (*n* 19)	final (*n* 20)
Vegetables	5.7	5.5	5.6	5.9	5.3	5.9	5.5	5.6
Salads	3.0	3.3	3.0	3.3	2.7	4.1*	2.7	3.6
Fresh fruit	5.7	5.8	5.7	5.5	5.1	5.7	4.8	5.1
Other fruit†	1.0	0.6	1.0	0.3	0.7	0.7	0.6	0.8
Confectionery	1.8	1.6	1.8	1.9	2.2	2.2	3.1	2.7
Crisps	2.3	2.5	2.3	1.4*	2.2	1.8	2.9	2.5

†other fruit included tinned, frozen and cooked fruit

* value was significantly different from that at baseline $p<0.05$

3.6.1.1 Parents' diets and children's diet

A strong association was seen between parents' and children's diets. At baseline there were significant positive associations between parental intake of crisps (r 0.598, $p<0.001$), vegetables (r 0.669, $p<0.001$), salad (r 0.484, $p<0.001$), fresh fruit (r 0.342, $p<0.01$), other fruit (r 0.639, $p<0.001$) and fat (r 0.450, $p<0.001$) and fibre scores (r 0.457, $p<0.001$) and children's intake and scores. Similar results were apparent at the final stage.

3.6.2 Discussion

The fact that fruit and vegetable intake (apart from salad) remained the same in the parents indicates that the change detected in the children was not the result of a seasonal effect. As with the children, the diets of the parents were 'healthier' than average as the majority of parents were low fat high fibre consumers. The association between the diets of parents and children highlights the importance of an intervention which reaches the family, particularly where dietary habits are poor. Young children may have a limited influence on the food that they eat, although in this research change was observed in children's diets independent of their parents.

3.6.3 Physical activity assessment

Physical activity in work and leisure was assessed (as described in chapter 2), using 2 validated activity questionnaires. Parents were asked about the physical component of their work, including running a household. The results at baseline for all the groups are shown in Table 3.18. Parents were also asked to report minutes spent walking or cycling to and from work, school and shopping in a day. The results for the group as a whole and then per group at baseline and final stage are shown in Table 3.19. In all groups, except Play Smart, there was a reduction in the percentage of parents reporting < 5 minutes walking or cycling per day. In all groups, except Eat Smart Play Smart, there was an increase in the percentage of parents reporting >45 minutes walking or cycling per day.

Table 3. 18 Physical component of parents' work at baseline expressed as percentage of parents' work (*n* 109)

Activity	Never	Seldom	Sometimes	Often	Always
Sit	6	26	33	13	22
Stand	6	16	27	42	9
Walk	6	9	26	45	14
Lift heavy loads	30	26	31	11	2
Become tired	2	9	36	42	11
Become breathless	59	26	13	2	0

Table 3. 19 Minutes spent walking or cycling to and from work, school and shopping per day and baseline and final stage, expressed as percentage of parents

	Eat Smart		Play Smart		Eat/Play Smart		Be Smart	
	base (*n* 27)	final (*n* 18)	base (*n* 27)	final (*n* 18)	base (*n* 28)	final (*n* 20)	initial (*n* 26)	final (*n* 19)
<5 min	7	5	11	11	14	5	12	5
5-15 min	21	11	15	6	4	5	14	16
15-30 min	21	39	22	28	21	45	26	21
30-45 min	30	28	37	22	32	35	18	11
>45 min	21	17	15	33	29	10	30	47

Parents were also asked about exercise undertaken in leisure time. Tables 3.20 to 3.22 show percentage of parents and the frequency at which they undertook strenuous, moderate and mild activity (for >15 minutes), at baseline and final stage. At final stage, there was a significant ($p<0.01$) increase in moderate exercise overall. There was no significant difference in leisure time exercise between groups at baseline; at final stage Eat Smart parents undertook significantly ($p<0.05$) more mild exercise compared with Play Smart parents. Between baseline and final stage, a significant ($p<0.05$) rise in mild exercise was seen in Be Smart parents and a significant rise ($p<0.05$) in moderate activity in Eat Smart Play Smart parents. No significant changes in leisure activities were seen in Eat Smart and Play Smart parents between baseline and final stage.

Table 3. 20 Percentage of parents undertaking strenuous exercise per week at baseline and final stage

Frequency of	Eat Smart		Play Smart		Eat/Play Smart		Be Smart	
strenuous	base	final	base	final	base	final	base	final
exercise*	(*n* 26)	(*n* 17)	(*n* 25)	(*n* 17)	(*n* 27)	(*n* 19)	(*n* 25)	(*n* 17)
0	46	35	68	40	45	26	64	40
1	15	18	12	24	22	11	12	18
2	7	6	12	18	11	21	12	12
3	19	35	4	12	11	21	4	12
4	4	0	0	0	0	11	0	6
5	7	0	0	0	7	5	0	0
6	0	0	0	6	4	0	4	0
7	0	12	0	0	0	5	4	12
9	0	0	1	0	0	0	0	0

* Number of times undertaken per week

Table 3. 21 Percentage of parents undertaking moderate exercise per week at baseline and final stage

Frequency of moderate exercise*	Eat Smart		Play Smart		Eat/Play Smart		Be Smart	
	base (*n* 25)	final (*n* 16)	base (*n* 26)	final (*n* 18)	base (*n* 28)	final (*n* 20)	base (*n* 24)	final (*n* 18)
0	28	13	35	11	32	15	25	17
1	24	37	19	33	14	25	33	6
2	20	19	8	11	18	5	13	22
3	8	0	15	11	14	10	13	11
4	8	6	8	6	4	5	4	22
5	8	19	4	11	18	5	4	6
6	0	6	0	6	0	0	0	0
7	1	0	4	11	0	30	8	17
10	0	0	7	0	0	0	0	0
14	0	0	0	0	0	5	0	0

* Number of times undertaken per week

Table 3. 22 Percentage of parents undertaking mild exercise per week at baseline and final stage

Frequency of mild exercise*	Eat Smart		Play Smart		Eat/Play Smart		Be Smart	
	base (*n* 26)	final (*n* 16)	base (*n* 25)	final (*n* 18)	base (*n* 27)	final (*n* 18)	base (*n* 25)	final (*n* 17)
0	20	0	27	22	37	6	16	6
1	4	19	12	11	15	22	24	12
2	16	13	32	22	11	5	28	12
3	4	6	7	22	11	17	8	18
4	4	0	7	6	0	6	4	6
5	24	25	7	11	7	5	0	0
6	0	0	0	6	0	0	0	0
7	28	25	7	0	15	28	20	46
8	0	6	0	0	0	5	0	0
10	0	0	0	0	4	6	0	0
14	0	6	0	0	0	0	0	0
20	0	0	4	0	0	0	0	0

* Number of times undertaken per week

3.6.3.1 Parental physical activity and children's activity

At baseline there was a weak association between parents undertaking of moderate/strenuous exercise and children's activity at the weekend (r 0.196). This relationship was not apparent at final stage (r 0.054).

3.6.4 Discussion

There were no clear intervention effects on parents' activity levels, which is not a surprising finding given that parents' lifestyle habits were being targeted only indirectly and secondary to their children's. Evidence for the tracking of physical activity habits from childhood to adulthood is apparent (Kelder et al., 1995), but to date is weak (Malina, 1996). A study which looked at activity levels in a group of normal weight and obese children and associations with parental activity found that parent inactivity was a strong positive predictor of child inactivity (Fogelholm et al., 1999). In addition, the relationship between parental and child activity patterns has shown that fathers' but not mothers' behaviours are associated with child activity levels (Duncan et al., 2002). In this study, at baseline, there was a suggested link between parental (mainly mothers') and children's leisure activity. This shows the importance of targeting families to effect positive change.

3.6.5 Nutrition knowledge

There were no significant differences in scores for the nutrition knowledge questionnaire between groups at baseline and final stage. In addition, no significant changes in scores per group were seen between baseline and final stage. Table 3.23 shows the mean percentage scores per section, and the total score per group at baseline and final stage. In all groups, section 4 (the relationship between diet and disease), was the least well answered section. Association between children's and parents' nutrition knowledge was not undertaken due to concerns about the reliability of the children's assessment and the problem of the 'ceiling effect' as discussed earlier (Section 3.5.1).

3.6.5.1 Parental nutrition knowledge and diet

At baseline, there was a moderate negative relationship (r -0.431, $p<0.001$) between crisp intake and nutrition knowledge score. A positive relationship was seen between knowledge and intake of fruit, salads and vegetables and fibre scores, but the levels did not reach significance. There was a significant inverse relationship (r -0.317, $p<0.01$) between nutrition knowledge and fat scores. At the final stage, positive associations were seen between knowledge and intake of fruit (r 0.347, $p<0.05$), vegetables (r 0.406, $p<0.001$), salads (r 0.417, $p<0.001$) and fibre scores (r 0.405, $p<0.001$).

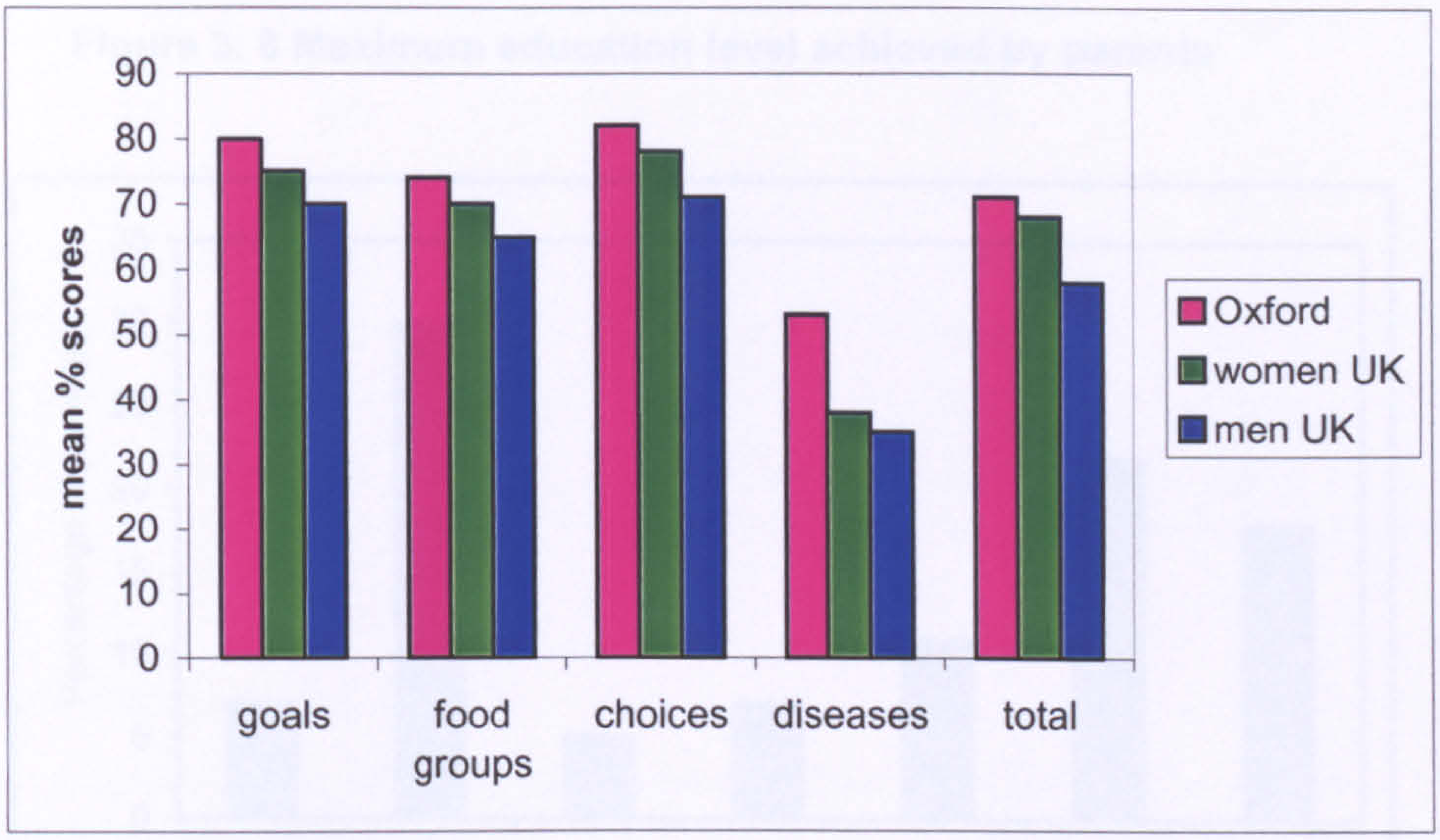
Table 3. 23 Mean ± SD percentage scores per section of nutrition knowledge questionnaire per group at baseline and final stage

	Eat Smart		Play Smart		Eat/Play Smart		Be Smart	
	base (*n* 17)	final (*n* 19)	base (*n* 18)	final (*n* 15)	base (*n* 26)	final (*n* 20)	base (*n* 19)	final (*n* 20)
Section 1 mean	85	78	87	79	81	85	76	79
± SD	± 13.9	± 23.9	± 27.2	± 10.7	± 12.9	± 12.3	± 16.0	± 20.5
Section 2 mean	74	79	74	73	75	77	73	76
± SD	± 16.8	± 12.5	± 19.0	± 13.0	± 20.7	± 17.6	± 16.4	± 16.9
Section 3 mean	80	87	83	87	78	86	84	77
± SD	± 14.4	± 18.4	± 17.1	± 11.8	± 24.3	± 16.9	± 20.9	± 21.3
Section 4 mean	55	57	53	46	49	48	52	50
± SD	± 22.2	± 14.8	± 18.8	± 24.0	± 20.3	± 15.8	± 17.6	± 25.6
Total mean	69	75	70	70	68	73	67	71
± SD	± 16.2	± 10.8	± 15.4	± 11.1	± 17.5	± 13.6	± 14.2	± 15.4

3.6.6 Discussion

A comparison of a recent UK survey of nutrition knowledge (using the same tool) (Parmenter et al., 2000) with the Oxford study at baseline is shown in Figure 3.7. In all sections, the Oxford subjects performed better than the UK sample, which may be reflective of the relatively high socio-economic status of the Oxford cohort. In both groups, the final section, which looked at the link between diet and disease, was poorly answered and, in some cases, serious gaps in even basic knowledge of recommendations were apparent. This was especially true for the role of the starchy food group in the diet, indicating that the starches were perceived as fattening as shown by both sets of results. Choice of low fat/high fibre snack foods and the types of fat contained in foods were found by respondents to be more difficult to answer.

Figure 3. 7 Comparison of scores (per section and total score) for nutrition knowledge between Oxford parents and UK sample



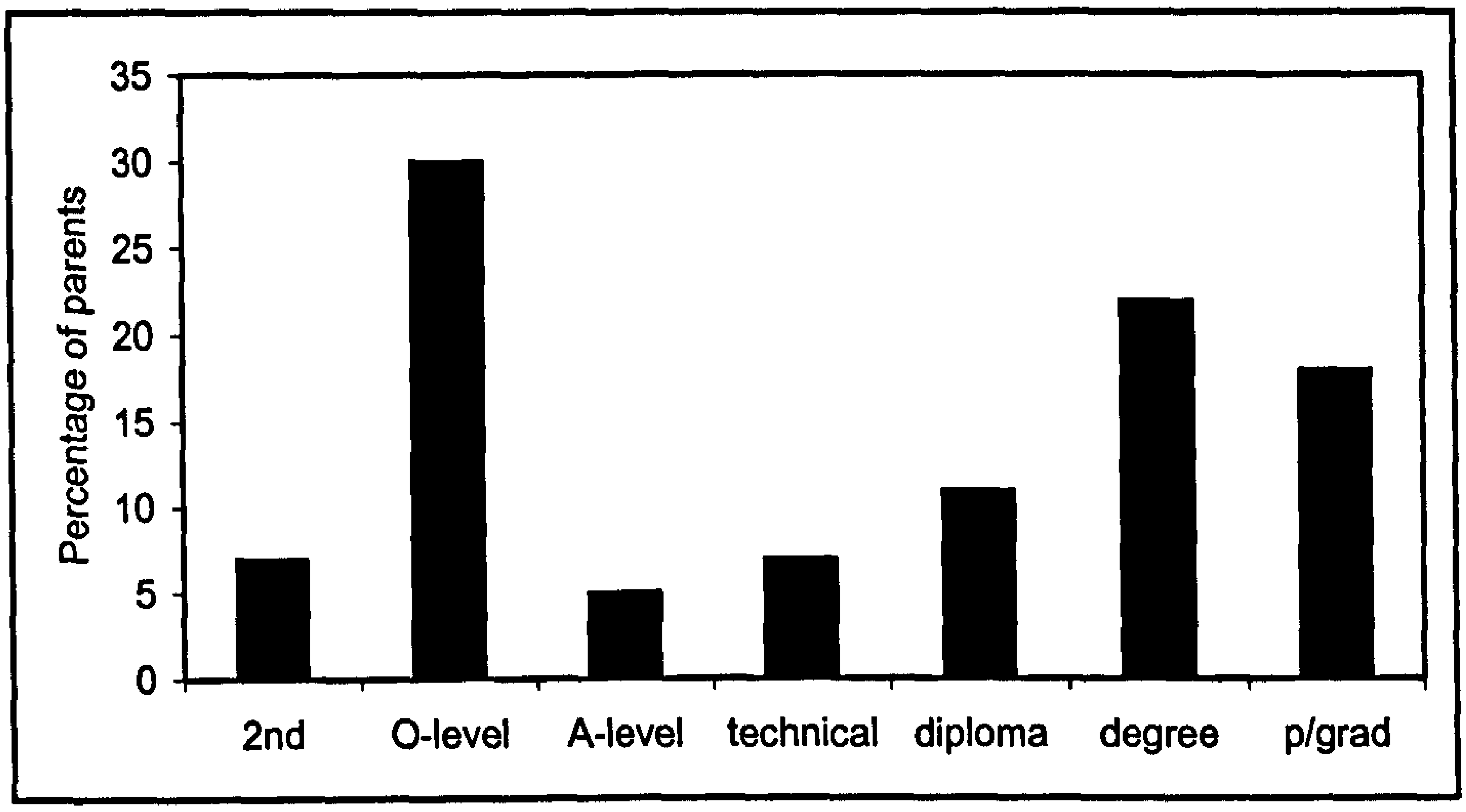
3.6.7 Social and medical history

One hundred and fifty two parents completed a social and medical history questionnaire, of which 89% were completed by mothers. Fifty-five percent of parents were aged between 35-44 years and 36% were aged between 25-34 years. Most of the children were UK white in origin (88%). The ethnic origins of the remaining children were South Asian, mixed origin, white European, black Caribbean and white (other). The education level achieved by the parents is shown in Figure 3.8. Thirty-nine percent of parents had obtained either a degree or a post-graduate qualification. O-level qualifications were the maximum education level in 31% of parents.

Three percent of parents reported heart or circulatory problems and 9% reported blood pressure problems, 30% of these had occurred during pregnancy. Smoking was reported by 24% of parents and 24% also reported taking medication. The mean ± SD BMI was calculated to be 24.3 ± 3.6 from the self-reports of height and weight.

Details of children's medical history were completed by parents for 149 children. Forty-two percent had visited a specialist doctor since birth. Asthma was reported in 5% of children. There was one incidence each of hearing problems, dyspraxia, Tourette's syndrome, Attention Hyperactivity Disorder and leukaemia. The latter two children were later discounted from the assessment process. Food allergies were reported for 4% children and 79% were reported to have a good appetite.

Figure 3. 8 Maximum education level achieved by parents



3.6.7.1 Parents' BMI and education level

Parents educated to O-levels had significantly higher ($p<0.001$) BMI than degree educated parents. The average BMI in the O-level parents (*n* 43) was 26.3 compared to 22.7 in the degree parents (*n* 33). There were more parents in these education groups than any other group.

3.6.7.2 Parents' diet and education level

At baseline, parents with O-level education consumed crisps more frequently ($p<0.01$) than degree parents. They also consumed significantly fewer salads than degree ($p<0.01$) and postgraduate parents ($p<0.05$) (Table 3.24). Similar differences between education level and food intake frequency at final stage were also observed.

Table 3. 24 Average consumption of foods per week for parents with varying education level at baseline

	Crisps	Salads	Vegetables	Fresh fruit	Other fruit
Secondary (*n* 3)	5.0	4.1	5.0	4.3	0.3
O levels (*n* 20)	3.8	1.2	4.9	4.5	0.8
A levels (*n* 2)	1.8	2.8	7.0	5.5	0.4
Trade cert. (*n* 2)	5.0	2.5	5.0	4.9	1.0
Diploma (*n* 7)	2.2	3.0	5.6	4.9	0.7
Degree (*n* 21)	1.3	3.5	5.9	5.3	0.5
Postgrad. (*n* 13)	1.5	3.5	5.8	6.5	0.3

3.6.8 Discussion

The analyses of the effect of social class on BMI and diet were speculative. Education was used as a marker for social class rather than job/profession as many of the mothers had given up work at the time of the study. As discussed in section 1.2.3, there is a tendency for women from the lower social classes to have a higher BMI compared to women in higher social classes. Small differences in food intake with social class have also been reported, particularly with a lower intake of fresh fruit and vegetables in the lower classes (Gregory et al., 1990). The results from the present study are in keeping with these findings.

Involving parents proved very challenging; as a consequence an intervention effect on parental assessments was not observed. It was difficult to assess to what extent parents read the activity books as children sometimes forgot to bring their activity books to the lunchtime club. There were poor attendances at parent meetings held in the University and school, which is in keeping with previous studies (Crockett et al., 1989b; CDC, 1996). Poor attendance at after-school activities for parents has also been reported (Nader et al., 1989; Baranowski et al., 1990). Mailing interactive components, such as worksheets and games, have been found to be more effective than a newsletter (Lytle, 1995). Family involvement is logical and has theoretical support (Crockett et al., 1989a; Rowe et al., 1997), but when the effect of a family component was recently evaluated as part of a programme, it was not found to be of added benefit (Luepker et al., 1996). This UK study confirms findings from previous international research - that involving families in health promotion initiatives is difficult and often unsuccessful. Innovative ways of involving parents, such as health fairs, exhibitions of nutrition projects and inviting parents to eat at the school cafeteria with their children, have been suggested (CDC, 1996). It has also been suggested that children may be able to pass on nutrition knowledge gained at school to the rest of the family in order to have a beneficial effect on the diet of the whole family (Basdevant et al., 1999).

3.7 Evaluation

3.7.1 Children's quiz-content questionnaire

The quiz on the programme content was completed by 311 children:

- 33 Eat Smart children
- 40 Play Smart children
- 32 Eat Smart Play Smart children
- 44 Be Smart children
- 162 non-study children

The average total scores for the quiz were significantly higher in the intervention groups compared to both the Be Smart group (p=0.048, p=0.048 and p=0.010) and children not involved in the study (p=0.003, p=0.034, p=0.002).

In the nutrition questions, children in Eat Smart scored significantly higher than children in Be Smart (p=0.004), Play Smart children (p=0.002) and non-study children (p=0.002). Children in Eat Smart Play Smart scored significantly higher than non-study children (p=0.039). In the physical activity questionnaires, all intervention groups scored higher than non-study children and for Play Smart and Eat Smart Play Smart the differences in scores were highly significant (p=0.001 and p=0.000 respectively).

3.7.1.1 Parents' survey

Eighty parents completed the parental survey about their perceptions of the intervention. Parents were asked to rate the content and their child's enjoyment of the Be Smart programme. The results of responses are shown in Table 3.25. Ninety-three percent of parents rated the programme content as being average or above and 88% parents rated their child's enjoyment of the programme to be above average. Parents were also asked if they had benefited from the programme and 83% responded that they had benefited to some extent.

Table 3. 25 Parents rating (%) of the content and children's enjoyment of the Be Smart programme

	Content	Enjoyment
Poor	0	2
Below average	7	10
Average	14	24
Good	58	53
Excellent	21	11

3.7.1.2 Teachers' survey

Eleven teachers completed the short teachers' survey, which was mainly to monitor the impact of the programme on school life. The teachers were also asked if they would find it useful to incorporate some of the materials developed in the Be Smart programme into the curriculum, e.g. in Personal Social and Health Education (PSHE). All teachers responded that they would find this useful or very useful.

3.7.2 Discussion

3.7.2.1 Process evaluation

From the lesson evaluations in term 1 it was clear that children enjoyed quizzes, making things and practical tasting sessions; these were incorporated as far as possible in future lessons. The ongoing dialogue with the teachers throughout the intervention indicated that they were satisfied and felt the children were enjoying the programme. There were no complaints from parents about the intervention. Any parents who asked that children be withdrawn from the study did so because their child wanted to be with friends during the lunch break. From the parents' survey it appears that parents felt that this was a worthwhile programme, which was of benefit to the children and was also enjoyable for them. The teachers' appraisal of the lessons is also valuable when considering outcomes and applications of this research.

3.7.2.2 Impact evaluation

The results of the final quiz undertaken by all children in the relevant year groups undertook indicated that the programme had been delivered and understood in a satisfactory manner.

3.8 Summary

This school-based intervention aimed at the prevention of obesity in children resulted in modest changes in children's diet and nutrition knowledge. Anthropometric markers were unchanged by the intervention, probably due, in part, to the short time frame of the study. Parental assessments allowed links between parent and child lifestyles to be explored. A strong association with parents' and children's diet was observed but the relationship between their leisure time physical activity was weak. Evaluation of the programme indicated an increase in knowledge as a result of the programme and high parental and teacher satisfaction with the programme. This is an important pilot study for the UK and may be of value to future prevention strategies in children. Recommendations for future work are outlined in Chapter 7.

Chapter 4

Anthropometric data analysis

In this chapter, further analysis of the anthropometric data obtained at baseline of the school-based intervention (Chapter 3) is presented. As outlined previously, height, weight, skinfolds at five sites, MUAC, waist and hip circumferences were measured in 212 predominately Caucasian children. In the further analysis, two aspects were addressed:

1. comparison with UK reference values for height, weight and waist;
2. investigation of gender differences in the data.

Growth is a dynamic process, which in general occurs on a very regular basis. Count Philibert Guéneau Montbeillard, who took 6 monthly measures of his son's height from birth to 18 years of age, made one of the earliest records of human growth from 1759-1777. In this record, the now-accepted pattern of growth velocity (i.e. rate of growth) is apparent - a rapid decline from birth up to the age of 4 to 5 years, followed by a lessening of the deceleration until the beginning of the adolescent growth spurt (Tanner, 1978). A slight increase in velocity is apparent at 6-8 years in this particular record. A similar pattern has been observed in a minority of children in recent times, however, this juvenile or mid-spurt is not fully understood and is relatively rare (Tanner, 1978; Sinclair and Dangerfield, 1998). In some children, the growth velocity is practically constant from 5 or 6 years until the growth spurt (Tanner, 1978).

During the last 100 years in industrialized countries, children have been getting larger and growing to maturity quicker (Tanner, 1978). This change in mean size (or shape) of a population from one generation to the next is known as a secular trend in growth (Bogin, 1999). In 1972, the National Study of Health and Growth was commenced. This continued to monitor the growth of children aged 5-11 years in England and Scotland until 1994 (Rona and Chinn, 1999). Initially, the remit of the programme was a surveillance for the presence of undernutrition indicated by slow height gain. However, the emphasis soon changed to detecting rises in obesity. The time frame of the programme coincided with major changes in welfare policy and socio-economic circumstances. At the end stages of the study, differences in the height of English and Scottish children were no longer significant and socio-economic status (apart from family size) did not appear to influence height.

These secular changes in growth have resulted in new reference height and weight centiles for the UK (Cole, 1995b); the Tanner centiles developed in 1966 have now been declared obsolete for the UK population (Wright et al., 2002). The current centile charts, known as the 'UK90' charts, were developed using a cross-sectional population from 1990. This is the same reference population used in the formulation of BMI centile charts (Cole, 1995a).

4.1 Comparison with reference data

4.1.1 Height and weight

Mean height and weight for each decimal age was calculated separately for males and females. These values were then plotted with the corresponding values for the 50th centile height or weight using the relevant UK90 centile chart. For males, there was reasonable agreement with the 50th centile height values and close agreement with the 50th centile weight values (Figures 4.1 and 4.2).

Figure 4. 1 Mean height (male) compared to 50th centile of growth chart (1995)

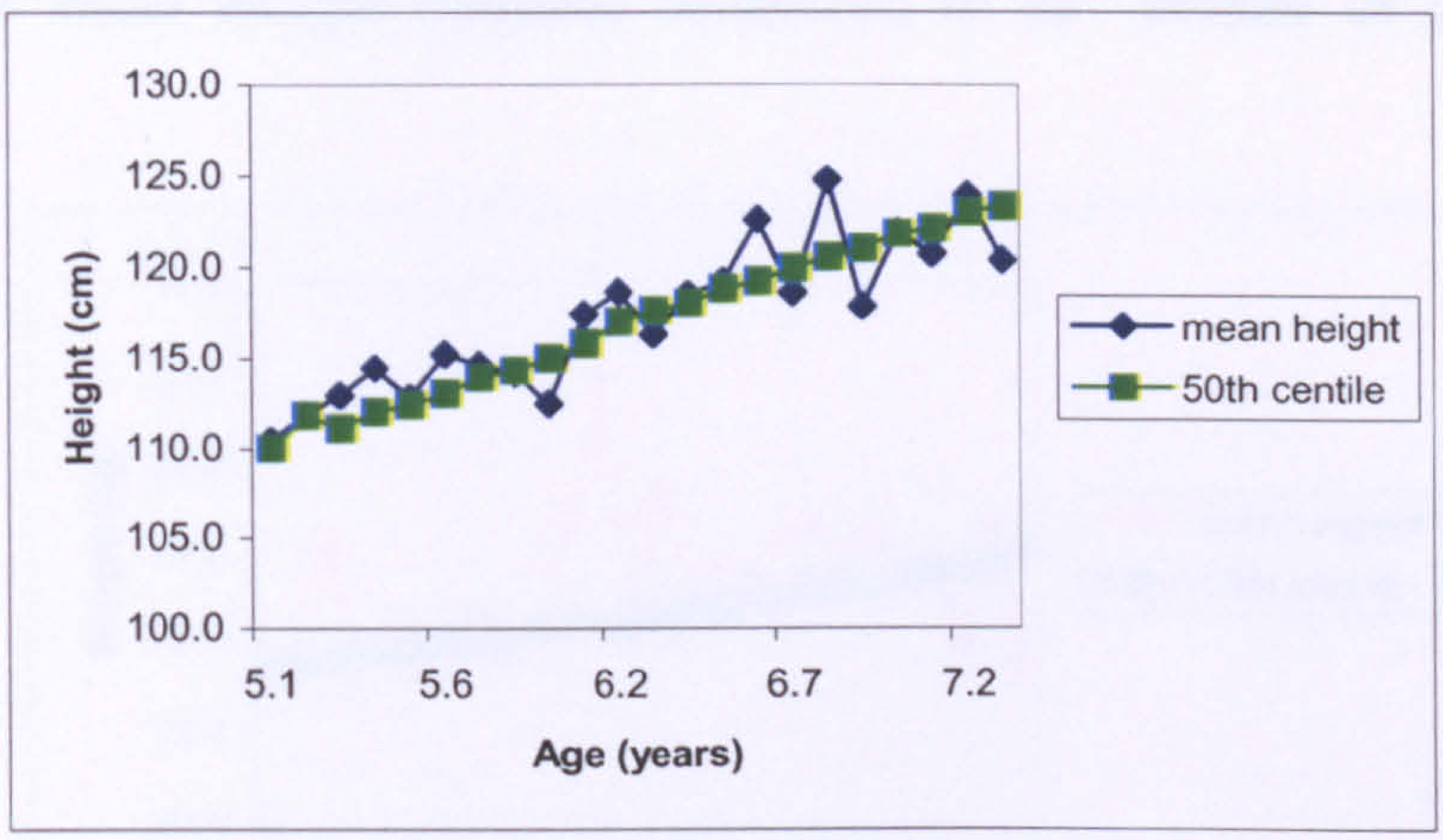
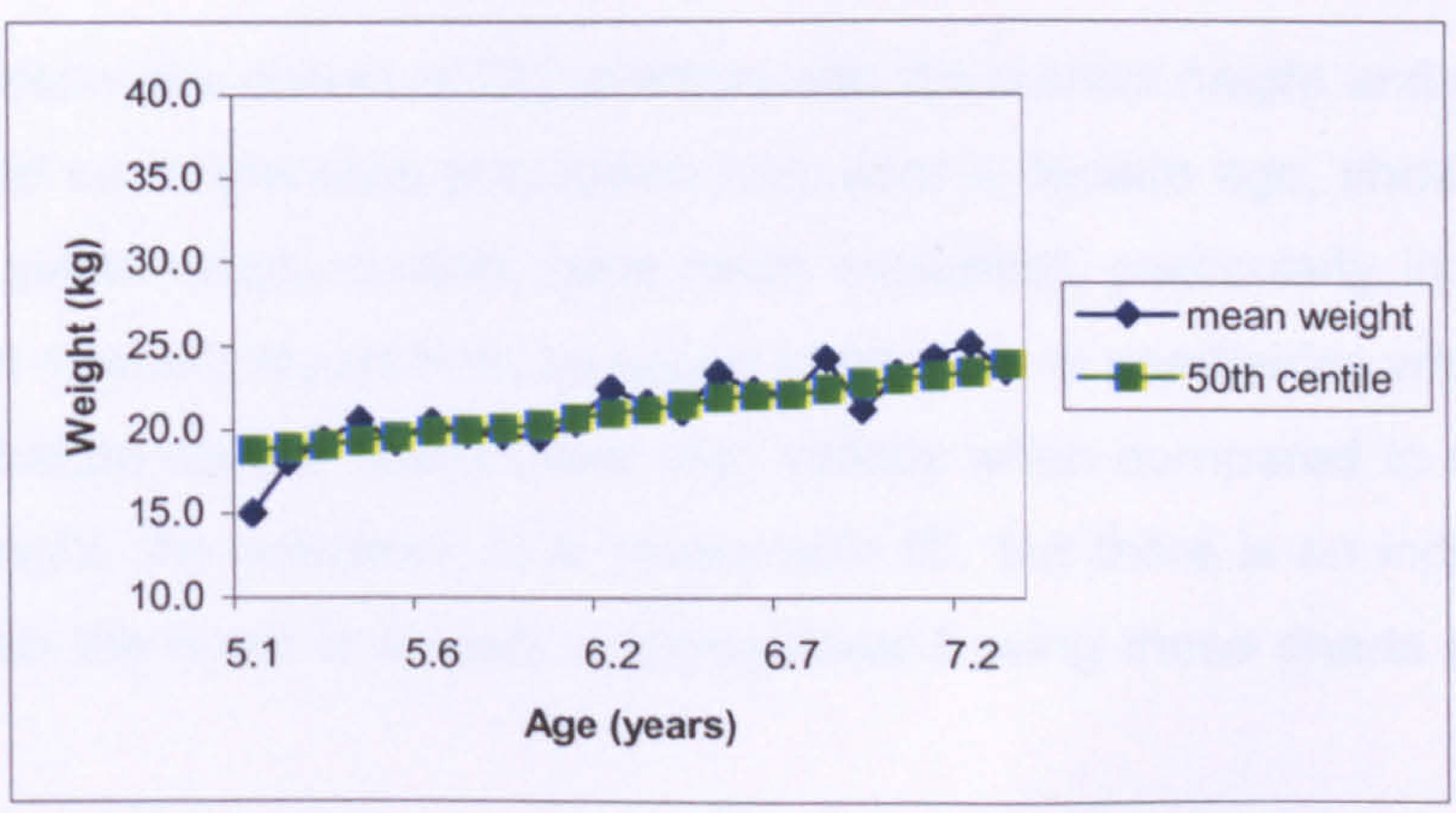


Figure 4. 2 Mean weight (male) compared to 50th centile of growth chart (1995)



There was some variation above and below the 50th centile for females' height and weight (Figure 4.3 and 4.4). The overall trend was a drift above the 50th centile for weight. The outliers at ages 6.2 and 7.8 years for both height and weight are due to two individuals only and are therefore not representative of the cohort.

Figure 4. 3 Mean height (female) compared to 50th centile of growth chart (1995)

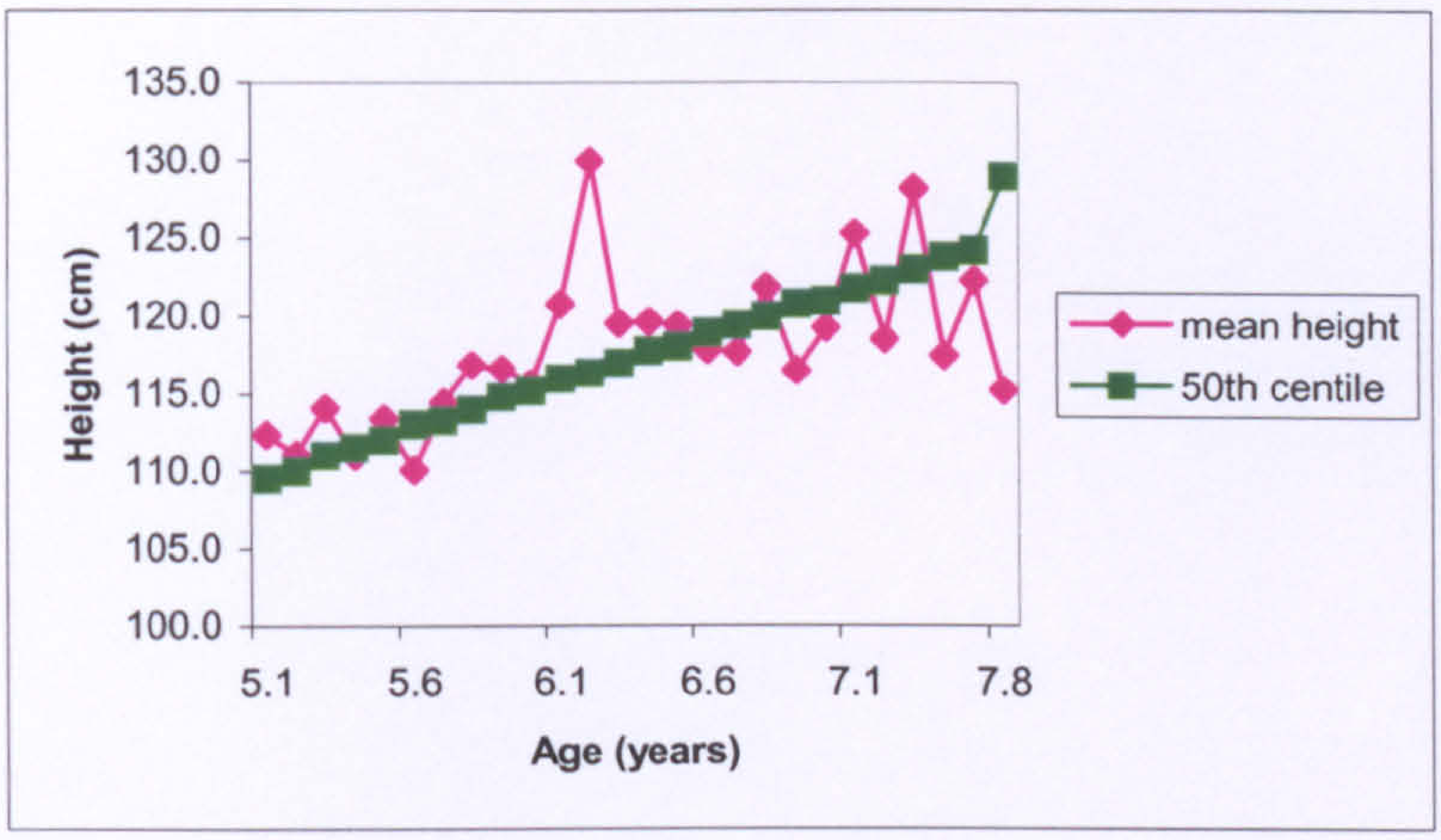
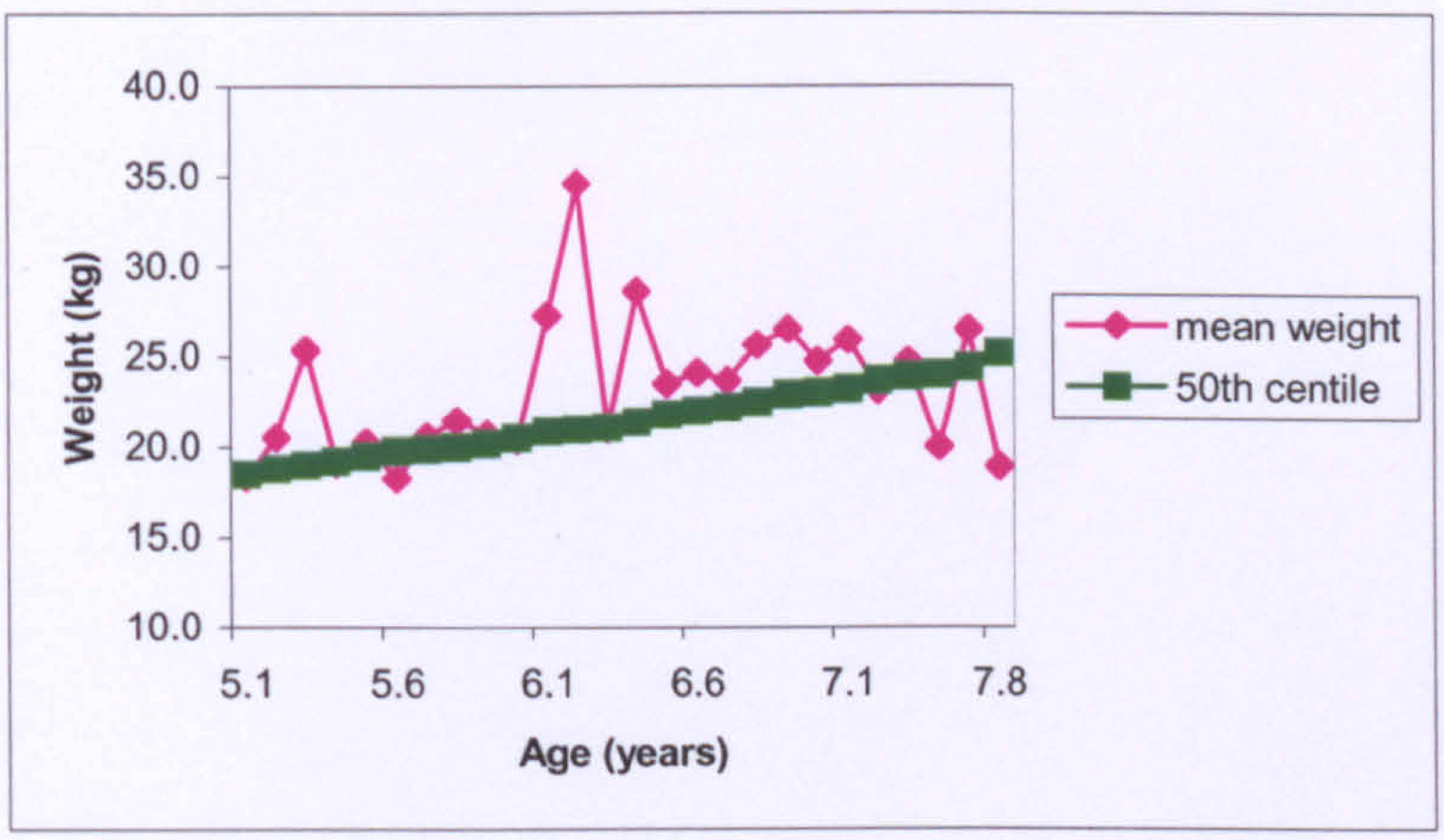


Figure 4. 4 Mean weight (female) compared to 50th centile of growth chart (1995)



This comparison of a cohort of 212 children with the current height and weight centile charts, based on a reference population from over a decade ago, shows reasonable agreement (when single outliers have been excluded), particularly in males. This concurs with a recent report from an expert committee in paediatrics which noted that the 'UK90' height centile charts have high validity when compared to contemporary data; for weight, the reference is a 'reasonable fit', but there is an indication that in older children the norm is already underestimated using these charts (Wright et al., 2002).

4.1.2 Waist circumference

Waist circumference is an index of relative fat distribution, not an absolute measure of fat. Whilst waist circumference has been used as a powerful predictor of CHD in adults, the significance of childhood central adiposity for future disease risk has still to be elucidated (Savva et al., 2000; Maffeis et al., 2001). The first waist circumference percentiles for the UK have recently been published using cross-sectional data from four measurement surveys undertaken in 1988 (McCarthy et al., 2001). The mean waist circumference for 5+, 6+ and 7+ years for the Oxford males and females were plotted against the published values for selected centiles. It can be seen that for males the mean value started just above the 50th centile and drifted to above the 75th centile (Figure 4.5); for females the mean values were between the 75th and 90th centile (Figure 4.6).

Figure 4. 5 Mean waist circumference (males) compared to percentile reference values (2001)

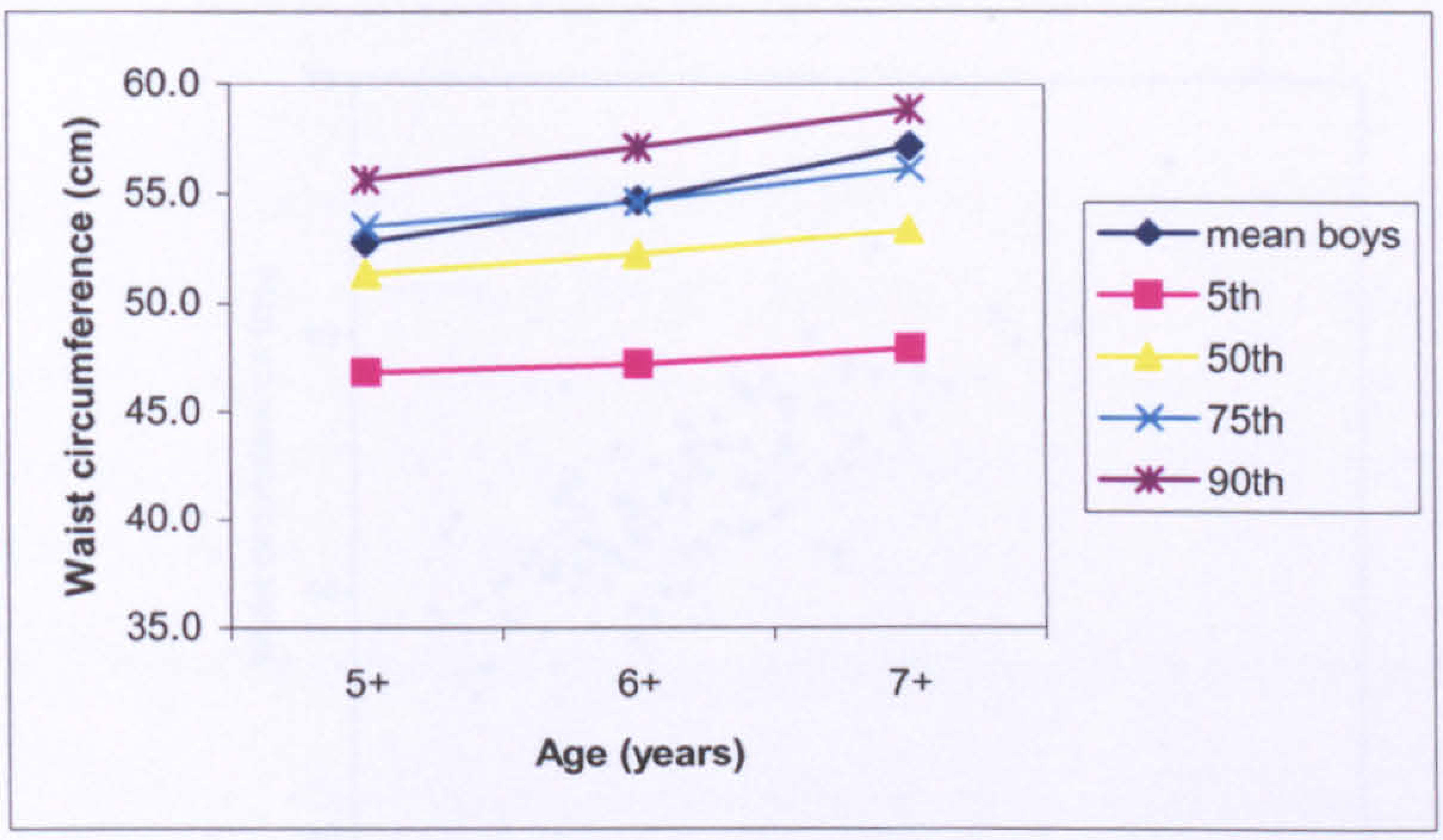
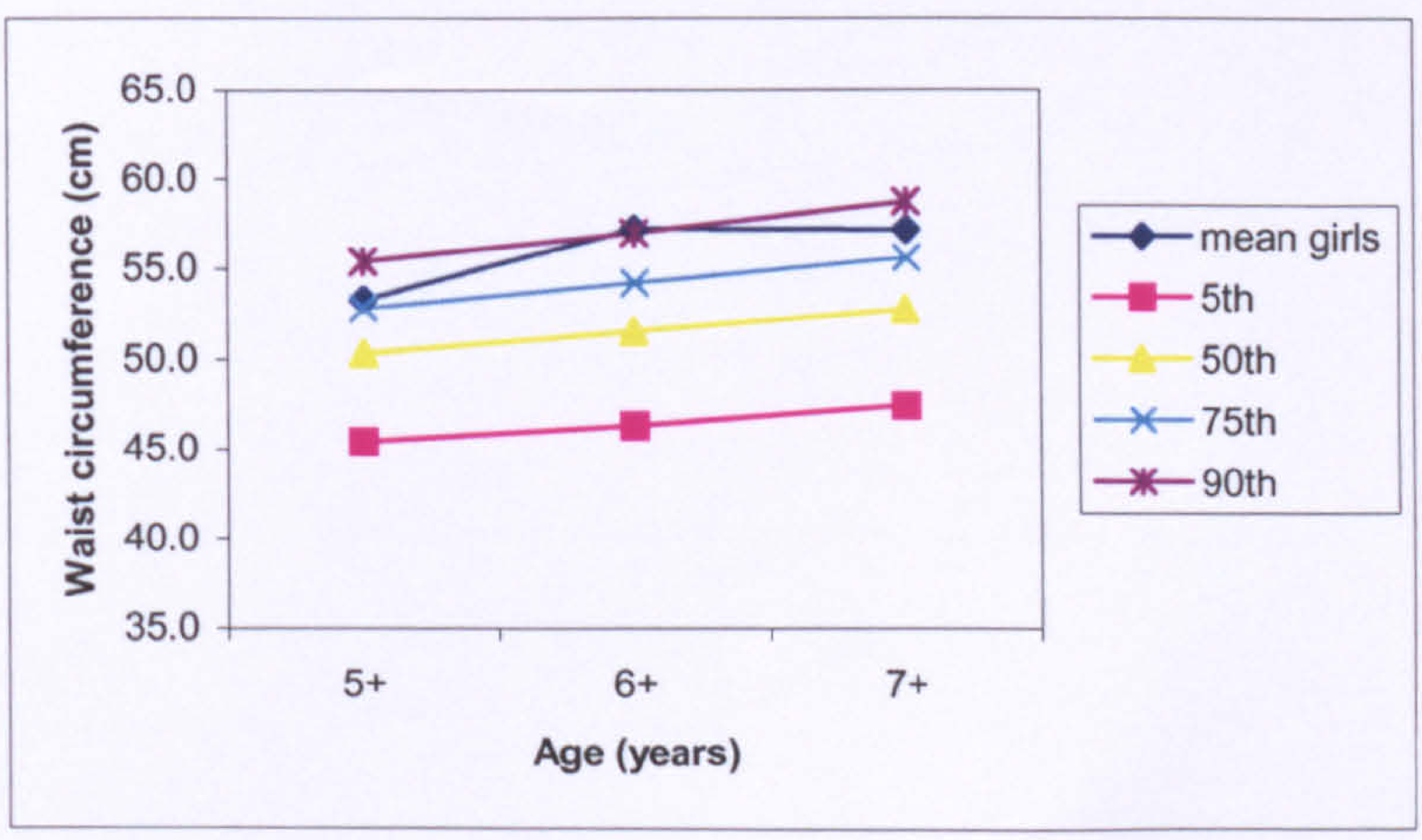


Figure 4. 6 Mean waist circumference (females) compared to percentile



These comparisons clearly indicate an increasing tendency towards central adiposity, particularly in girls, such that at age 6+ years the mean waist circumference of the Oxford girls was on the 90th percentile of the reference. Excess adiposity has been linked to the tendency towards early menarche which has been apparent during the 20th century (Frisch, 1994). As discussed in Chapter 1, early menarche has been identified as a risk factor in the aetiology of obesity.

4.1.2.1 Derived anthropometric measures

BMI has been used to predict disease risk in adults, but further work is required to investigate the use of BMI in children as an indicator for morbidity. There is limited evidence that waist circumference may be a predictor of disease in children (McCarthy et al., 2001). Therefore, the relationship between BMI and both waist and hip circumference was investigated. There was a strong relationship between BMI and waist circumference in both males and females (r 0.792, $p<0.000$ and r 0.842, $p<0.000$ respectively) (Figures 4.7 and 4.8).

Figure 4. 7 Relationship between waist circumference and BMI in males

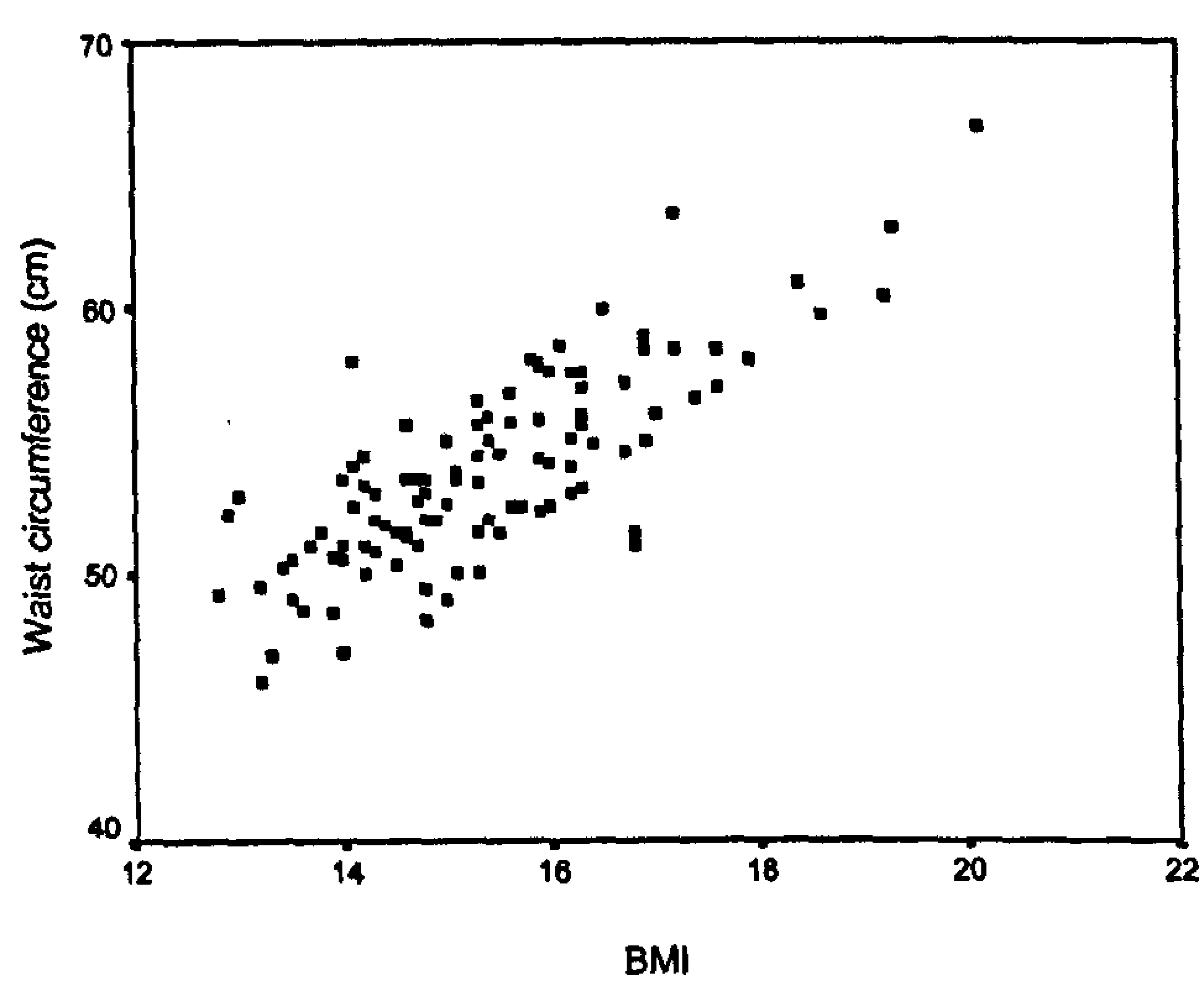
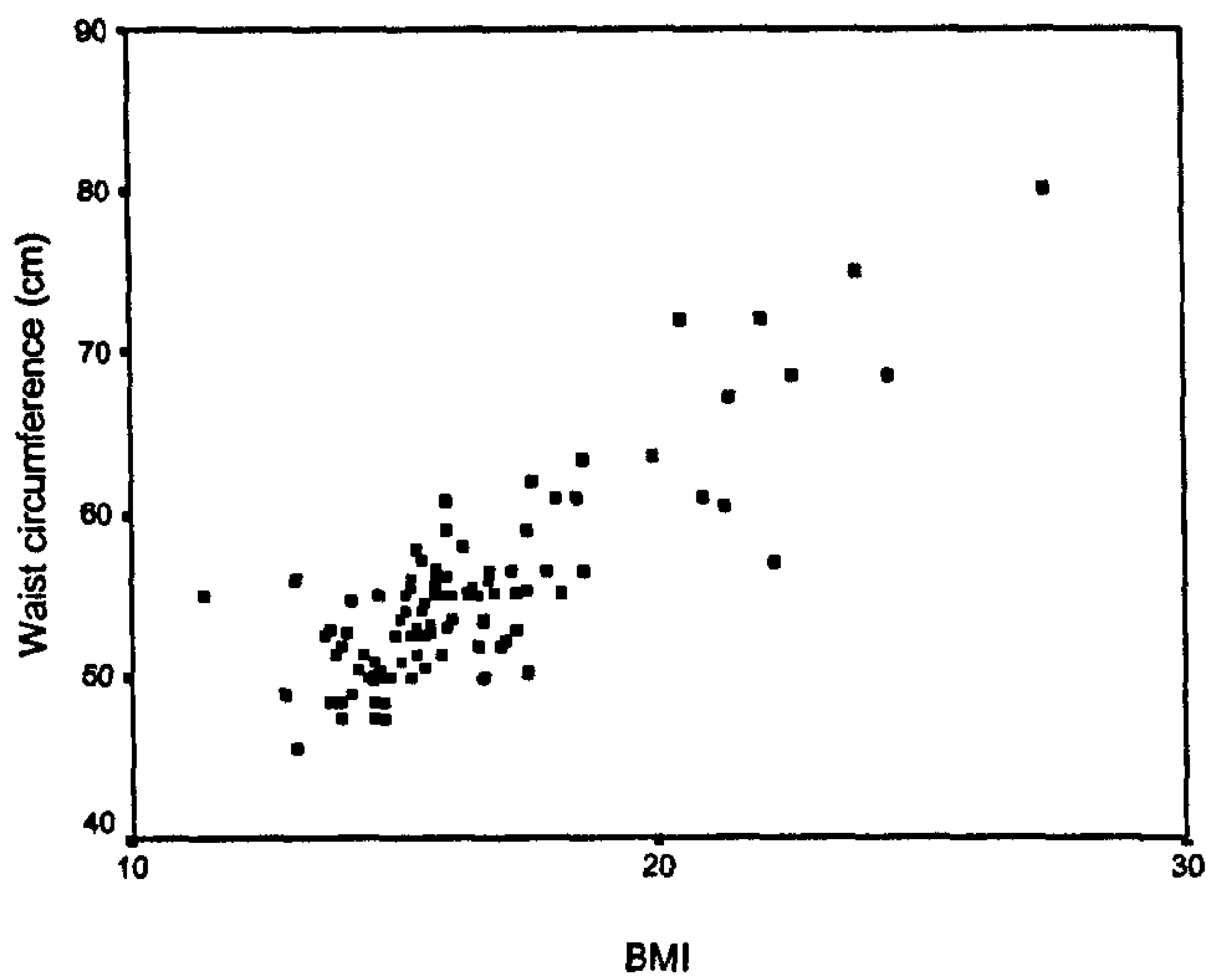


Figure 4. 8 Relationship between waist circumference and BMI in females



The strong relationship between BMI and waist circumference suggests that individuals with a high BMI have a high waist circumference. The clinical significance of this is unknown at this stage, as the relevance of waist circumference and BMI to the prediction of future disease risk, in pre-pubescent children, requires more investigation.

The relationship between hip circumference and BMI was moderate in males (r 0.662) and strong in females (r 0.825) (Figures 4.9 and 4.10). It is clear from the adult literature that waist circumference is a better indicator of disease risk than hip circumference or WHR (in Caucasian populations), therefore it is unlikely that this relationship will have clinical application.

Figure 4. 9 Relationship between hip circumference and BMI in males

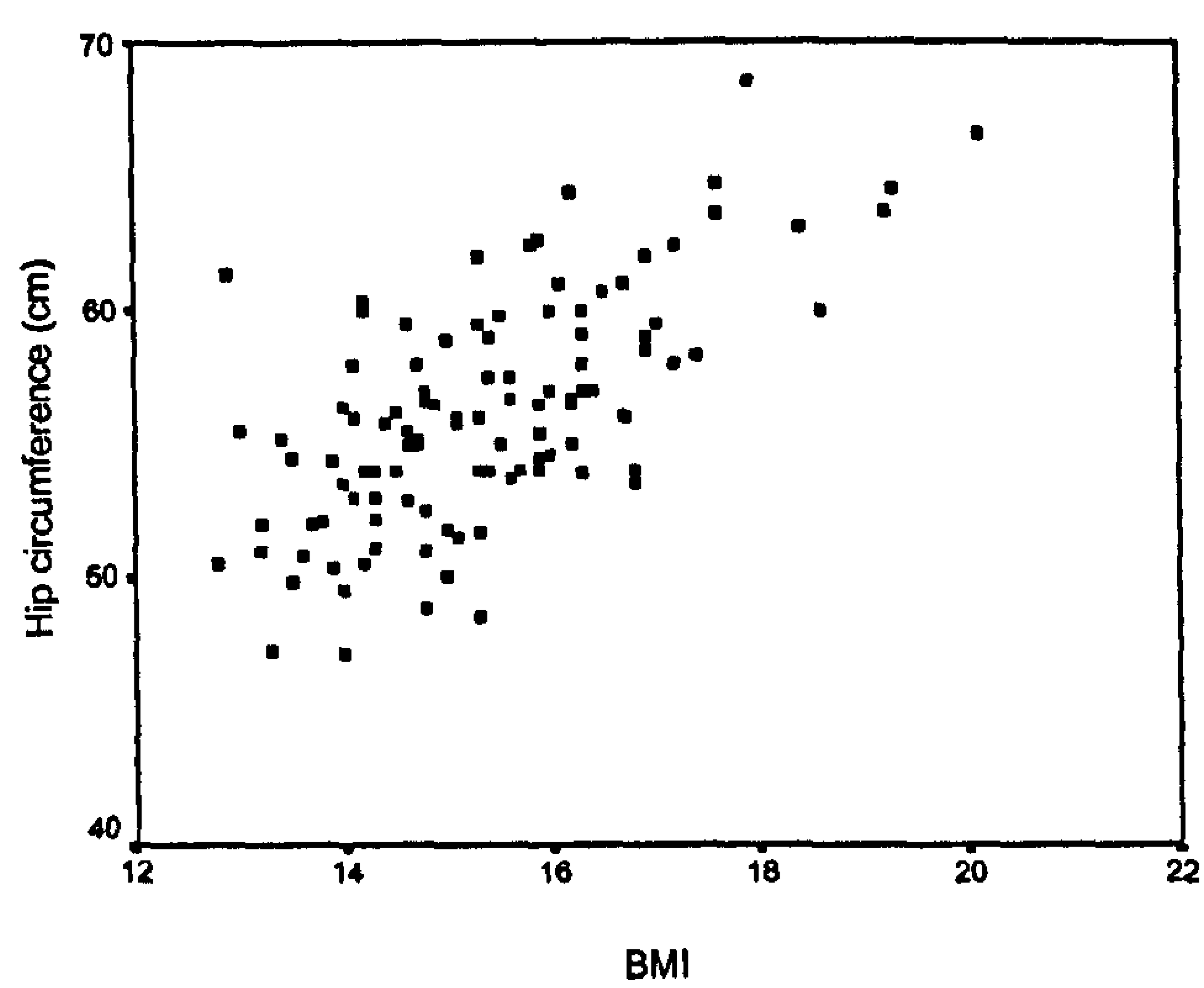
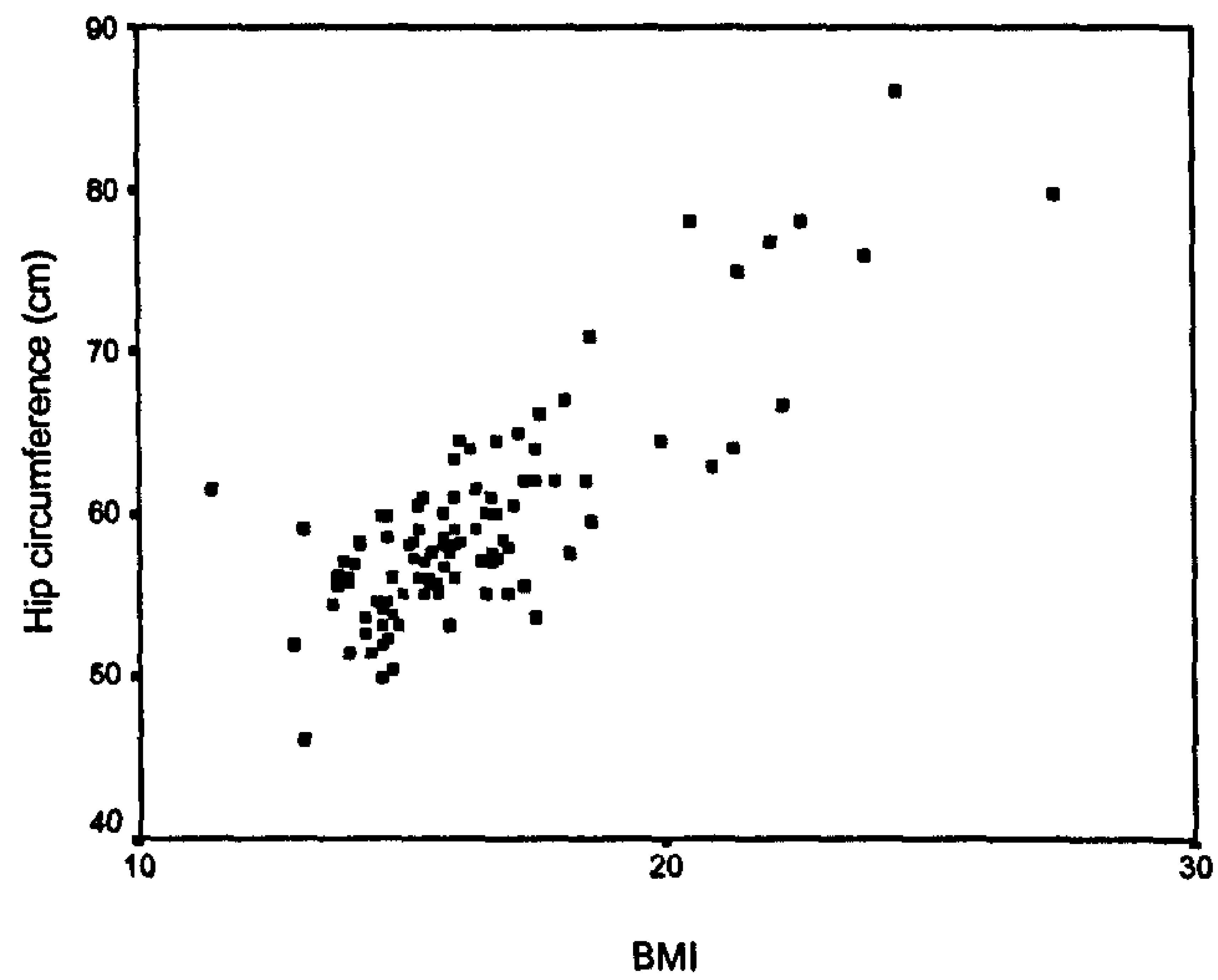


Figure 4. 10 Relationship between hip circumference and BMI in females



4.2 Investigation of gender differences in anthropometry

Both sexes are born with almost similar amounts of body fat; this level increases markedly in the first six months of life and continues at a slower rate for the next six months (Sinclair and Dangerfield, 1998). A decrease in fat accretion occurs after 1 year of age; this decrease is less in females than males, so that after 1 year, girls have more fat than boys (Sinclair and Dangerfield, 1998). During mid-childhood, fat deposition decreases and children gain FFM, especially males (Wells, 2001). Body fat does not increase again until the age of 6-8 years; this is referred to as adiposity rebound (as discussed in section 1.3.1). Excessive accumulation of body fat at this stage has been highlighted as a high risk period for the development of childhood obesity (section 1.3.5).

Table 4.1 shows the mean (± SD) and range of anthropometric values for boys and girls.

Table 4. 1 Description of baseline anthropometric measurements in males and females

	Sex	N	Mean ± SD	Range
Height (cm)	F	105	116.7 ± 5.5	105.6-132.0
	M	108	116.8 ± 6.0	98.9-134.1
Weight (kg)	F	105	22.3 ± 4.5	15.0-40.1
	M	107	21.1 ± 3.3	13.1-31.2
Waist (cm)	F	105	55.0 ± 5.9	45.7-80.0
	M	108	54.0 ± 3.7	46.0-66.8
Hip (cm)	F	105	59.3 ± 6.6	46.2-86.0
	M	108	56.3 ± 4.3	47.2-68.5
MUAC	F	105	18.5 ± 2.4	14.4-27.5
	M	108	17.4 ± 1.8	14.4-23.5
Triceps (mm)	F	99	11.2 ± 5.2	4.4-45.3
	M	101	8.8 ± 2.6	4.1-18.2
Biceps (mm)	F	101	8.2 ± 3.7	3.0-21.9
	M	103	6.1 ± 2.0	3.1-12.5
Subscap (mm)	F	99	7.8 ± 4.6	3.5-33.2
	M	102	5.7 ± 1.8	3.6-12.9
Suprailiac (mm)	F	98	7.6 ± 4.3	2.8-22.9
	M	98	5.2± 2.0	2.8-12.0
Calf (mm)	F	90	13.5 ± 4.9	6.9-34.2
	M	94	11.3 ± 3.0	5.4-19.8

Independent t-tests showed that the mean height, weight and waist circumference did not differ significantly between boys and girls. At this age, a gender difference in height and weight would not be expected. Height differences are not apparent until the adolescent growth spurt, which occurs at 10.5-11 years in girls and 12.3-13 years in boys. In the NDNS for Young People (Gregory and Lowe, 2000) height differences between the sexes were not significant until 14 years. MUAC was significantly higher in girls than boys ($p<0.001$). This finding differed from the NDNS for Young People (Gregory and Lowe, 2000), where boys had significantly higher MUAC in the 7-10 and 15-18 year groups compared to girls, but differences at 4-7 years were not significant. Hip circumference and skinfolds at the five sites (triceps, biceps, subscapular, suprailiac and calf) were also significantly higher in girls than boys ($p<0.000$). These findings may not be surprising given the higher lean body mass deposition apparent in young boys. In Figures 4.11 and 4.12, the waist and hip circumferences for males and females are compared and the sexual dimorphism in the hip circumferences is apparent.

Figure 4. 11 Scatter plot of male and female waist circumferences (cm)

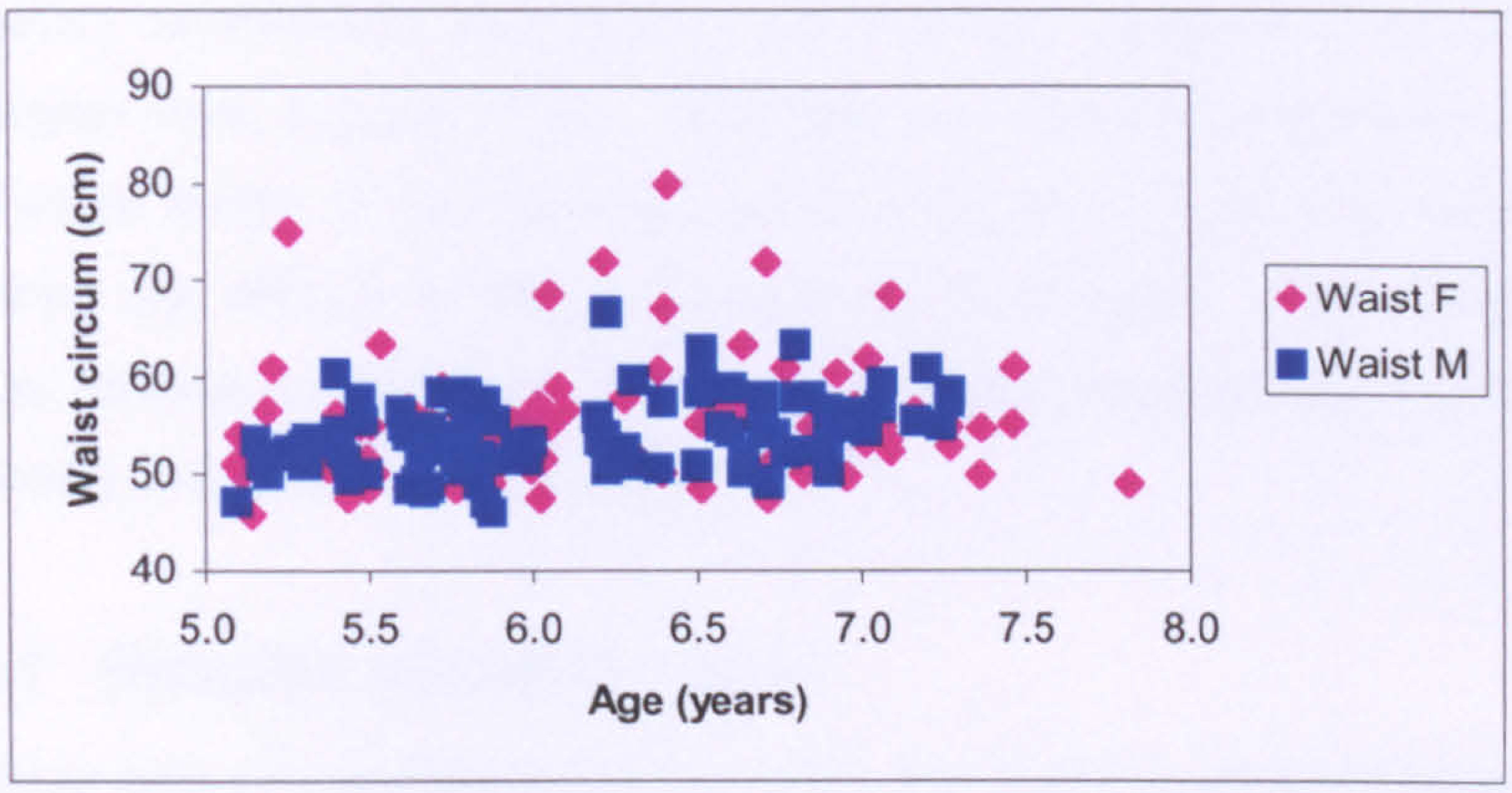
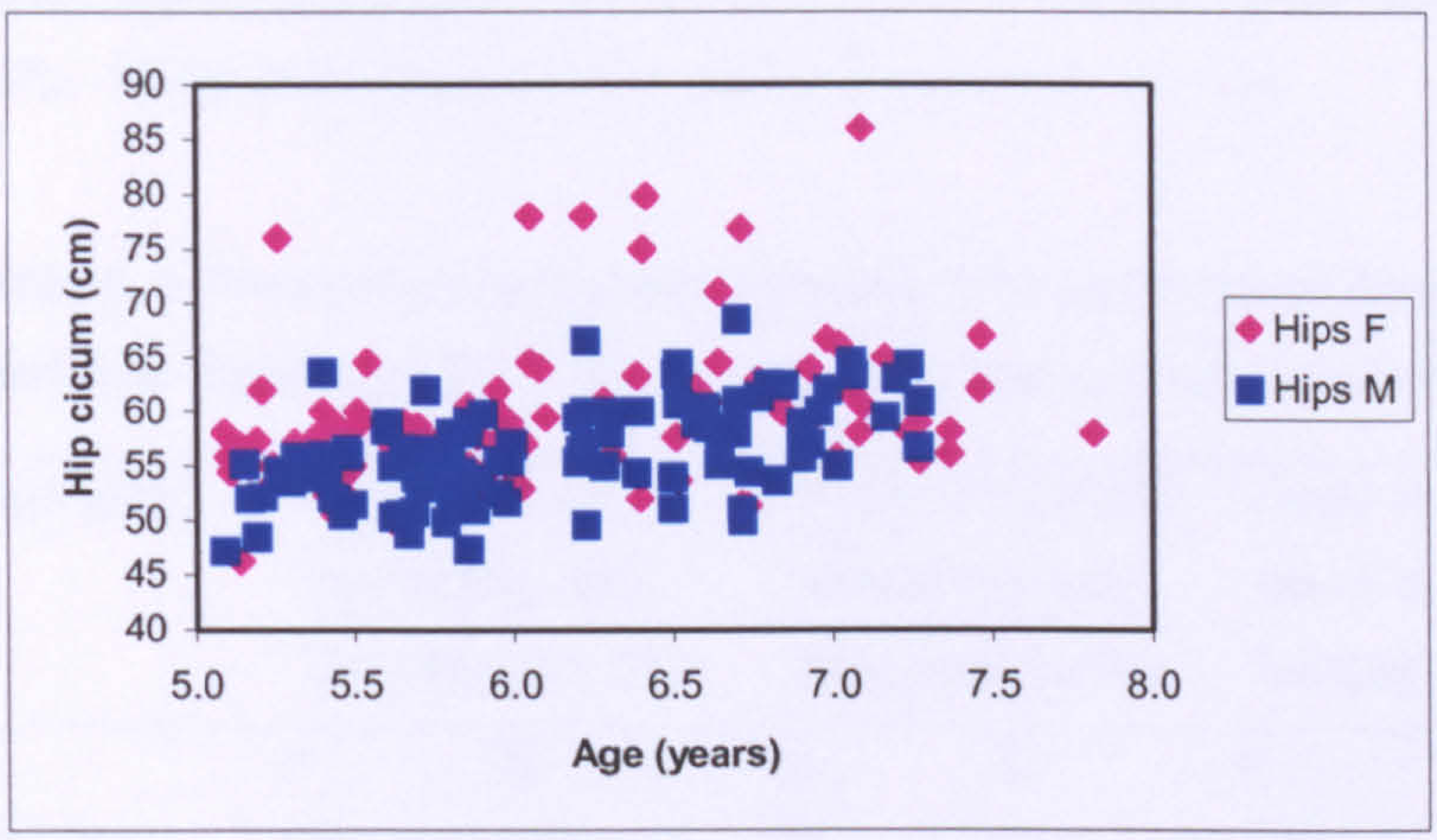


Figure 4. 12 Scatter plot of male and female hip circumferences (cm)



4.2.1 Summary

Further analysis of the anthropometric data indicated that weight, height and waist circumferences were equal or higher than the 50th centile of the reference percentiles, particularly for waist circumference. Females had higher skinfolds, MUAC and waist circumference, i.e. indicators of body fat than males. In addition, females had higher levels of body fat at a young age. Given the limited size of this data set, this preliminary analysis of the anthropometry from a recent cohort suggests sexual dimorphism and certain anthropometric features occurring at a younger age than previously reported.

Chapter 5 How well do children aged 5-7 years recall food eaten at school lunch?

During the initial assessment stage of the school intervention study (Chapter 3), the opportunity arose to undertake a validation study on children's dietary recall ability. Dietary assessment has been a key outcome measure of previous school-based health programmes (section 1.4). However, as discussed in section 2.2.2, there are many inherent errors in diet survey methodology, thus, valid and reliable measures of dietary intake are difficult to obtain, particularly in children. The outcome of this investigation may have implications for dietary assessment methodology in this age group, which has tended to rely on parental report.

5.1 Results of lunch recall

There was no significant difference in the mean number of food items provided by both PL (4.9 ±1.2, range 2-8) and SD (4.9 ± 0.8, range 3-7). All foods provided in PL and SD were classified and recorded and it should be noted that some meals, especially PL, contained more than one food from the same category (Table 5.1). A main dish and side dishes were among the most common foods provided; sweet foods were more prevalent in PL. None of the children who ate SD consumed any fruit.

Table 5. 1 Proportion of packed lunches (PL) and school dinners (SD) containing at least one food item from the food groups and overall breakdown of food items

Food type	Proportion of PL containing each food item (*n*=132)		Proportion of SD containing each food item (*n*=71)		Total no. food items in PL (*n*=648)		Total no. food items in SD (*n*=345)	
	n	%	*n*	%	*n*	%	*n*	%
Main dish	132	100	71	100	132	20	71	21
Side dishes	132	100	68	96	133	21	68	20
Sundries	11	8	46	6	11	2	46	13
Vegetable	11	8	22	3	11	2	22	6
Fruit	62	47	0	0	62	10	0	0
Sweet food	132	100	71	100	177	27	73	21
Drink	122	92	65	92	122	19	65	19

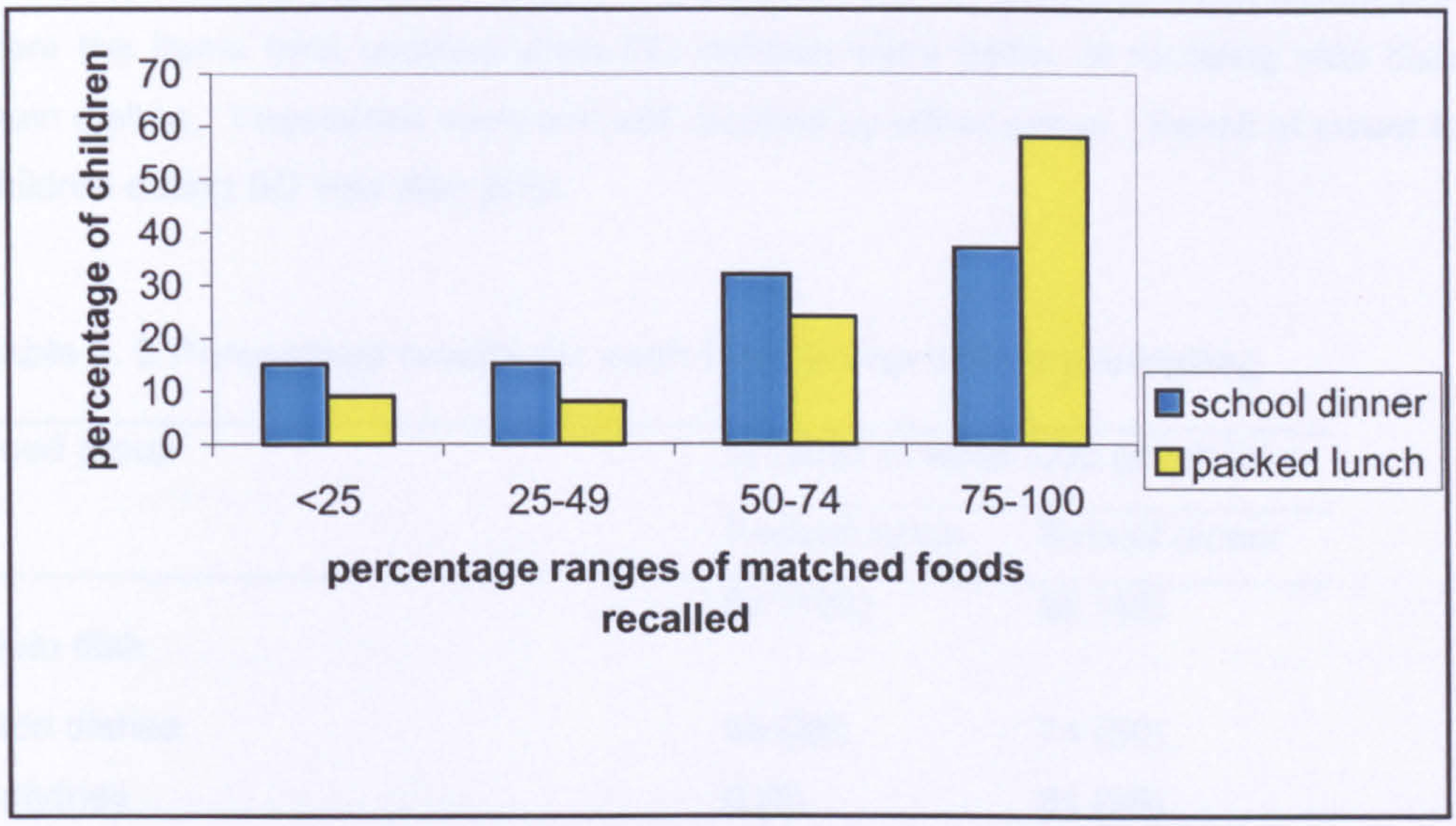
Main dish(e.g. sandwich, fish fingers, pizza); side dishes (e.g. potato, crisps, rice, chips); sundries (e.g. sauce, crackers); vegetable; fruit; sweet food (pudding, biscuit, yoghurt); drink.

Figure 5. 1 Examples of packed lunches

5.1.1 Percentage recall

The proportion of children in each percentage recall quartile for PL and SD is shown in Figure 5.2. This was calculated by dividing the number of foods correctly recalled with the number of foods observed eaten and converting this to a percentage. For example, a child who correctly recalled 3 out of the 4 foods observed eaten would have a percentage recall of 75% and therefore be in the upper quartile of percentage recall.

Figure 5. 2 Percentage recall of packed lunch and school dinner children



The mean number of foods observed as eaten and reported by the children was similar for PL (3.3 ± 1.4) and SD (2.8 ± 1.3). However, the percentage of accurate recall was significantly higher ($p<0.01$) in PL children (mean 70% ± 29%) compared to SD children (mean 58% ± 27%). A significant proportion ($p<0.001$) of children eating PL (70%) and SD (87%) omitted at least one food from their recall. The percentage recall in year 2 children (aged 6-7 years) was significantly higher ($p<0.01$) than that of year 1 children (aged 5-6 years).

For all children, there was a tendency for recall accuracy to diminish as the number of foods served increased. None of the packed lunch children given 6 or 7 foods recalled all 6 or 7 foods. Those given 8 foods recalled a maximum of 4 of them. This was similar for SD except that fewer children were offered 6 foods or more. Main dishes, side dishes and beverages were better recalled than fruit and sweet foods.

For the majority of children, main dishes or drinks were the first items recalled. Forty percent of children eating PL recalled their main dish first and 37% recalled their drink first. The figures for children eating SD were 32% and 39% respectively. Five percent or less of the children recalled vegetables, fruit, or sundries first.

The total percentage recall of each food group is shown in Table 5.2. This was calculated by dividing the total number of food groups offered by the total number of correct recalls of each food group. For example, 132 main dishes were offered and recorded as eaten in the children eating PL, of which 108 were correctly recalled, therefore the percentage recall for main dishes in PL children was 82%. For PL children, main dishes and drinks were the items best recalled while SD children were better at recalling side dishes and main dishes. Vegetables were not well recalled by either group. Recall of sweet foods by children eating SD was also poor.

Table 5. 2 Percentage recalls for each food group before prompting

Food group	% recall of each food group (*n*)	
	Packed lunch	School dinner
Main dish	82 (108)	68 (48)
Side dishes	65 (86)	74 (50)
Sundries	0 (0)	61 (28)
Vegetable	45 (5)	45 (10)
Fruit	50 (31)	-*
Sweet food	60 (106)	34 (25)
Beverage	79 (96)	55 (36)
Total foods recalled	70 (432)	58 (197)

*No fruit presented at school dinner

5.1.2 Phantom foods and problems identifying foods

Phantom foods are foods recalled as eaten but not observed as eaten. There was no significant difference between the mean number of phantom foods reported between groups: 1.4 (± 0.99, range 1-5) in the PL group and 1.9 (± 0.99, range 1-3) in the SD group. However, PL children were twice as likely as SD children to report phantom foods (Table 5.3).

Five percent of children eating PL and 17% of children eating SD were unable to give the exact name of a food (Table 5.3). Nevertheless, these children gave a good description of the recalled food and, in two cases, also gave the name of an equivalent food. These descriptions were accepted as a correct recall - for example, a triangle with vegetables was a description given for a samosa.

Table 5. 3 Percentage (*n*) of children reporting phantom foods, leftover foods and having problems providing the name of foods

	Phantom Foods	Problems providing name of food	Incomplete report of leftover food	Failure to report leftover food
Packed Lunch	22% (29)	5% (7)	10% (11)	77% (81)
School Dinner	11% (8)	17% (12)	9% (3)	76% (26)

5.1.3 Leftover food

Leftover food was observed in 80% of PL children and 48% of SD; 13% and 15% of these PL and SD children respectively gave a correct report of their leftover foods (Table 4.3).

5.1.4 Use of prompts

Using prompts at the end of recall significantly improved average recall in PL children from 70% to 81% and in SD children from 58% to 79% ($p<0.001$ and $p<0.001$ respectively). Prompting also improved the report of leftover food by 20% in PL children and 14% in SD children.

5.2 Discussion

The average percentage accuracy of recall of the number of foods eaten was similar to that reported by Emmons and Hayes (1973) for Grade 1 children (aged 6-7 years). The wide range in accuracy (0-100%), however, suggests that the data will not be reliable at an individual level. Further work is required to investigate the reliability of such data at a group level.

In the present study, recall was higher in children eating PL compared to children eating SD. One possible explanation may be an increased familiarity and interest in the foods brought from home compared to those provided in school. As the large majority of children eating packed lunch were year 1 children (who had a less accurate recall than year 2 children), the packed lunch/school dinner difference may be underestimated as it was not adjusted for age.

The finding that the children eating both PL and SD who were offered more foods failed to recall all of them is in agreement with previous findings. Meredith et al. (1951) and Baranowski et al. (1986) investigated recall in children who were all eating school meals and found that when children were offered more foods the level of accurate recall decreased.

For both groups, the foods recalled first were either the main dish (e.g. sandwiches, fish fingers, shepherd's pie) or beverage (e.g. juice or water). The best recalled foods for PL children were main dishes and drinks, while for SD children main dishes and savoury side dishes (potatoes, rice, chips, crisps, cheese savoury snacks) were best remembered. Emmons and Hayes (1973) also found that primary foods (main course foods such as eggs, poultry, meat, fish) were better recalled than secondary foods (such as desserts, starches and accessory foods). Baxter et al. (1999) concluded that salience of food was more important than liking of food in recall, although both were important factors of recall. The recall of the main dish was found to be predictive of the overall accuracy of recall. Results from the current study also indicate that the perceived importance of the food was an important factor in recall as the main dish was the best-remembered food in the PL group and second best in the SD group. Sweet foods had a 60% and 34% correct recall in children eating PL and SD respectively. Assuming that children inherently like sweet foods (Birch, 1999), this finding suggests that liking of food may not be the most important factor for recall. Although the preference for foods was not tested in this study, the enhanced recall by PL children may be due to an overall higher preference for the foods provided compared to SD children.

Leftover food was omitted or inadequately reported by all children. This may be due to a total disregard of leftovers or, possibly, leftovers may be perceived as undesirable by some children's families and therefore were not reported. Social desirability has been seen to influence the report of young children in some studies (Van Horn et al., 1990), but not others (Baranowski et al., 1986). No pattern emerged as to successful predictors of reporting of leftover food. This has implications for any nutritional analysis of a dietary recall in this age group.

The prompts employed in this study were purposefully non-directive. Cues and prompts have been shown to be vital to gain maximum recall and specific pathways of storage and retrieval of information have been elucidated (Baranowski and Domel, 1994). However, a full understanding of the cognitive processes involved in food recall is essential to ensure that cues do not over-burden or confuse (Livingstone and Robson, 2000). Consequently a child should first be allowed a free recall of a meal with no interruptions, followed by recapping and non-directive prompts, as in this study. To elicit the best recall in children, probing about the main dish, preference and familiarity of the foods should then follow. The findings from this research confirm that these may be important facets of the recall process. Finally, leftover food should be specifically asked about at the end of the recall process.

No pattern was observed in the reporting of phantom foods since foods from all groups were reported but not eaten, although PL children were twice as likely to report phantom foods. Where children struggled to provide the exact name of a food, but had a clear memory of the food eaten and were able to provide an adequate description of the food, this was accepted as a correct recall. This may be a potential source of error in other studies where investigator observations are unlikely to have occurred and therefore descriptions of food would be more difficult to interpret. More children had difficulty giving the exact names of food in the SD group compared to the PL group (17% compared to 5%). This may be attributed to the possible influence that PL children may have over the food offered, as previously mentioned. A limited knowledge of food and its preparation is a recognised problem in the dietary assessment of children (Samuelson, 1970; Emmons and Hayes, 1973); this may be reduced if children are familiar with the foods eaten. Allowing children to draw and/or describe the food or showing them pictures may be useful in alleviating this problem. However, this warrants further investigation to ensure that these methods do not influence and lead children's responses.

5.2.1 Summary

This study indicated that there was a wide range in the ability of children aged 5-7 years to recall intake from a packed lunch and/or school dinner. This dietary assessment method is unlikely to be suitable at an individual level. Investigators using dietary recall to estimate food intake in children aged 5-7 years need to be aware of the limitations of this method..

Chapter 6

Glycaemic index study

Food intake is clearly a major factor in the aetiology of obesity. Food intake is partly regulated by the mechanisms that control satiety. Increasing the satiation effect of food and/or satiety may be a further strategy in the prevention of obesity. In the second part of this thesis a dietary intervention was undertaken to investigate the effect of glycaemic index (GI) on appetite and satiety. Body weight regulation and appetite control has already been discussed in chapter 1, including theories relevant to the GI hypothesis. This chapter begins with a review of GI to provide a context for the results of the GI study.

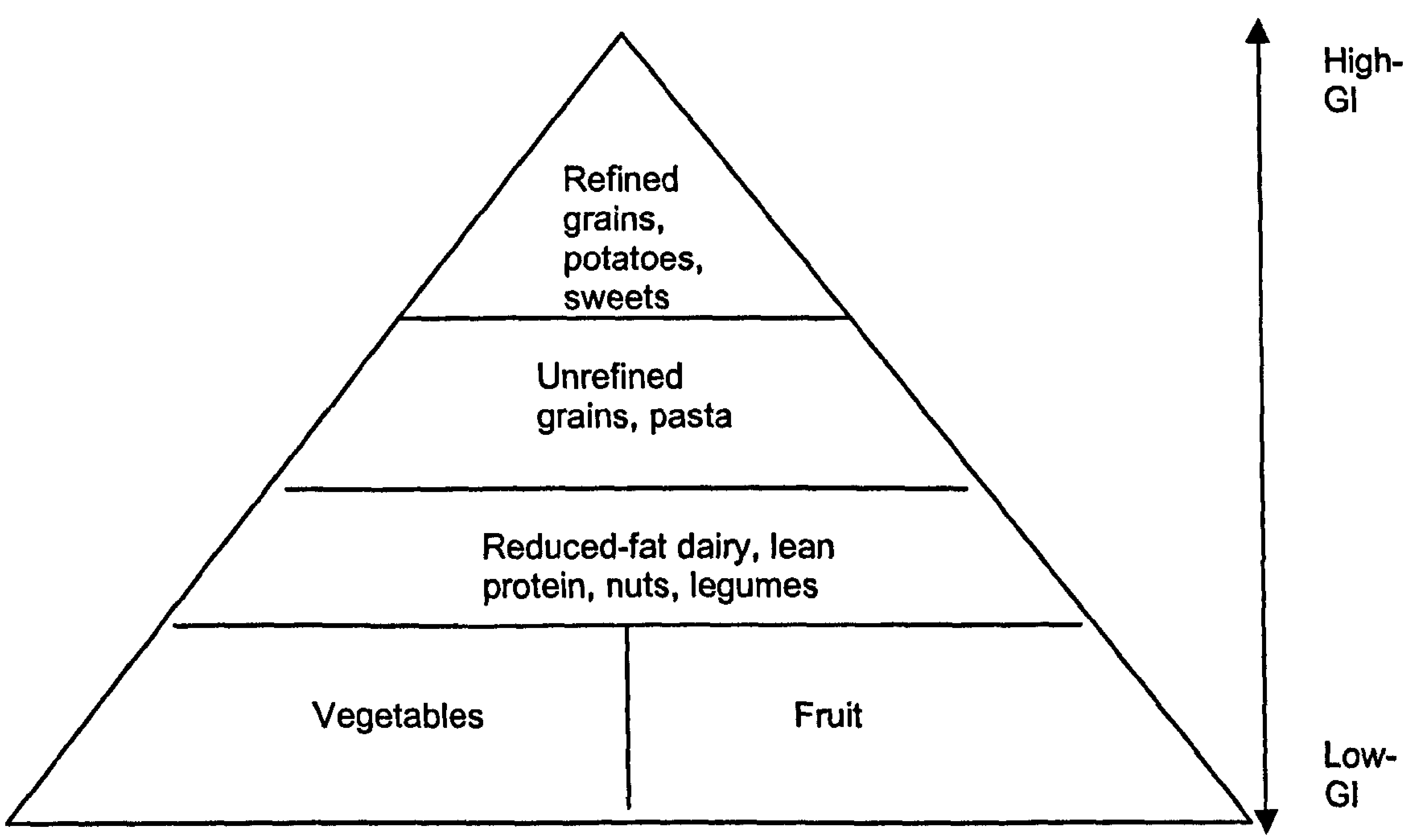
6.1 Glycaemic index

A classification of carbohydrates based on their glycaemic response was first undertaken by Otto and Niklas in 1980 reviewed by Wolever et al. (1991). Independently, the glycaemic index (GI) was introduced by Jenkins and co-workers in the early 1980s as a concept for the ranking of carbohydrate foods based on their effects on post-prandial glycaemia (Jenkins et al., 1981). The GI of a food is defined as the area under the glycaemic response curve (AUC), 2 hours after consumption of a portion of food containing 50g of carbohydrate, divided by the AUC for a reference food (white bread, previously glucose) containing the same amount of absolute carbohydrate (Ebbeling and Ludwig, 2001).

GIs range from less than 20 to approximately 120%; most carbohydrates in the western diet have a high-GI (over 70), e.g. common bread and many bakery products, potato and potato products, breakfast cereals and wholemeal cereal products, often produce a similar GI to white equivalents. Modern food processing (e.g. extrusion and milling) changes the starch molecules resulting in a rapid absorption and digestion. Foods with a higher amylose:amylopectin ratio are digested more slowly and have a lower GI (Morris and Zemel, 1999). In contrast, dietary fibre as part of an intact botanical structure, as in barley and pumpernickel bread, reduces the GI value of a food (Bjorck et al., 2000). Although the findings are mixed, insoluble fibre seems to have less effect on GI than soluble fibre, which has the potential to extend glycaemic effect (Ebbeling and Ludwig, 2001). It has been shown that fat and protein have a minimal effect on GI (Wolever et al., 1991; Roberts, 2000). The GI of a mixed meal can be predicted from the constituents of that meal (Ebbeling and Ludwig, 2001; Ludwig, 2002). Many fruits, most vegetables, legumes, dairy foods, meat, fish and bread with intact seeds or kernels have a low-GI (less than 50). A revised comprehensive list of the GI of foods based on new research and all available values has recently been published (Foster-Powell et al., 2002). Most GI values for the same food fall within a range of 10-15 units which is the acknowledged variation, but for a few foods the variation is much wider; the GI of porridge depends on the cooking, processing and the molecular and physical characteristics of the starch (Foster-Powell et al., 2002). GI has dispelled the traditional idea of simple and complex carbohydrates, as chain length is not a good predictor of the GI of a food. It has been noted that the addition of acid (e.g. vinegar) can lower the GI of a food and factors such as ripeness of fruit, physical form of food and preparation can alter the GI of a food (Pi-Sunyer, 2002).

An alternative low-GI food pyramid has been developed (Ebbeling and Ludwig, 2001) and is described in Figure 6.1. It can be seen that the emphasis is on fruit and vegetables and reduced-fat/lean protein foods rather than cereal foods. It has been suggested that a potential adverse effect of current low-fat healthy eating guidelines is an increase in carbohydrate intake and a concomitant rise in dietary GI (Ludwig et al., 1999). However, as already noted reducing fat intake appears to be a key dietary factor in the prevention of obesity.

Figure 6. 1 Glycaemic index food pyramid



The GI does not consider carbohydrate amount and a glycaemic load variable has recently been introduced in epidemiological studies to account for the quantity of carbohydrate consumed (Liu et al., 2001). For example, carrots have a high GI of 131, but the glycaemic load for a serving of carrots is low because the amount of carbohydrate in a serving of carrots is minimal (Liu et al., 2001).

6.1.1 Potential health benefits of a low-GI diet

Obesity

There are no long–term clinical trials examining the effects of dietary GI on body weight regulation (Ludwig, 2002). Among 16 single day studies in humans, 15 found lower satiety, increased hunger or higher voluntary food intake after consumption of high-GI compared to low-GI meals (Ludwig, 2002). It should be noted that in these studies there are differences in test variables, such as macronutrient content, energy density and palatability, therefore caution is needed in interpretation of data.

In one study, on three separate occasions, obese children were given high, medium or low-GI breakfasts and lunches of equal energy content; the protein and fat content of the medium- and high-GI meals were identical. Voluntary food intake for the rest of the day was highest after the high-GI, and lowest after the low-GI meals, with a 53% difference in energy intake (Ludwig et al., 1999). In an outpatient setting, Spieth et al. (2000) studied a group of obese children who were prescribed either a diet based on current recommendations or on low-GI foods. Reductions in BMI were greater in the low-GI group after accounting for the effects of confounding factors. These findings must be considered preliminary, as the children were not randomly assigned to treatment groups.

A low-GI diet has also been implicated in improving glycaemic control and blood lipid profiles; evidence is limited to date.

6.1.2 Possible mechanisms of reported health benefits

It has been hypothesised that low-GI foods may benefit weight control in two ways: by promoting satiety, and promoting fat oxidation at the expense of carbohydrate oxidation (Brand-Miller et al., 2002). High-GI meals have been found to result in higher serum insulin levels, lower plasma glucagon levels, lower post-absorptive plasma glucose and serum fatty acid levels and elevation of plasma adrenaline (Ludwig et al., 1999). It was concluded that this combination of relative hyperinsulinaemia and hypoglucagonaemia would tend to promote glucose uptake in muscle and liver, restrain hepatic glucose production, and suppress lipolysis, accounting for the lower levels of fatty acids after absorption of the high-GI meal. It was suggested that the elevations in counter-regulatory hormones is evidence that the reduction observed in the availability of these two major metabolic fuels is of physiological importance; meals resulting in a rapid glucose influx challenge the body's ability to shift smoothly from absorptive to postabsorptive physiology, partly due to altered glucagon and insulin secretions.

These sequences of lower circulating levels of metabolic fuels stimulating hunger and favouring fat storage, which may promote excessive weight gain, have been reported elsewhere (Ritz et al., 1991; Morris and Zemel, 1999; Roberts, 2000; Spieth et al., 2000). In addition, it has been suggested that as both normal and obese subjects are susceptible to the potentially adverse effects of a high-GI diet, it may be that susceptibility is at the level of response to the effects of GI rather than alterations in glycaemic response (Roberts, 2000). These responses are said to concur with the Friedman model of energy regulation, as outlined in Chapter 1 (Roberts, 2000) and subscribe to the theory that glucose is under tight regulatory homeostatic control (Ludwig, 2002). The postprandial hypoglycaemia which frequently occurs after a high-GI meal may be especially pronounced in the obese (Ludwig, 2002).

Studies attempting to relate the GI of foods to satiety are inconsistent (Roberts, 2000). Researchers have investigated cholecystokinin (CCK) as an alternative candidate satiety signal (Holt et al., 1992). In this study, six test meals of equal carbohydrate content and a control meal were consumed in random order, after an overnight fast. Serum CCK, plasma glucose and insulin and subjective satiety were measured over 3 hours. Significant inverse relationships were observed between the peak satiety score and both the glycaemic and insulin index, and a direct relationship between CCK response and satiety was observed. CCK response, as predicted, was highest for the control meal, which was high in protein and fat; there was a twofold difference in the area under the CCK curve among the six carbohydrate test meals. It is hypothesised that CCK may be exerting an inhibitory effect on gastric emptying, thereby delaying digestion and absorption of the carbohydrate. In this study, the nature of the glycaemic/insulin response as a major predictor of hunger/satiety is in the opposite direction to those cited above. This is consistent with other studies (Krishnamachar and Mickelsen, 1987; Leathwood and Pollet, 1988; Holt and Miller, 1995; Holt et al., 1996; Stewart et al., 1997). Researchers have also proposed that a key factor in satiety, other than glucose, is the time of contact with carbohydrate receptors in the small intestine, therefore a delayed transit time is associated with an increased satiety (Lavin and Read, 1995).

It has been emphasised that studies which compare different types of carbohydrate foods and find that lowered levels of glucose and insulin are associated with increased levels of satiety do not prove a causal relationship (Holt et al., 1996; Pi-Sunyer, 2002). Insulin sensitivity varies greatly between even healthy, non-diabetic individuals which must be accounted for in any model which uses insulin as a satiety signal (Holt et al., 1996). Insulin response to an ingested food is also influenced by osmolality, gastric emptying, gut hormone release, viscosity of gut contents, antecedent diet, obesity status, age and gender (Pi-Sunyer, 2002). Factors such as total carbohydrate, physical form and energy density may be stronger determinants of short-term satiety. In addition, the sensory features and form of food may have an overriding importance when considering appetite control (Blundell and Stubbs, 1999); oral-pharyngeal stimulation may be greater in bulky carbohydrate foods (Holt et al., 1996).

Although many wholemeal cereals have a high-GI, many of the studies undertaken in the area have compared low fibre, high-GI carbohydrates with high fibre, low-GI carbohydrates. Dietary fibre may be a potentially confounding variable because its unique physical and chemical properties aid in early signals of satiation and enhanced or prolonged signals of satiety (Burton-Freeman, 2000; Pereira and Ludwig, 2001). Early signals of satiation may be induced through cephalic and gastric phase responses related to the bulking properties of dietary fibre on energy density and palatability (Pereira and Ludwig, 2001). The viscosity-producing effects of certain fibres may enhance satiety through intestinal-phase events related to modified gastrointestinal function and subsequent fat absorption (Burton-Freeman, 2000).

Evidence is emerging about the potential of GI in the management of disease and promotion of health, and bodies such as the Food and Agriculture Organisation (FAO) and WHO have endorsed its use (FAO/WHO, 1997). However due to the questions which remain about its mode of action and effect in the long-term, it has been suggested that it is premature to recommend it as a public health message (Pi-Sunyer, 2002).

6.2 Results of GI study

The results of the study looking at the effect of consuming breakfasts of different GI on appetite and food intake are presented. As discussed, this is the first time such a study has been undertaken in a group of lean and overweight children.

6.3 Recruitment and compliance

A total of 38 children (15 males and 23 females) aged 9.5-12.5 years (mean age 10.8 years ± 0.80) were recruited from a middle school in Oxford. Children with a food allergy or who followed a therapeutic diet were excluded from the study. There was one withdrawal (female) at the early stages of the study and that has been excluded from subsequent analysis.

6.4 Anthropometry

At baseline, a comprehensive anthropometric assessment was carried out (Table 6.1). Over the relatively small age span of the subjects, a wide range in anthropometric values was noted. As described in Chapter 3, children were classified as being normal weight, overweight or obese using the international cut-off values for BMI (Cole et al., 2000). Almost 30% of the children had BMI values above the normal range for their age and gender (Table 6.2).

The percentage of overweight children is higher than in the previous study reported in Chapter 3. The children in the current study were approximately 4-7 years older than those reported previously. The increase in percentage overweight may be due to (a) temporal differences; (b) some children having commenced the initiation of puberty which is known to alter body weight and composition. The catchment area for the current school was similar in socio-economic mix to the schools in the previous study. Compared to a recent UK cohort, the prevalence of overweight in the current study is lower for males but higher in females where 25% of male and 23% of female 10 year olds were overweight (Rudolf et al., 2001). The percentage of obese children is much lower than the 14% of male and female 10 year olds reported in the UK cohort (Rudolf et al., 2001).

Table 6. 1 Anthropometric details of all subjects

	Male (*n* 15)		Female (*n* 22)	
	Mean ± SD	Range	Mean ± SD	Range
Weight (kg)	37.0 ± 5.8	27.3-48.0	42.1 ± 11.0	22.1-63.9
Height (m)	1.43 ± 0.07	1.30-1.53	1.45 ± 0.08	1.25-1.58
Waist circum (cm)	64.4 ± 4.8	57.5-71.5	66.9 ± 9.3	53.1-88.1
MUAC (cm)	22.3 ± 2.1	19.5-26.0	24.3 ± 4.2	17.3-34.0
Triceps (mm)	14.8 ± 3.8	11.1-21.2	20.5 ± 8.2	5.0-37.0
Biceps (mm)	9.2 ± 3.2	5.2-17.0	13.3 ± 5.2	5.0-22.2
Suprailiac (mm)	11.6 ± 4.3	6.3-19.1	20.0 ± 10.5	3.6-39.3
Subscapular (mm)	8.67 ± 2.7	5.0-13.9	16.8 ± 10.4	4.2-33.3

Table 6. 2 Percentage of children overweight, obese and non-overweight

	% (n)	% m* (n)	% f* (n)
overweight	24 (9)	13 (2)	32 (7)
obese	6 (2)	0 (0)	9 (2)
non-overweight	70 (26)	87 (13)	59 (13)

* male, female

6.5 Dietary assessment

Details of the dietary analysis from the 24-hour recall are shown for selected nutrients in Table 6.3. Particular attention was paid to breakfast and lunch intakes and details of the energy content of these at group level are presented in Table 6.4.

Table 6. 3 Nutritional analysis of 24-hour recalls at baseline

	Males (*n* 11)		Females (*n* 22)	
	Mean± SD	Range	Mean± SD	Range
Energy (kcal)	2043 ± 358	1569-2716	1758 ± 289	1304-2337
Energy (kJ)	8580± 1504	6590-11407	7384 ± 1214	5477-9815
CHO total (g)	274 ± 73	184-477	230 ± 44	144-294
Protein (g)	60 ± 14	38-92	57 ± 17	30-107
Fat (g)	86 ± 18	59-119	75 ± 21	38-123
NSP (g)	11.0 ± 6.1	4.0-24.2	10.1 ± 3.8	4.6-18.1
Thiamin (mg)	1.2 ± 0.4	0.58-1.8	1.4 ± 0.5	0.61-2.5
Vitamin C (mg)	111 ± 89	22-376	128 ± 77	11.4-271
Calcium (mg)	866 ± 369	421-1563	827 ± 296	302-1402
Iron (mg)	9.4 ± 2.7	5.5-13.8	8.7 ± 2.5	4.4-14.1

Table 6. 4 Energy intake of breakfast and lunch as assessed by 24-hour recall and diet history

		Males (*n* 11)		Females (*n* 22)	
		Mean ± SD	Range	Mean ± SD	Range
Breakfast	Energy (kcal)	360 ± 126	205-714	348 ± 91	176-522
	Energy (kJ)	1512 ± 529	861-2999	1462± 382	739-2192
Lunch	Energy (kcal)	605 ± 214	328-983	555 ± 190	293-970
	Energy (kJ)	2541 ± 899	1378-4129	2331 ± 798	1231-4074

As discussed in Chapter 2, 24-hour recalls do not provide an indication of habitual intake and the associated error is amplified in children due to their stage of cognitive development. However, they may provide a useful descriptor at group level. Reported mean energy for males was between the Estimated Average Requirement (EAR) of 1970 kcal (8.24 MJ) and 2200 kcal (9.27 MJ) for 7-10 year olds and 11-14 year olds respectively (Department of Health, 1991). Reported mean energy intake for females was lower than both of these age-specific recommendations. The wide range of reported intakes suggests that this data should be interpreted with caution. Fat contributed a mean of 38% of energy intake, which is higher than current recommendations. Mean micronutrient intakes were higher than recommended nutrient intakes at mean group level (Department of Health, 1991).

6.6 Breakfasts

6.6.1 Composition of habitual and test breakfasts

The low-GI (test 1) and high-GI (test 3) breakfasts were designed to match the energy and macronutrient content of the habitual breakfast intake as closely as possible. However, due to differences in the composition of the cereals and breads used in the two types of breakfast, it was not possible to do this with precision. The group mean energy and macronutrient composition of the habitual, low-GI and high-GI breakfasts and the approximate percentage of energy derived from each macronutrient is shown in Table 6.5.

Table 6. 5 Mean composition of habitual and test breakfasts

	Habitual	Low-GI	High-GI
Energy (kcal)	361	363	359
Energy (kJ)	1512	1491	1491
CHO (g)	55.2	53.0	67.7
% energy CHO	60	60	75
Protein (g)	13.0	13.6	9.1
% energy protein	15	15	10
Fat (g)	9.8	10.7	5.8
% energy fat	25	25	15
Dietary fibre (g)	3.8	5.9	1.3

The second test breakfast was identical to the low-GI breakfast in all aspects except with the inclusion of sucrose to 10% energy. For example, a breakfast of 200kcal had 5g sucrose added, which provided an additional 20 kcal.

6.6.2 Satiation

The satiation of test breakfasts 1, 2 and 3 were compared separately for the first, second and third experimental days using the Friedman test. There were no significant differences between the test breakfasts in immediate satiation ($\chi2=1.575$, df=2, p=0.455, $\chi2=1.680$, df=2, p=0.432, $\chi2=0.746$, df=2, p=0.689).

6.6.3 Palatability

The palatability of test breakfasts 1, 2 and 3 were compared separately for the first, second and third experimental days using the Friedman test and any significant differences were explored using the Wilcoxon signed ranks test. A significant difference in palatability was found on day 1 and day 2 of the experimental days: day 1 ($\chi 2=13.209$, df=2, p=0.001); day 2 ($\chi 2=13.683$, df=2, p=0.000); day 3 ($\chi 2=5.512$, df=2, p=0.064). On experimental days 1 and 2, the high-GI breakfast was rated to be significantly more palatable than either the low-GI (p=0.001, p=0.008) or low-GI with added sucrose (p=0.02, p=0.03) breakfasts. On experimental days 1 and 2 there were no significant differences in palatability between the low-GI breakfast and the low-GI breakfast with added sucrose.

6.7 Lunch intakes

6.7.1 Lunch intakes after different breakfast types

Details of lunch energy intake at group level in the 37 subjects are shown in Table 6.6 and Figure 6.2. In these analyses, the mean lunch intakes following each of the test breakfasts have been used.

Table 6. 6 Mean energy intakes (kcal,kJ) of lunches following each test breakfast

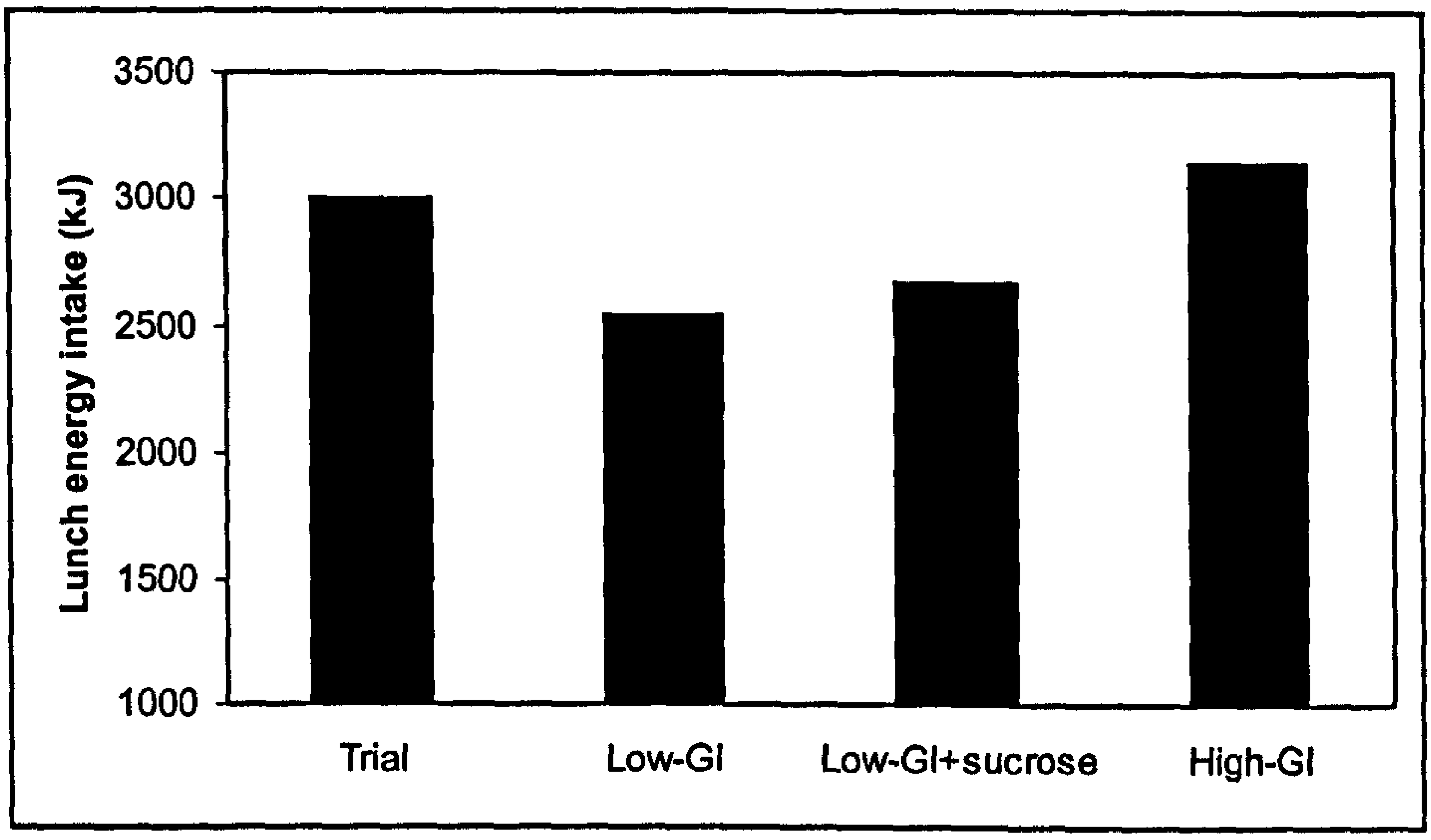
	N	Mean ± SD	Range
Trial lunch* (kcal)	37	717 ± 206	371-1266
Trial lunch (kJ)	37	3004 ± 863	1554-5304
Lunch 1** (kcal)	37	607 ± 154	319-978
Lunch 1** (kJ)	37	2543 ± 645	1337-4098
Lunch 2** (kcal)	37	636 ± 147	351-881
Lunch 2** (kJ)	37	2665 ± 616	1471-3691
Lunch 3** (kcal)	37	750 ± 155	497-1325
Lunch 3** (kJ)	37	3143 ± 649	2082-5552

*lunch following habitual breakfast

** average lunch intake after test breakfasts 1(low-GI), 2 (low-GI + sucrose) and 3 (high-GI) respectively

In order to investigate intra-individual variation in lunch intake, the coefficient of variation (CV) was calculated for all 10 lunches. This gave some indication if 'big' eaters were consistently 'big' eaters and similarly for 'small' eaters (variance is investigated in more detail in the following section). The mean intra-individual variation in lunch intake for the group was 21.9% CV ± 6.4 (range 12.4%- 40.0% CV).

Figure 6. 2 Mean lunch intake (kJ) after habitual and test breakfasts



6.7.2 Multilevel modelling of lunch intakes

In the multilevel model, the structure of the data was nested or hierarchical with level 1 units (occasions) nested within children (level 2). There were 37 children (level 2 units) and calorie intakes were recorded for 362 occasions (8 responses were missing). A simple two level model was defined as follows:

$$y_{ij} = \beta_0 + u_j + e_{ij}$$
$$u_j \sim N(0, \sigma_u^2)$$
$$e_{ij} \sim N\left(0, \sigma_e^2\right)$$

Here, y_{ij} is the energy intake of child j on day i; u_j and e_{ij} are random variables associated with child j and child j_{ou}, day i respectively. Hence, β_0 is the mean energy intake for all children, u_j is the individual child's variation from the mean and e_{ij} is the difference between the child's consumption and their mean on a particular day.

σ_u^2 is the variance of children's mean intakes and σ_e^2 is the variance of an individual's intake on different occasions. Fitting this model to the data led to the parameter estimates, with standard errors in brackets, described in Table 6.7.

Table 6. 7 Parameter estimates of mean lunch intake (SE) and within and between person variation

	Mean (SE) lunch intake estimates (kcal)
Fixed	
β_0	670 (23)
Random	
Children σ_u^2	17,229 (4585)
Occasions σ_e^2	24,195 (1898)
-2logL (total deviance)	4695

Thus, the standard deviation of lunch intakes (σ) between children was 131 kcal (549 kJ) (i.e. the square root of σ_u^2) and the standard deviation of intakes within children on different lunch occasions was 156 kcal (654 kJ) (i.e. the square root of σ_e^2).

The likelihood ratio statistic (-2logL) was used to test the contribution of independent variables. The intra-child correlation (correlation between intakes for same individual on different days) is equal to $\frac{\sigma_u^2}{\sigma_u^2 + \sigma_e^2}$. Using estimates shown above, the intra-child correlation was 0.42. This model assumes that lunchtime intake did not depend on the type of breakfast eaten. The next step was to incorporate the effects of different types of breakfast into the model

6.7.2.1 Effect of breakfast type, gender and weight status on lunch intake

Defining the mean energy intake as a function of the independent variables (gender, weight status or breakfast type), led to the following model:

$$y_{ij} = \beta_0 + \beta_1 female_j + \beta_2 overweight_j + \beta_3 lowgi_{ij} + \beta_4 lowgiplus_{ij} + \beta_5 highgi_{ij} + u_j + e_{ij}$$
$$u_j \sim N(0, \sigma_u^2)$$
$$e_{ij} \sim N(0, \sigma_e^2)$$

The independent variables were all coded 1 (yes) or 0 (no). As a result, the beta parameters measured the difference between mean calorie intakes for children/occasions in the named category compared to the mean intake in the relevant base categories (male/ normal weight/ habitual breakfast).

As a result of adding these independent variables, β_0 represented the mean energy intake at lunch for children who were male, normal weight and consuming their habitual breakfast. Females ate less lunch than males (-66 kcal, -277 kJ) and overweight children ate more than their lean counterparts (93 kcal, 218 kJ), other things being equal. However, neither of these differences was significant.

In contrast, breakfast type did have a statistically significant effect on subsequent lunch intake. Compared to baseline, mean lunch intakes after the low-GI breakfast and low-GI breakfast plus sugar were 109 kcal (457 kJ) and 83 kcal (348 kJ) less respectively; lunch intake after the high-GI breakfast was 36 kcal (151 kJ) more than baseline (Table 6.8).

Table 6. 8 Effect of gender, weight status and intervention breakfast on lunch intake compared to baseline

	Mean (SE) lunch intake estimates (kcal)
Fixed	
β_0	729 (43)
female	-66 (49)
overweight	93 (52)
Low-GI	-109 (27)
Low-GI +sugar	-83 (27)
High-GI	36 (27)
Random	
Children σ_u^2	17327 (4483)
Occasions σ_e^2	20,116 (1578)
-2logL (total deviance)	4691

Some of the variation between occasions may be explained by the fact that the children had eaten different types of breakfast. This is shown in Table 6.8 where the estimate of σ_e^2 was smaller than that reported in Table 6.7 (σ_e i.e. standard deviation is now 142 kcal, 595 kJ compared to 156 kcal, 654 kJ), i.e. 17% of the variance in lunch intake was accounted for by the breakfast eaten. The variation in lunch intake between children was similar in the simple model and the more advanced model (Tables 6.7 and 6.8). The test on the fixed parameters associated with breakfast types had a significant result which will now be discussed in more detail.

The effect of each independent variable on calorie intake was tested after allowing for the other factors (gender, weight status and breakfast type). The test statistic used in each case was change in the likelihood ratio statistic. If the independent variable(s) had no effect, this statistic followed $\chi2$ distribution with degrees of freedom corresponding to the number of variables tested. The results were:

Female ($\chi2$ = 1.825, df =1, ns)

Overweight ($\chi2$ = 3.143, df = 1, ns)

Breakfast ($\chi2$ = 68.621, df = 3, $P < 0.001$)

Further analyses were carried out to explore interactions between variables, however these were not statistically significant:

Sex x overweight ($\chi2$ = 0.032, df = 1, ns)

Sex x breakfast ($\chi2$ =2.855, df = 3, ns)

Overweight x breakfast ($\chi2$ = 4.268, df = 3, ns)

Comparisons between the three types of test breakfast provided are of particular interest. Confidence intervals for pairwise differences between mean calorie intakes are shown below (Figure 6.3). An overlap (with zero) indicates that results did not differ significantly. Lunch intake after the high-GI breakfast was significantly higher than after the low-GI breakfast and low-GI breakfast with added sucrose. These intervals had a ***joint*** 95% confidence level:

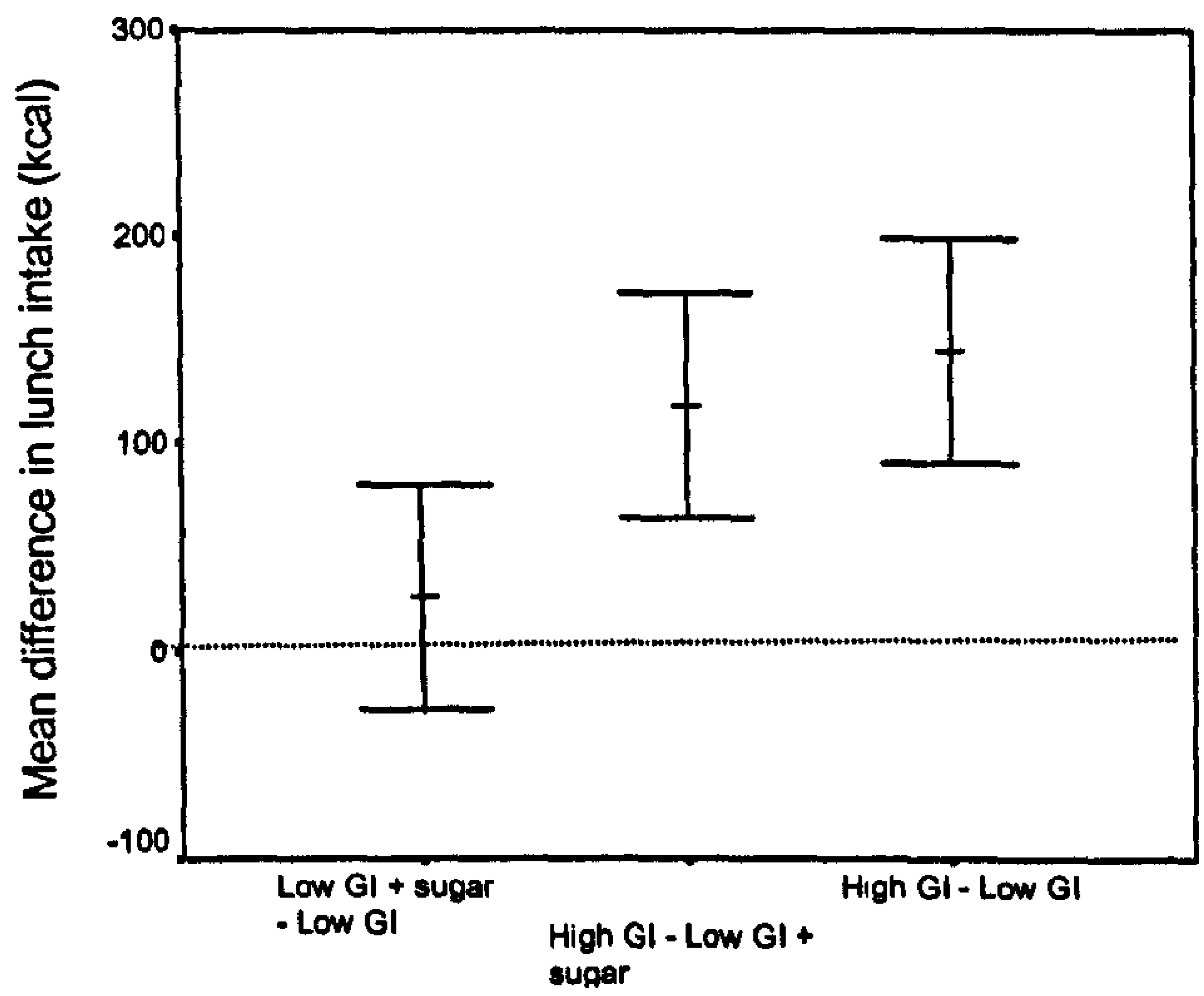
High GI – low GI 145 ± 54

High GI – low GI plus sugar 119 ± 53

Low GI plus sugar – low GI 27 ± 54

Joint confidence intervals were calculated to ensure an overall confidence level of 95%. These intervals were wider (i.e. more conservative) to allow for multiple tests/intervals.

Figure 6. 3 Parameter estimates of mean lunch intake (SE) and within and between person variation

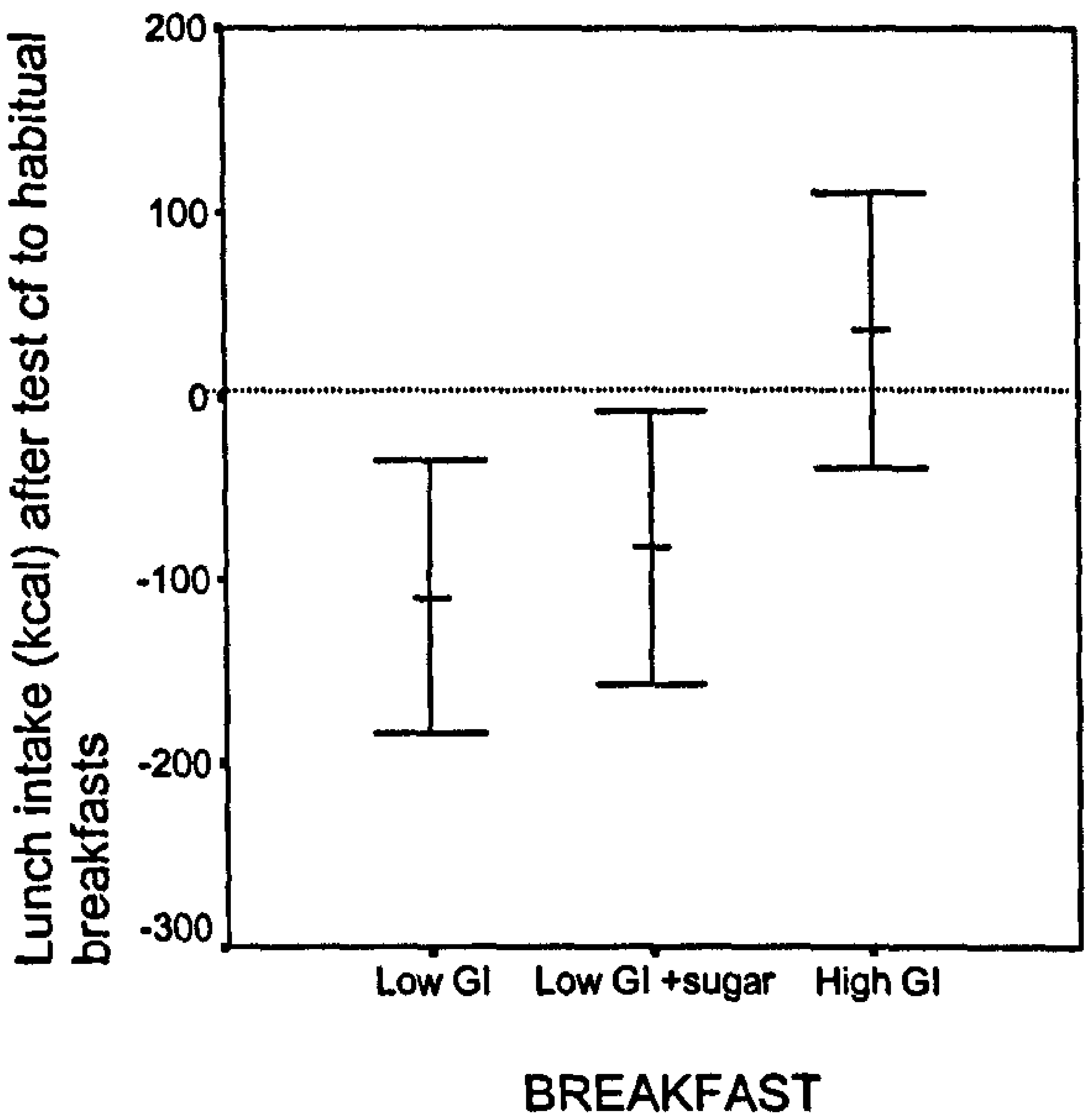


Comparisons of lunch intake after the test breakfasts and habitual breakfast were also made. Confidence intervals for pairwise differences between mean calorie intakes are shown in Figure 6.4, the intervals are as follows:

Low-GI – habitual	-109 ± 75
Low-GI plus sugar – habitual	-83 ± 75
High GI – habitual	36 ± 75

Figure 6.4 shows the joint (i.e. allowing for multiple comparisons) 95% confidence intervals for the differences in mean calorie intake following test breakfast compared to habitual. In the joint test where the confidence interval for the difference includes zero it is not significant i.e. for high GI.

Figure 6. 4 Confidence intervals for pairwise differences between lunch intakes (kcal) after habitual and test breakfasts



6.7.2.2 Power of analyses

The confidence intervals reported above show that the sample size had sufficient power to detect differences in lunch intakes within a range of 54kcal. Therefore, in the present study, a sample size of 37 was acceptable.

6.7.2.3 Check on assumptions

The model assumes that after allowing for the effects of the independent variables, variation within and between children is normally distributed with constant variance. Checks on the residuals supported both of these assumptions (Figures 6.5 and 6.6).

Figure 6. 5 P-P plot of residuals for children

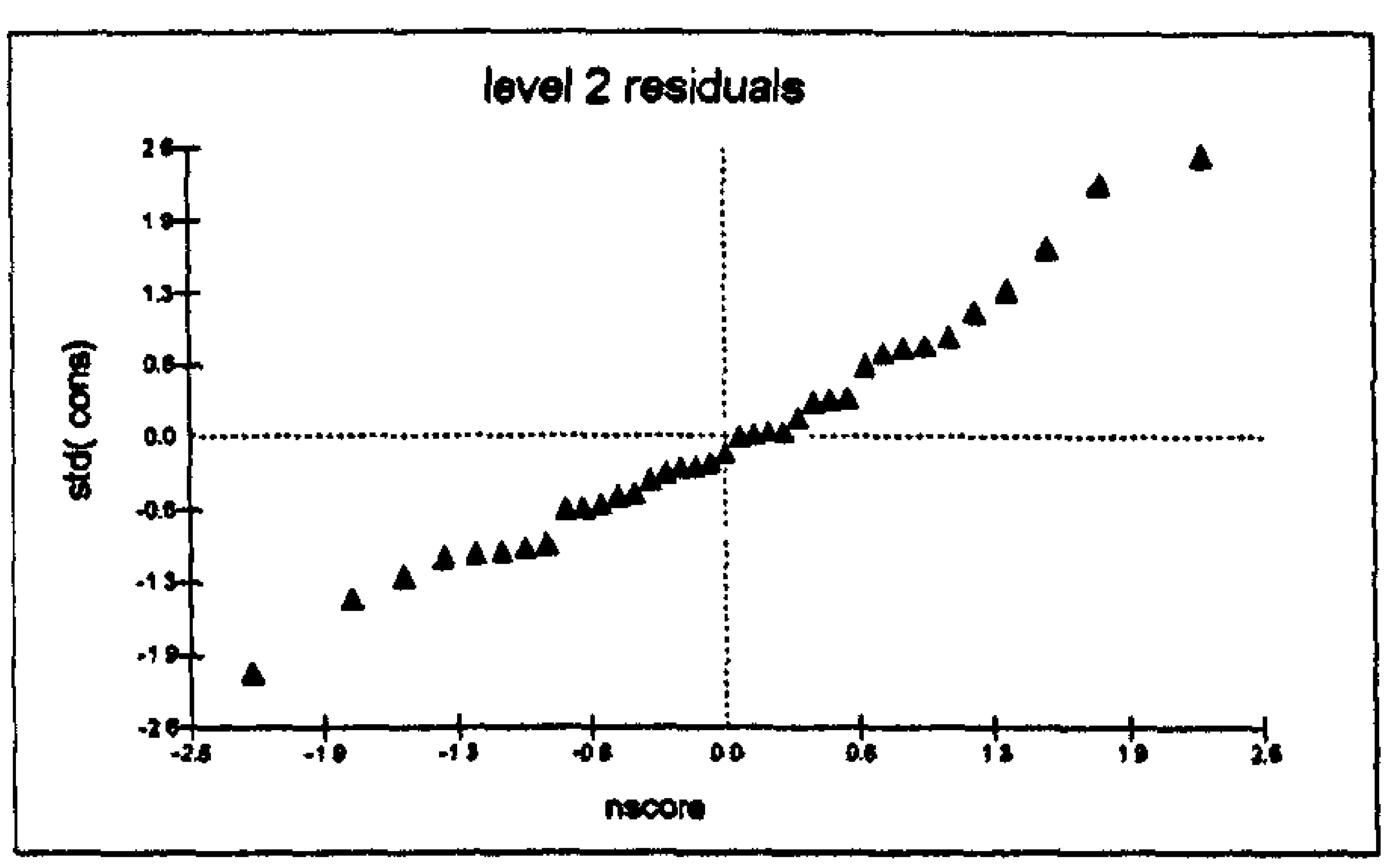
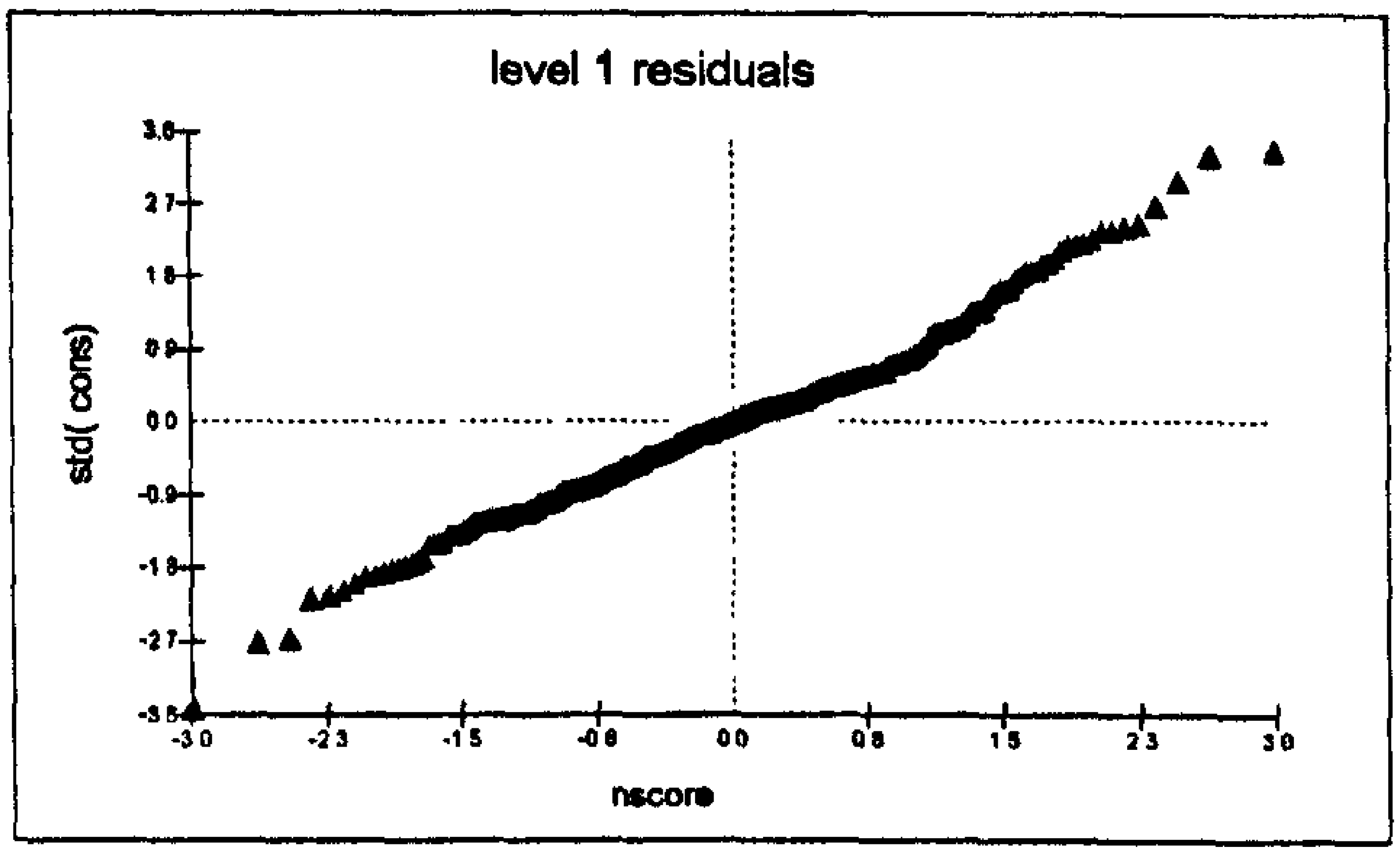


Figure 6. 6 P-P plot of residuals for occasions



6.7.2.4 Other analyses

Potential differences in the foods eaten at lunch after the different breakfasts were investigated. Average frequencies of food consumption for each of the three experimental days following each test breakfast were calculated. No differences in the types of food eaten at any of the lunches were apparent. The total number of servings of each of the eight food types is shown in Table 6.9. In this table, the mean aggregate number of servings for the whole group is reported per lunch. A "serving" consisted of 1-2 sandwiches, 1-2 biscuits, an individual packet of crisps, one cake, one yoghurt, one fromage frais, one piece of fresh fruit or one glass of squash. Salad was recorded when more than 3 slices of cucumber and/or two cherry tomatoes were eaten.

Table 6. 9 Mean number of servings of each food consumed at lunchtime following habitual and each test breakfast

	Trial lunch*	Lunch 1**	Lunch 2**	Lunch 3**
Sandwiches	55	48	45	57
Crisps	63	58	62	65
Biscuits	41	44	41	46
Cakes	21	22	24	25
Yoghurts	6	6	8	8
Fromage frais	3	4	4	4
Salad	1	1	2	1
Fresh fruit	5	3	3	4
Fruit squash	32	35	29	34

*lunch following habitual breakfast

** average lunch intake after test breakfasts 1, 2 and 3 respectively

6.7.2.5 Contribution of lunch intake to energy requirements

In order to set the lunch intakes in context, the energy provided by this meal was compared to daily requirements. Each subject's BMR was calculated using the Food and Agriculture Organisation (FAO) prediction equations (FAO/WHO/UNU, 1985) (Table 6.10) and the percentage energy contribution of each lunch to estimated BMR was calculated (Table 6.11).

Table 6. 10 Estimated BMR (kcal) using prediction equations

	Estimated group values of BMR	
	Mean ± SD	Range
Estimated BMR (kcal)	1286 ± 127	996 - 1526
Estimated BMR (kJ)	5388 ± 532	4173 - 6394

Table 6. 11 Percentage energy contribution of lunch to estimated BMR

Lunch	Energy contribution of lunch as a proportion of estimated BMR	
	Mean ± SD	Range
Trial	0.56 ± 0.15	0.29 - 0.91
1a	0.47 ± 0.14	0.23 - 0.83
1b	0.47 ± 0.15	0.19 - 0.97
1c	0.49 ± 0.16	0.20 - 0.94
2a	0.48 ± 0.14	0.28 - 0.85
2b	0.49 ± 0.11	0.20 - 0.71
2c	0.50 ± 0.13	0.30 - 0.78
3a	0.59 ± 0.15	0.32 - 0.97
3b	0.58 ± 0.16	0.32 - 1.07
3c	0.58 ± 0.16	0.31 - 1.00

6.7.3 Pre-lunch satiety ratings

The pre-lunch satiety ratings after test breakfasts 1, 2 and 3 were compared separately for the first, second and third experimental days using the Friedman test and any significant differences were explored using the Wilcoxon signed ranks test. Hunger ratings were greater following the high-GI breakfast compared to the other two test breakfasts for two of the three experimental days. A significant difference in satiety was found on day 2 of the experimental days: day 1 ($\chi2$=3.823, df=2, p=0.148); day 2 ($\chi2$=

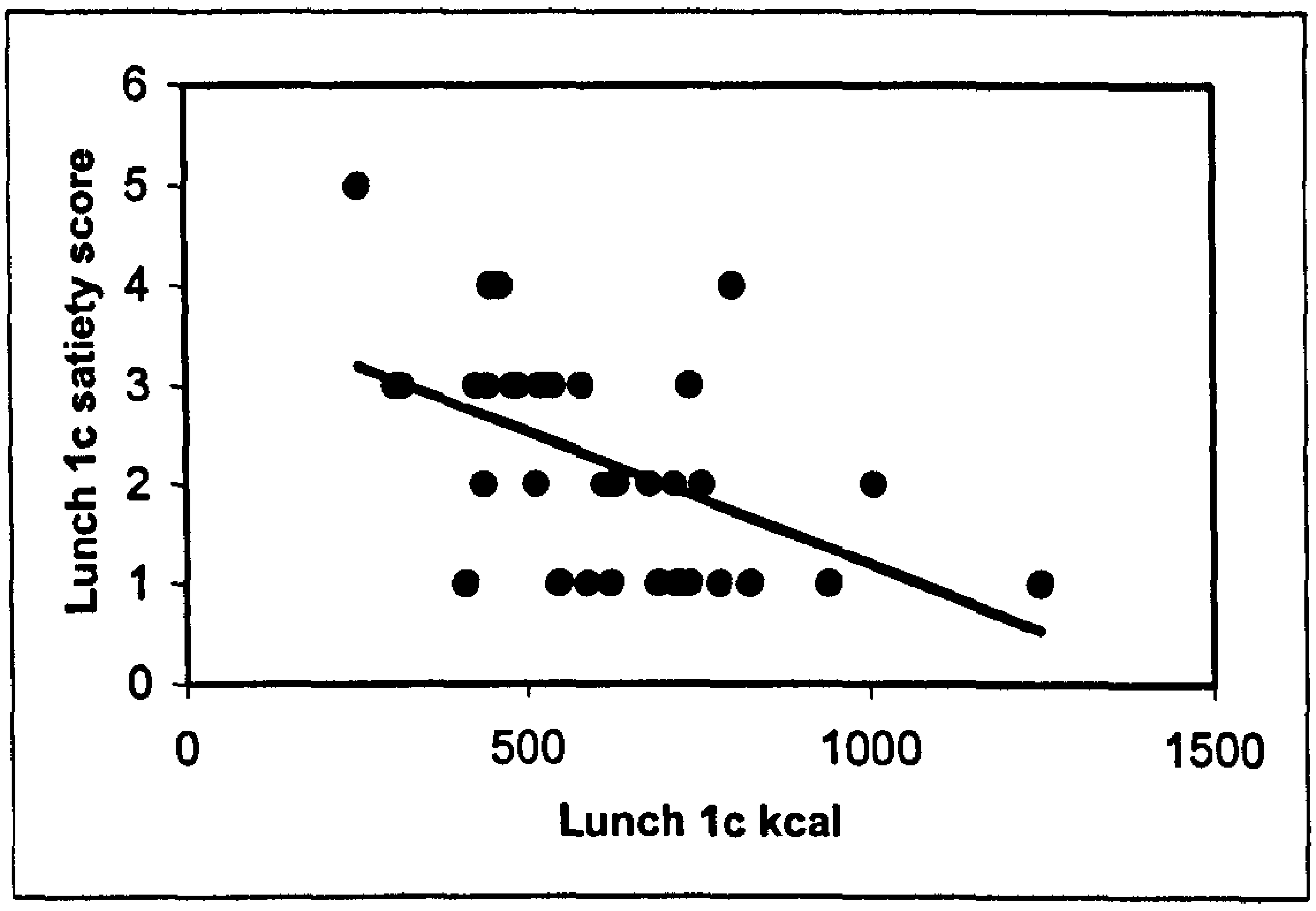
6.500, df=2, p=0.039); day 3 ($\chi 2$= 0.197, df=2, p=0.906). On day 2, hunger pre-lunch was significantly greater after the high-GI breakfast than after the low-GI with added sucrose breakfast (p=0.05).

The relationship of the pre-lunch satiety rating and subsequent lunch intake was analysed using Spearman's Correlation. For each of the 10 occasions, a negative relationship was apparent, i.e. a greater hunger rating (a low satiety rating) was associated with higher energy intakes. This relationship was significant on three of the lunch occasions (Table 6.12). The strongest of these relationships is shown in Figure 6.7 where the satiety rating was as follows: 1= extremely hungry, 2=hungry, 3=quite hungry, 4=neither hungry nor full, 5=quite full.

Table 6. 12 Relationship between pre-lunch satiety rating and lunch intake

Satiety rating and lunch intake	Spearmans Rho	Significance
Trial	-0.192	0.255
Lunch 1a	-0.271	0.121
Lunch 1b	-0.241	0.151
Lunch 1c	-0.516	0.001
Lunch 2a	-0.085	0.618
Lunch 2b	-0.237	0.158
Lunch 2c	-0.439	0.008
Lunch 3a	-0.096	0.583
Lunch 3b	-0.511	0.001
Lunch 3c	-0.093	0.589

Figure 6. 7 Relationship between satiety rating and energy intake at lunch on day 3 of the low-GI breakfast



6.8 Discussion

There was a significantly lower lunch intake following the low-GI breakfast with and without the addition of sucrose compared to lunch intake after the high-GI and habitual breakfast. Lunch conditions were identical for all groups on every experimental day, so this was a spontaneous response to the breakfast eaten. A range of factors which influence the GI of foods has been studied: disruption of plant structure due to processing (Haber, 1977; Leathwood and Pollet, 1988; Holt and Miller, 1994; Holt and Miller, 1995; Ludwig et al., 1999); alteration of amylose: amylopectin ratio (VanAmelsvoort and Weststrate, 1992); and addition of soluble fibre (Lavin and Read, 1995). All of these studies reported an increase in satiety and/or a decrease in food intake as a result of effectively lowering the GI of the food.

Only one of the above studies was undertaken in children (Ludwig et al., 1999). In this study, children were given two test meals (breakfast and lunch) and then *ad libitum* food intake was measured for 5 hours. Voluntary intake after the high-GI meals was 53% higher than after the low-GI meals. In the current study, the mean difference between lunch intake after the high and low-GI breakfast was 29%. However, only one meal had been given and the duration of the study was shorter than the study of Ludwig et al. (1999).

In the current study, when a small amount of sugar was added to a low-GI breakfast a reduced food intake at lunch was still observed. In a previous study, when sugar replaced starch in a high-GI cereal, the presence of sugar did not compromise glycaemic control (Brand-Miller and Lobbezoo, 1994). The addition of sucrose to the low-GI breakfast (test breakfast 2) did not alter palatability. The effect of sucrose may however have been underestimated; if toast only, rather than breakfast cereal was eaten, the sucrose was added to the breakfast fruit juice as it was considered important to be consistent with the type of added sugar. Low-GI breakfast with added sugar was eaten on 109 occasions (2 children missing), with children eating toast only and no cereal on 53 occasions. This may explain, in part, why no increase in palatability with test breakfast 2 was seen; it is likely that children were assessing palatability on the basis of the main part of the meal, not on a secondary item such as fruit juice. The addition of sucrose may have some practical application as some low-GI foods may be more acceptable to children with the addition of a small amount of sugar, e.g. porridge. As palatability has been inversely related to satiety (Drewnowski, 1998b), the addition of sucrose requires a cautious approach.

A subjective observation was, that for a minority of children, it was difficult to persuade them to finish all of their low-GI breakfast and for two children alternative low-GI choices (fruit and yoghurt) had to be offered. No such problems were encountered with the high-GI breakfast. In many subjects, the soya and linseed bread became a preferred option to the low-GI cereals. It was not surprising that palatability of the high-GI breakfast, which included the choice of cocopops and cornflakes, was rated higher than the low-GI breakfast, which included the choice of porridge and All Bran.

In the study of Ludwig et al. (1999), children assessed satiety using a VAS. The mean age of the children in Ludwig's study was 15.7 years so their relative cognitive maturity may make this tool suitable. There is little research about the use of visual analog scales (VAS) or rating scales in children in nutrition. In the current study, it is encouraging that there was a consistently negative association between satiety at lunchtime and subsequent food intake, although it is acknowledged that this relationship was only significant on 3 of the 10 measurements. Due to time constraints, satiation after breakfast was rated very quickly after completion of breakfast, especially if the child was running late! It has been noted that maximum satiation is normally reached within 30 minutes post ingestion (Holt et al., 1995). It seems prudent at this stage to treat rating scale measurements in children of this age with caution.

The coefficient of variation in lunch intakes is in keeping with previous findings that show that although children's daily energy intake varies relatively little compared to adults, their meal- to- meal variation is estimated to be 35% (Birch et al., 1991). It is not possible to ascertain how the within-subject and between-subject variation in lunch intakes (131 kcal and 156 kcal respectively) compare to variation under normal conditions; the intervention may have reduced or increased habitual variation. The type of breakfast eaten explained 17% of the within-subject variation, but did not appear to influence between-subject variation. It is apparent that some children had a very high food intake at lunchtime with energy intakes equal to estimated daily BMR requirements after two of the high-GI breakfasts (Table 5.12). There is every possibility that the availability of palatable 'free food' in a completely uninhibited environment influenced intake. However, as each subject acted as his or her control this is a constant factor. In addition, as the order of the test breakfasts for each of the experimental weeks was random, the novelty of the lunch should have no effect.

Overweight/obesity did not alter the effect of the test breakfasts on lunch intake. At a group level, the addition of sucrose at breakfast had a positive effect on subsequent food intake in the overweight children, which was not apparent in the normal weight children. The lunch intakes of the overweight/obese children were not significantly higher than those of normal weight children. In 1962, Widdowson observed that there is wide variation in the intakes of children, and overweight children did not appear to eat more than normal weight children (Widdowson, 1962). Since then, debate has ensued about the energy intake of overweight children compared to their lean counterparts with several studies failing to demonstrate that fatter children have higher energy intakes (McGloin et al., 2002). However, there are serious doubts about the reliability of dietary data in the overweight (Livingstone, 2000), and underreporting has been observed in this group (Maffeis et al., 1994). In addition, low energy expenditure from physical activity in overweight children has been suggested (Rocandio et al., 2001). Recent work suggests that overweight children have higher fat intakes, even when their reported energy intakes are slightly lower than normal weight controls (McGloin et al., 2002).

It is very important in this type of experiment to match macronutrient content to reduce the possibility of confounding variables. Failure to do this has been a criticism of previous studies and makes comparisons of results difficult (Barkeling et al., 1995; Holt et al., 1996). However, given the constraints of the study (time and lack of food preparation facilities) and the fact that a 'typical' breakfast meal had to be provided, it was not possible to match low-GI cereals ± bread with high-GI cereals ± bread exactly, without the use of nutrient isolates (e.g. glucose polymer) or other manipulations. These may affect palatability and satiation, therefore were not utilised. Although there were differences in the protein, carbohydrate and fat content of the low-GI and high-GI breakfasts, these were relatively small (Tables 5.5 and 5.6). As the macronutrient content of the habitual breakfast was similar to the low-GI breakfast, a comparison of the lunch intakes after each test breakfast and the trial lunch was important as it eliminates this potentially confounding variable. The dietary fibre content of the low GI breakfasts was appreciably higher than the high-GI breakfast and this needs to be considered when interpreting results.

Biochemical measurements were beyond the scope of the study, therefore the mechanism of the effect of the breakfasts with different GIs is a subject of speculation only. As discussed at the beginning of this chapter, there is a sizeable school of thought that attributes the high insulin and glucose responses of high-GI foods, which are followed by hypoglycaemia, and the concurrent sequence of hormonal and metabolic changes to the promotion of increased food intake. However, as also discussed, there are other studies which have not found an association between glucose and/or insulin levels and satiety. Instead, other candidate satiety signals, CCK and carbohydrate receptors in the small intestine may have a role in the satiety effects of low-GI foods. It does seem likely that the presence of dietary fibre, which has unique bulking and chemical properties and effects on transit time, may have an important role in the satiating effect of low-GI foods. Although there have been few studies in children looking at the effect of dietary fibre on energy intake, there is no reason to suppose that the mechanisms or effects will be any different to that of adults (Pereira and Ludwig, 2001). The results of the current study are particularly important as it has been observed that the effects of one meal upon another, with normal inter-meal intervals, are rarely observed in the study of human appetite (Delargy et al., 1995).

In summary, the current study has investigated the effect of high versus low GI foods on appetite in a group of lean and overweight children; this is a novel investigation. The lower-GI breakfast resulted in a reduced food intake at lunch. This study supports the growing body of evidence that low-GI diets may have a role in obesity management.

Chapter 7

Final discussion and conclusions

In the introduction (Chapter 1), the extent of the obesity problem and the concurrent health risks were highlighted. The aetiology of obesity is complex and multifaceted and many questions about appetite and body weight regulation remain. Obesity, appetite and energy regulation are complex and it seems unlikely that there is one unifying explanatory model. Present evidence suggests that genetic and environmental factors influence the eating behaviour of people prone to obesity; high fat and energy dense diets undermine body weight regulation by promoting overconsumption of energy relative to need. In addition, energy expenditure appears to be decreasing due to widespread mechanisation and increasingly sedentary leisure pursuits. The successful long-term treatment of obesity is a difficult goal to achieve; therefore the prevention of obesity, particularly targeting children, is becoming a public health objective. In this thesis, two approaches to the prevention of obesity in children have been investigated: primary health promotion and dietary intervention. A summary of findings from these investigations will be presented in this chapter, along with associated limitations and recommendations for future research.

7.1 Summary of results

The purpose of a pilot study includes the assessment of feasibility, efficacy and acceptability, which in turn will lead to a decision on whether to pursue or reject a particular approach. In this thesis, a valuable pilot study for the UK has been undertaken which has used schools in a unique and innovative way to promote healthy lifestyles. The outcomes of this research are summarised below.

1. Significant improvements in nutrition knowledge were noted in all children and especially in those children who had received the nutrition intervention.
2. Modest behaviour changes, notably a rise in fruit consumption in the children who had received the nutrition intervention and were in the control group, emerged as a result of this project. The rise in fruit consumption was independent of a rise in parental fruit consumption.
3. From the lunch recall it appears prompts, cues and possibly familiarity with the food eaten enhance recall; leftovers are not readily reported in this age group.
4. School appears to provide important opportunities for young children to be active.

5. There was a suggestion that after the programme children in the physical activity groups were more active in the playground at lunch-time.
6. There were suggestions from the data that increased television viewing may be associated with higher body weight and that parental and child dietary and physical activity habits may be linked.
7. Gender differences in lifestyle were not apparent in these children aged 5-7 years.
8. The programme developed for this research appears to have been comprehensible to the target groups.
9. The materials developed for delivering the programme are to be disseminated nationally for use by teachers, researchers or health professionals.
10. Targeting the families proved very difficult in this study and there was poor attendance at the parental meetings held at the schools or the university.
11. This intervention, which involved the co-operation of teachers, parents and children, whilst being feasible, is not sustainable in the long-term.
12. The current research findings should influence and inform future health promoting programmes in the UK.

As discussed in chapter 1, the school-based obesity prevention study, along with the 'APPLES' study in Leeds, are the first of their kind in the UK. Both studies have led to positive changes in knowledge, but modest changes to behaviour. The viability of this approach in the UK has been questioned (Atkinson and Nitzke, 2001). From section 1.4 it is apparent that this type of approach has many inherent limitations yet some encouraging results have been reported in past studies. The ethos of the Health Promoting School is becoming an accepted concept in schools today in the UK (Lister-Sharp et al., 1999) and a school-based intervention has the potential to fit with this philosophy. It appears that a wider cross-curriculum approach involving the whole school environment and ideally the local community offers a way forward. However, careful consideration must be given to what is achievable within an over-burdened and under-funded school system. An innovative programme has been undertaken in Singapore (Toh et al., 2002), where a comprehensive school-wide intervention is delivered with the collaboration of the Ministries of Education and Health. This is an approach which may offer a model for future programmes in the UK. Whilst school-based prevention programmes may be promising, it is necessary to consider other approaches to obesity prevention such as dietary intervention. The second study on GI precisely addressed this issue.

There is increasing evidence that low-GI foods may have a role to play in the promotion of health, including the management of obesity. Many questions remain unanswered and more conclusive evidence is required before the promotion of a low-GI diet or, more specifically, a reduction in the intake of carbohydrates with a high-GI is advocated as a public health message. In this thesis, the effect of varying the GI of a breakfast on subsequent lunch intake has been demonstrated in a group of lean and normal weight children. This is a novel investigation and the results are summarised below.

1. Consumption of a low-GI breakfast compared to a high-GI breakfast resulted in a reduced intake at a subsequent *ad libitum* lunch.
2. The addition of 10% sucrose did not significantly diminish this effect.
3. The effect of a low-GI breakfast was independent of body weight and gender.
4. Overweight children consumed more lunch following the low-GI breakfast with added sucrose compared to their lean counterparts.
5. Satiety scales were inversely related to food intake, suggesting that rating scales may be a suitable assessment tool in children aged 9-11 years.

The GI concept is the subject of several popular diet books thus public awareness of the concept will increase. However, more conclusive research is required, particularly from long-term trials. In the meantime, low-GI foods do fit in with current healthy eating messages to reduce fat and increase carbohydrate intake, therefore their promotion within general healthy eating messages would seem prudent. Without further evidence, low-GI foods should be viewed as an alternative rather than a replacement to high-GI foods.

7.2 Limitations of the present research

Certain limitations to the present research are acknowledged and must be considered when interpreting the results. The duration of the school-based study to prevent obesity was not adequate to see any significant anthropometric changes or changes in the trends of overweight or obesity. In addition, the lack of reliable measurement tools limited the accurate assessment of diet and physical activity. Scores for the children's nutrition knowledge were high, which is suggestive of a 'ceiling' effect whereby it may not be possible to distinguish between children whose knowledge was significantly better (or worse) than others. For expediency, simplicity and practicality, the four interventions were carried out in each of the three schools. However, this may have led to contamination between intervention groups. Finally, as parents had to give consent for their children to join the study, recruitment was likely to be biased towards families with a greater interest in health and education. The socio-economic and ethnic mix of the population in this study means that the results have limited application.

The GI study monitored the effect of GI on the intake of one meal only and intake for the rest of the day was unknown. There were differences in the fibre content of the low- and high-GI breakfasts which may be a confounding factor in the effect of GI. In addition, the buffet lunch resulted in high lunch intakes, however, this was a constant throughout the study. Finally, biochemical measurements were beyond the remit of the study.

7.3 Recommendations for further work

1. Novel and innovative ways of delivering a multi-faceted health promotion initiative aimed at preventing obesity in children, which involve the whole school and wider community, need to be explored.
2. Future research studies need to investigate appropriate age-specific measures of habitual diet, physical activity and nutrition knowledge.
3. Studies of this type should run for sufficient length to allow for sustained behaviour change. This is especially important if anthropometry is a key outcome measure.
4. Health-promoting studies aimed at changing lifestyle behaviours should be followed up in the long-term to monitor for continued effect and the tracking of behaviours.
5. Strategies for reaching families should be further investigated.
6. Other study designs, which are robust and acceptable for evaluating health promotion interventions, need to be explored. The randomised-controlled trial has become the recognised study design in the medical literature, but this design may not be optimal for a health promotion study.
7. Further work is required to determine societal, environmental, familial and individual factors which determine diet and activity.
8. School-based health promoting strategies should not appear threatening and should be inclusive. Qualitative data, through focus groups, should be collected to investigate children's experience of participating in such programmes. In addition, school-based health promoting strategies should not be burdensome for teachers.
9. Further investigation of the tracking of lifestyle habits throughout childhood to adolescence and into adulthood is required using longitudinal studies.
10. Longer-term studies in both children and adults are needed to assess the putative effects of a low-GI diet on appetite and satiety and weight control.

11. More research is required to elucidate the mechanisms by which a low-GI diet may exert its effect on appetite and satiety in both children and adults.
12. The promotion of a low-GI diet is hampered by the lack of suitable alternatives to staples such as bread and breakfast cereal. On the basis of robust scientific evidence for the health benefits of low-GI foods, food manufacturers should be encouraged to develop suitable low-GI alternatives.

7.4 Conclusion

The challenge which faces health researchers and professionals is encapsulated within the following statement: 'prevention is slow and difficult and requires radical changes in lifestyle in a climate where many people feel overloaded by health and nutritional information and compliance to lifestyle and dietary change is often poor' (Rossner, 2001). It is clear that no single intervention to prevent obesity in children is going to be successful; rather multiple initiatives spanning school, transport, recreation facilities, food advertising and food availability are required. Education alone is not sufficient to change health-related behaviours; environmental and societal intervention is also required to promote and support behaviour change. In this thesis, a school-based study aimed at the prevention of obesity in children, a pilot for the UK, has shown modest outcomes in terms of knowledge increases and behaviour change. In addition, low-GI foods were found to reduce appetite and food intake. These two approaches are potential strategies which could be used to tackle the escalating problem of obesity, a problem with such serious health risks that it cannot be ignored.

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Appendix A

Appendix A.1 Nutrition Programme (Eat Smart)

Term 1

*Week 1 Definition of 'healthy'**

Children's concepts of 'healthy' were explored using children's own pictorial definitions. The take home activity was to colour in a picture of a healthy person.

*Week 2 The Balance of Good Health **

The UK national food model was introduced without any detail to emphasise that many foods are needed for health, more of some and less of others. The take home activity was cutting out and sticking food pictures onto the correct sections of a Balance of Good Health outline.

*Week 3 Fruits and vegetables make you 'glow and sparkle'**

Using food cards, fruit and vegetables were discussed. Children made a sparkling pencil for a visual reminder of 'fruit and vegetables make you glow and sparkle'.

The take home activity was a word puzzle about fruit and vegetables.

Week 4 Power foods

A definition of 'energy' was established and the children made a spinner to show an energy source. The take home activity was a picture of different types of power foods to be discussed with someone at home (parent/carer/sibling).

Week 5 Milk and dairy foods

The role of dairy foods in maintaining the skeleton and teeth was discussed, followed by a colouring quiz. The take home activity was to make a skeleton with all materials supplied.

Week 6 Building and growing foods

The protein food group was introduced and its role in the body described as building blocks. To demonstrate, building blocks 'Jenga' was played. The take home activity was a picture of a builder and wall for colouring.

*Week 7 Foods containing fat and sugar**

The fat and sugar content of common snack foods were described by placing them on brown paper (the brown paper absorbed the fat) or by showing the equivalent number of sugar cubes. These foods were not described as 'bad' foods, rather less important foods. The take home activity was a cutting and gluing exercise using a tooth model to demonstrate tooth friendly foods.

Week 8 The Balance of Good Health

Revision of previous sessions bringing all the messages together, using a floor mat based on the Balance of Good Health. The take home activity was a laminated Balance of Good

Health chart for the children to draw or write foods that they had eaten from the various food groups that day.

Term 2 Fruit and vegetables

*Week 1 Introduction**

The children were given a paper plate on which they were encouraged to make a face using lots of different types of fruit and vegetables. This was followed by a practical tasting session. The take home activity was to try a new fruit and vegetable and to fill in a sheet with happy and sad faces to say whether they liked them or not.

*Week 2 Fruit and vegetables make me glow and sparkle**

Recapped and expanded on a similar lesson in term 1. The take home activity was colouring cartoon pictures of fruit and vegetables.

Week 3 How to eat 5 a day – 'Anytime, anyplace, anywhere.'

Practical suggestions about how to eat 'five a day' were made. Care was taken to give a balanced view and not to discourage energy dense foods that are very important for growing children. The take home activity was a word puzzle wherein the children had to complete the beginning and end of the names of some common fruit and vegetables.

Week 4 Are you getting enough?

Children counted up how many portions of fruit and vegetables they had eaten that day. The take home activity was making a "Give me 5 snapper" – published by the British Dietetic Association.

Term 3 Power foods

Week 1 Introduction to power foods – their function in the body

Recapped and expanded on a similar lesson in term 1. A game was played whereby the children called out pairs of words for "fuel" and "user". The take home activity was a related picture to colour in.

*Week 2 Breakfast – importance of breakfast every morning**

The importance of eating breakfast every day was highlighted. The children made a collage picture using breakfast cereals and sheets printed with the word "POWER".

The take home activity was a related message which needed decoding.

*Week 3 Snacks**

The consumption of high carbohydrate (and therefore low fat) snack foods was encouraged. The take home activity was to identify the power foods in a picture of various foods.

Week 4 Energy to go

The need to re-fuel throughout the day was established. A torch with and without batteries was used to demonstrate this. The take home activity was to colour two pictures of a car – the first one when the car is running out of petrol and the second one after it has refuelled.

Term 4 Teeth and health

*Week 1 Tooth unfriendly**

The role of plaque and acid in tooth decay was discussed and demonstrated using a plaque-disclosing tablet and some very decayed teeth. The take home activity was a related colouring activity.

Week 2 Tooth friendly

The importance of caring for teeth and eating tooth-friendly foods was discussed. The lesson ended with a practical tasting session of tooth friendly crunchy vegetables. The take home activity was tooth-related word search and a brush chart, to be completed daily, for a week, after tooth brushing.

Week 3 Tooth friendly too

The role of dairy foods (milk and milk foods) in strengthening and maintaining healthy teeth was highlighted in addition to some 'fun facts' about teeth. The take home activity was naming the different types of teeth.

*Week 4 'Eat smart' to keep healthy**

Recap that food is important to keep us healthy and the foods that are good for teeth are good for the rest of the body (power foods, fruit and vegetables). The children made their own 'all glowing, all sparkling' Eat Smart mascot. The take home activity was matching happy and sad faces with 'tooth-friendly' and 'tooth –unfriendly' foods.

* included in the combined programme

Appendix A.2 Physical Activity Programme (Play Smart)

The programme was developed to encourage children to be more active in their everyday lives and to understand the benefits of being active. Children were encouraged not to think of activity as only playing sports. Ways of increasing activity at home and school were suggested. Lessons were meant to be fun, energetic and easy to follow.

Term 1 An insect theme was used throughout this term

*Week 1 What is activity**

A definition of activity was established using colour pictures of different activities which emphasised that activity included everyday tasks like walking to school, climbing stairs, skipping and dancing and not just sports games like football and swimming. Children pretended they were ants and tasks they would do in a day were discussed. Activities were carried out e.g. collecting food, building anthill and playing. The take home activity was to find a set of stairs and while climbing them, count the number of steps.

Week 2 Movement

Referring back to the insect theme children were shown a number of different insects and they had to demonstrate the movement for each insect. The objective was to recognise that insects move in different ways and they should move in as many ways as possible. The take home activity was to draw an example of movement undertaken during the weekend.

*Week 3 Active and non-active insects**

The objective of this lesson was to divide the insects up into active and non-active insects and explain that it was better for health to be active like an active insect. Children had to collect food pretending they were different insects and decide which were active and which were not. The take home activity was an insect colouring picture and selection of the active insect.

Week 4 Different types of activities

A definition of energy was established in the context of physical activity. A rag doll and wind up toy were used to demonstrate the importance of energy in moving. Different tasks (both low and high energy) were given to the children and they had to decide which of the tasks were active and high energy. The take home activity was a selection of high-energy activities from a range of activities.

*Week 5 Change**

The objective was to discuss ways to be more active. The caterpillar (an inactive insect) changing into a butterfly (an active insect) demonstrated changing activity levels. Games were played where activity changed from being inactive to active (e.g. walking to running). The take home activity was to complete a simple record of the time taken to walk a set distance at a slow and then a fast pace this was repeated for skipping.

Week 6 When we are active how do we feel

The objective was for children to recognise and describe the changes that happen to their bodies during activity. Each child completed a sheet describing the way they felt before an activity and after an active game e.g. tag. The take home activity was to blow up a balloon, counting the number of breaths required.

*Week 7 What activities can we do?**

The objective was to give the children a wide variety of activities that they could do both indoors and outdoors which did not cost money. At home, children were encouraged not to use remote controls for electrical equipment and, with an adult, walk instead of taking the car for a short journey.

Week 8 Bugs Ball

The objective was to have fun whilst being active. Dancing is an everyday activity that uses up lots of energy and is both active and fun. A variety of games were played e.g. musical statues and dancing. The take home activity was an activity spinning wheel, to be spun daily and the selected activity undertaken.

Term 2

Term 2 covered the benefits of activity and why fitness is important referring to the physical changes in the body.

*Week 1 Why is activity important. Activity and the heart**

As an introduction, the previous term was reviewed. The objective was to discuss the role of the heart in activity. Heart beat and pulse rate were measured before and after activity to illustrate the change in the heart's beat due to activity. The take home activity was to grade a range of activity pictures based on their effect on the heart.

*Week 2 Activity and energy**

The objective was to explain the role of energy in activity. A definition of energy was discussed. The different amounts of energy used for different activities were shown using a bar chart. Different tasks were done to demonstrate the link between high-energy activities and those that make the heart beat fast. The take home activity was from a range a of day to day and leisure activities to select the ones different amounts of energy were used and the difference in heart rates.

Week 3 Activity and stamina

The objective was to understand the term stamina and its role in activity. The definition of stamina was explained, the ability to keep going without getting too worn out. Stamina enables tasks to be carried out more easily. By doing activities each lasting different lengths of time, the concept of stamina was demonstrated. The take home activity was undertaking three activities with a balloon for varying lengths of time.

Week 4 Activity and strength

Objective was to understand the role of activity with strength. A 'strength game' played: children were divided into two teams and each team was given a bag, either a weak plastic bag or a strong bag to pick up either light or heavy weights. The take home activity was to distinguish between objects on the basis of the strength needed to carry them.

Term 3 Why don't you........... was the theme for this term

*Week 1 Why don't you play smart in playground**

The objective of this lesson was to encourage children to be active in the playground. Four main playground activities discussed and played: running, hopscotch, skipping and jumping. These could be played alone or with friends. The take home activity was to complete a playground activity diary for a week.

Week 2 Why don't you play smart at the weekend

The objective was to encourage children to be more active during the weekend and activities that they could be done were discussed. One of these activities was skipping, as it is an easy and a fun way to be active. Skipping ropes were made using rope and hosepipe and children were encouraged to use them at home.

*Week 3 Why don't you play smart and turn off the TV**

The objective was to encourage children to turn off the TV and do something active. The physiological differences between watching TV and playing an active game were discussed. Children sat for 2 minutes in front of an imaginary TV and then filled in a described how they felt using by selecting the appropriate picture. This was repeated after an active game and the differences in responses discussed. For the take home activity children were given materials to make a bat and ball game as an alternative to watching television.

Week 4 Why don't you play smart with a friend

The objective was to encourage children to be active and play with a friend. Games played in the lesson were Frisbee, football and catch. In the take home activity children were asked to draw a picture of someone they could play with and what they could play together.

Term 4 The theme for this term was the activity pyramid

The activity pyramid is a model which promotes physical activities with the emphasis on everyday activity. It encourages children to participate in physical activity with friends, parents or by themselves. Sedentary behaviour such as television viewing is not encouraged in the model. The activity pyramid summaries the points made in terms 1, 2 and 3.

Week 1 The activity pyramid level 1 (everyday activities)

The objective of the lesson was recap on everyday activities that can be done which are active. Children moved between workstations and undertook (or mimed) a series of these activities. The take home activity was a blank picture of the rooms in the house and children were asked to draw an everyday activity done in each, which involves movement.

Week 2 The activity pyramid level 2 (games and activities that make the heart beat faster).*

The objective was to go through activities in level 2 and discuss how they differ from level 1. Children were encouraged to take part in these activities when they have the opportunity to do so. The hall was set up with stations of level 2 activities; children completed each activity. The take home activity was an activity based puzzle.

Week 3 Activity pyramid level 3 (activities that improve strength and flexibility)

The objective was to identify the activities in level 3 and explain why they are important. Stretching was demonstrated doing a variety of movements e.g. bending, touching toes, the splits and playing twister. Strength was demonstrated by playing a strength game. The take home activity was a quiz and game based on the use of muscles.

*Week 4 Activity pyramid level 4 (rest and inactivity)**

The objective was to summarise the activity pyramid and discuss level 4. Level 4 represents sedentary activities such as television viewing and playing sedentary video/computer games these should be limited. For the take home activity children were given a blank pyramid and asked to complete it using activities that they do regularly.

* included in the combined programme

Appendix A.3 Control Group (Be Smart)

The children in the control group were not given any guidance on nutrition or physical activity. However, it was considered very important to include an educational element to this group. The time spent by the control group was divided equally between interactive educational CD-ROMs and lessons.

CD-ROMs:

Two CD-ROMS produced by Dorling Kingersley were used: 'All About Me' and 'My Amazing Human Body'. 'All About Me' is aimed at 5-8 year olds and enables the user to create a secret interactive fact file all about themselves. 'My Amazing Human Body' is aimed at 6-10 year olds and builds up knowledge of the body systems and life processes. Both programmes help to build up children's keyboard and computer skills in an educational context.

Lessons Term 1

Week 1 What we eat

The objective of this lesson was to build up an understanding of the reasons for our food choices that include preference and tradition. The take home activity was to match up traditional foods eaten in the UK with their region of origin e.g. Cornish pasties and Cornwall.

Week2 Foods from the world

Through group discussion foods that are grown in this country and foods that are not were listed. Reasons for these were established and a game played with food cards to categorise home-grown and imported foods. The take home activity was to match the foods in the picture with their country of origin e.g. tea and India.

Week 3 Food Processing

The concept of food processing was introduced using bread as a model. After further discussion a game was played with photographs of food at different stages of processing which the children had to put in correct order. The take home activity was to name the foods being produced in a set of pictures.

Week 4 Food Preparation

The idea that some foods can be eaten straight away while others may need to be prepared first, was introduced. Examples of food processing from commonly eaten meals were discussed. The take home activity was to name various types of food preparation and match them to the appropriate food, e.g. peeling and potatoes.

Term 2

Week 1 Food and culture

The aim of this lesson was to make the children aware of cultural differences expressed by food using recipe books and pictures. The take home activity was to match the food to its country of origin.

Week 2 Meals for special occasions

Meals for Arctic and space adventures were considered examples of other specialised foods were displayed. The take home activity was to colour pictures of a spaceman and an explorer.

Term 3

Week 1 Intestines and all that stuff

The objective of the lesson was to give the children a basic understanding of what happens to their food once it goes into their bodies. The children played a game where they had to label the main parts of the digestive system as fun facts were introduced. The take home activity was labelling a digestive system.

Week 2 'Squeezing, sliding, mixing, cutting and much more'

The various processes involved in the digestion of food were described as above and related to every day items such as scissors, a slide, food mixer and hosepipe. The take home activity was a word search containing words encountered in the lesson.

Term 4

Week 1 The heart

This lesson involved learning about the basic pumping function of the heart using a model of the heart. The take home activity was a quiz about the heart which covered work done in class.

Week 2 Hearbeat

The heartbeat was considered and children were taught about the pulse and how it is measured. The take home activity was to make a stethoscope out of a piece of garden hose and two small plastic funnels.

Appendix A.4 Review of dietary assessment methods

Method	Procedure	Advantages	Disadvantages
FFQ	Uses a list of food items to record intake over a given period. May be quantitative.	Used to estimate usual intake over a long period. Quick, cheap, low respondent burden. Self-administered can be posted.	Does not measure day to day variation. Reported diet may be a distortion.
Diet history interview*	Two-part interview: 24-hour recall followed by detailed questions about habitual dietary intake.	Can provide data on habitual intake, meal patterns and nutrient intake over a long period. No literacy skills required.	Labour intensive and complex requiring trained interviewers. Time-consuming. No measure of day to day variation.
24- hour recall	Subject asked to recall and describe intake in the previous 24 hours.	Rapid, cheap and easy to administer. Useful for large samples. No literacy skills required.	Requires interviewer. Foods are often omitted and intakes may be under-estimated. No measure of day to day variation.
Weighed food records	Subject weighs and records all food and drink consumed over a defined period.	Used to assess actual intake, and has been regarded as the 'gold standard' until recently.	High respondent burden. May lead to alteration of habitual intake. Requires high levels of literacy and motivation. Expensive for a large survey.
Estimated food records*	Subject records all food and drink consumed over a defined period.	Cheaper than weighed method. Can be posted. Lower subject burden. Less likely to alter intake.	Estimation of portion sizes may not be accurate. Subjects must be literate and cooperative.
Duplicate portion technique	A duplicate portion of all food and drink consumed collected. Diets are homogenised and chemically analysed.	Regarded as the most accurate method. No error from food composition tables. Low subject burden.	Accuracy depends on complete collection of samples. Difficult to implement in free-living population. Expensive, time-consuming and labour intensive.
Biomarker assessment	Biochemical indices are collected and analysed e.g. urine samples for protein; plasma samples for lipids.	Rapid, objective method. Predicts intake. Can detect deficiencies and assess compliance of taking prescribed supplements.	High respondent burden. Invasive. Requires good laboratory practice. High inter-individual variability in physiology and metabolism. Affected by age, gender and medication.

*Portion sizes in household measures, using food models/photographs Adapted from Hartwell D (1998)

Appendix B.4 Parent questionnaire of 24-hour child activity and diet

A record of what my child did and what my child ate in 24 hours

Please fill in each section from when you picked up your child from school to when you leave your child at school next morning. If someone else is involved in the care of your child please ensure that you obtain all the necessary information from him or her. It is easier to record food intake immediately after it is eaten to ensure nothing is forgotten.

After school

1) How did your child get home from school or to after school care?

2) Did your child go to any clubs yesterday? eg Brownies, Cubs, swimming or a club at school

3) Did your child eat anything on the way home from school, and before their evening meal. Please record details in the box.

After school

Food / drink	Description & preparation	Amount

4)What did your child do before their evening meal?

5) If your child had an evening meal please give details on the next page

Evening meal

Food / drink	Description & preparation	Amount

6) *What did your child do before they went to bed?*

7) How much TV did your child watch between leaving school and going to bed?

8) How long did your child spend playing computer/video games, watching videos or surfing the internet between leaving school and going to bed?

9) Did your child eat or drink anything before going to bed? Please record in the box. If your child had anything to eat or drink during the night please include in this box.

Bedtime

Food / drink	Description & preparation	Amount

10) What time did your child get up in the morning?

11) Did your child do any activities before leaving for school?
Please list below:

12) Please note in the box any food your child ate on awakening, for breakfast, or after breakfast.

Morning

Food / drink	Description & preparation	Amount

14) How did your child travel to school ?

15) Did your child eat anything on the way to school? Please record in the box below

Before school and break time

Food / drink	Description & preparation	Amount

16) Did you send a morning break time snack with your child? Please record in the box above.

17) Does your child usually eat a school dinner or a packed lunch?

18) If you sent a packed lunch with your child please record the details in the box below.

Packed lunch

Food / drink	Description & preparation	Amount

Thank you for taking the time to fill out this questionnaire

Appendix B.7 Child's activity questionnaire
(To be completed by the parent or carer)

Please circle the appropriate answer or fill in the space provided

CODE NUMBER

Section A : Weekdays

1) Does your child do any of the following activities before school?
   a) watch TV
   b) play computer/video games/internet/watch video
   c) read
   d) indoor play
   e) outdoor play
   f) other (please state)

2) How does your child travel to school?
   a) cycle
   b) walk
   c) bus
   d) car
   e) other

3) How does your child travel home from school?
   a) cycle
   b) walk
   c) bus
   d) car
   e) other

4) Does your child attend any activities after school?
   Yes / No

   If yes, what are they and for how long do they last?

5) What does your child spend most of their time doing when they get home from school?
   a) watch TV
   b) play computer/video games/internet/watch video
   c) read
   d) indoor play
   e) outdoor play
   f) other (please state)

6) How much TV does your child usually watch on a school day evening?
   a) none
   b) less than 1 hour
   c) between 1 and 2 hours
   d) between 2 and 3 hours
   e) greater than 3 hours

7) If your child spends time watching videos, playing computer/ video games or on the internet how much time is this per school day evening?
   a) none
   b) less than 1 hour
   c) between 1 and 2 hours
   d) between 2 and 3 hours
   e) greater than 3 hours

Section B: Weekend

1) What various activities does your child regularly do at the following times over the weekend.
   Please include all regular activities e.g. shopping, visiting, playing, sport etc.

a) Saturday morning

b) Saturday afternoon

c) Saturday evening

d) Sunday morning

e) Sunday afternoon

f) Sunday evening

2) How much television does your child watch on a Saturday morning?
   a) none
   b) less than 1 hour
   c) between 1 and 2 hours
   d) between 2 and 3 hours
   e) between 3 and 4 hours
   f) greater than 4 hours

3) How much television does your child watch for the rest of Saturday?
   a) none
   b) less than 1 hour
   c) between 1 and 2 hours
   d) between 2 and 3 hours
   e) between 3 and 4 hours
   f) greater than 4 hours

4) How much television does your child watch on a Sunday morning?
   a) none
   b) less than 1 hour
   c) between 1 and 2 hours
   d) between 2 and 3 hours
   e) between 3 and 4 hours
   f) greater than 3 hours

5) How much television does your child watch for the rest of Sunday?
   a) none
   b) less than 1 hour
   c) between 1 and 2 hours
   d) between 2 and 3 hours
   e) between 3 and 4 hours
   f) greater than 4 hours

Thank you for your time.
The information you provide is confidential.

Appendix B.8 Parents Physical Activity Questionnaire

To be completed by the adults in the household

Please answer the following questions about the activity in your job and leisure time. Circle the most appropriate answer or fill in the space provided.

CODE NUMBER

Are you a) male b) female (please circle)

What is your relationship to the child?

Section A

1) What is your main occupation, this includes the running of a household.

2) At work I sit

   never / seldom / sometimes / often / always

3) At work I stand

   never / seldom / sometimes / often / always

4) At work I walk

   never / seldom / sometimes / often / always

5) At work I lift heavy loads

   never / seldom / sometimes / often / always

6) **After working I am tired**

   never / seldom / sometimes / often / always

7) At work I become breathless

   never / seldom / sometimes / often / always

8) How many minutes do you walk and / or cycle per day to and from work, school and shopping?

   Less than 5 mins / 5 – 15 mins / 15 – 30 mins / 30 – 45 mins / greater than 45 mins

7.4.1.1 Section B

Consider a 7 day period, (a week), how many times, on average, do you do the following kinds of exercise for MORE THAN 15 MINUTES during your FREE TIME. Write on each line the appropriate number.

Times per week

1) Strenuous exercise
   (heart beats rapidly)

   e.g. running, jogging, hockey, football, soccer, squash, basketball, tennis, cross country skiing, judo, roller skating, vigorous swimming, vigorous long distance bicycling

2) Moderate exercise
   (not exhausting)

   e.g. fast walking, baseball, tennis, easy bicycling, volleyball, badminton, easy swimming, popular and folk dancing

3) Mild exercise
   (minimal effort)

   e.g. yoga, archery, fishing, bowling, golf, easy walking

4) Considering a 7 day period (a week) during your leisure time, how often do you engage in any regular activity to become breathless?

   often / sometimes / never

Thank you for your time.

This information is confidential

Appendix B.9 Nutrition Knowledge Questionnaire

In this questionnaire we are interested to see if 'healthy eating' messages are getting across. It is NOT a test. Please answer all questions by ticking the most appropriate response.

Answers are strictly confidential.

Thank you for your time

1) Do you think health experts recommend that people should be *eating more*, the same amount, or less of these foods? (tick one box per food)	more	same	less	not sure
vegetables				
sugary foods				
meat				
starchy foods				
fatty foods				
high fibre foods				
fruit				
salty foods				

2) How many servings of fruit and vegetables a day do you think experts are advising people to eat? (one serving could be for example, an apple or handful of chopped carrots)	

3) Which fat do experts say is most important for people to cut down down on? (tick one)	
a) monounsaturated fat	
b) polyunsaturated fat	
c) saturated fat	
d) not sure	

4) What version of dairy foods do experts say people should *eat*? (tick one)	
a) full fat	
b) lower fat	
c) mixture of full fat and lower fat	
d) neither, dairy foods should be cut out	
e) not sure	

<u>Experts classify foods into groups. We are interestedto see whether people are aware of what foods are in these groups:</u>

1) Do you think these are high or low in added sugar? *(tick one box per food)*	high	low,	not sure
bananas			
unflavoured yoghurt			
ice cream			
orange squash			
tomato ketchup			
tinned fruit in natural juice			

2) Do you think these are high or low in fat? (tick one box per food)	high	low,	not sure
pasta (without sauce)			
low fat spread			
baked beans			
luncheon meat			
honey			
scotch egg			
nuts			
bread			
cottage cheese			
polyunsaturated margarine			

3) Do you think experts put these in the starchy foods group? (tick one box per food)	yes,	no,	not sure
cheese			
pasta			
butter			
nuts			
rice			
porridge			

4) Do you think these are high or low in salt (tick one box per food)	high	low,	not sure
sausages			
pasta			
kippers			
red meat			
frozen vegetables			
cheese			

5) Do you think these are high or low in protein? (tick one box per food)	high	low,	not sure
chicken			
cheese			
fruit			
baked beans			
butter			
cream			

6) Do you think these are high or low in fibre / roughage? (tick one box per food)	high	low,	not sure
cornflakes			
bananas			
eggs			
red meat			
broccoli			
nuts			
fish			
baked potatoes with skins			
chicken			
baked beans			

7) Do you think *these fatty foods are high or lowin* saturated fat? (tick one per box)	high	low,	not sure
mackerel			
whole milk			
olive oil			
red meat			
sunflower margarine			
chocolate			

8) Some foods contain a lot of fat but no cholesterol.	
a) agree	
b) disagree	
c) not sure	

9) Do you think experts call these a healthy alternative to red meat? (tickone box per food)	yes,	no,	not sure
liver pate			
luncheon meat			
baked beans			
nuts			
low fat cheese			
quiche			

10) A glass of unsweetened fruit juice counts as a helping of fruit: (tick one)	
a) agree	
b) disagree	
c) not sure	

11) Saturated fats are mainly found in: (tick one)	
a) vegetable oils	
b) dairy products	
c) both a) and b)	
d) not sure	

12) Brown sugar is a healthy alternative to white sugar: (tick one)	
a) agree	
b) disagree	
c) not sure	

13) There is more protein in a glass of whole milk than in a glass of skimmed milk (tick one).	
a) agree	
b) disagree	
c) not sure	

14) Polyunsaturated margarine contains less fat than butter: (tick one)	
a) agree	
b) disagree	
c) not sure	

15) Which of these breads contain the most vitamins and minerals? (tick one)	
a) white	
b) brown	
c) wholegrain	
d) not sure	

16) Which do you think is higher in calories: butter or regular margarine? (tick one)	
a) butter	
b) regular margarine	
c) both the same	
d) not sure	

17) A type of oil which contains mostly monounsaturated fat is: (tick one)	
a) coconut oil	
b) sunflower oil	
c) olive oil	
d) palm oil	
e) not sure	

18) There is more calcium in a glass of whole milk than in a glass of skimmed milk (tick one)	
a) agree	
b) disagree	
c) not sure	

19) Which one of the following has the most calories for the same weight? (tick one)	
a) sugar	
b) starchy food	
c) fibre / roughage	
d) fat	
e) not sure	

20) Harder fats contain more: (tick one)	
a) monounsaturates	
b) polyunsaturated	
c) saturates	
d) not sure	

21) Polyunsaturated fats are mainly found in: (tick one)	
a) vegetable oils	
b) dairy products	
c) both a) and b)	
d) not sure	

The next few items are about choosing foods
Please answer what is being asked and not whether you like or dislike the food!

For example, suppose you were asked ......'If a person wanted to cut down on fat, which cheese would be best to eat?'	
a) cheddar cheese	
b) camembert	
c) cream cheese	
d) cottage cheese	
If you didn't like cottage cheese, but knew it was the right answer, you would still tick cottage cheese.	

1) If a person wanted to reduce the amount of salt in their diet, which would be the best choice? (tick one)	
a) ready made frozen shepherd's pie	
b) gammon with pineapple	
c) mushroom omlette	
d) stir fry vegetables with soy sauce	

2) Which would be the best choice for a low fat, high fibre snack? *(tick one)*	
a) diet strawberry yoghurt	
b) raisins	
c) museli bar	
d) wholemeal crackers and cheddar cheese	

3) Which would be the best choice for a low fat, *high fibre* light meal? (tick one)	
a) grilled chicken	
b) cheese on wholemeal toast	
c) beans on wholemeal toast	
d) quiche	

4) Which kind of sandwich do you think is healthier? (tick one)	
a) two thick slices of bread with a thin slice of cheddar cheese filling	
b) two thin slices of bread with a thick slice of cheddar cheese filling	

5) Many people eat spaghetti bolognese (pasta with a tomato and meat sauce). Which do you think is *healthier*? *(tick one)*	
a) a large amount of pasta with a little sauce on top	
b) a small amount of pasta with a lot of sauce on top	

6) If a person wanted *to reduce the amount of fat in their diet*, which would be the best choice? (tick one)	
a) steak, grilled	
b) sausages, grilled	
c) turkey, grilled	
d) pork chop, grilled	

7) If a person wanted *to reduce the amount of fat* in their diet, but didn't want to give up chips, which one would be the best choice? (tick one)	
a) thick cut chips	
b) thin cut chips	
c) crinkle cut chips	

8) If a person felt like something sweet, but was trying to cut down on sugar, which would be the best choice? (tick one)	
a) honey on toast	
b) a cereal snack bar	
c)plain digestive biscuit	
d) banana with plain yoghurt	

9) Which of these would be the healthiest pudding? (tick one)	
a) baked apple	
b) strawberry yoghurt	
c) wholemeal crackers and cheddar cheese	
d) carrot cake with cream cheese topping	

10) Which cheese would be the best choice as a *lower fat option*? (tick one)	
a) plain cream cheese	
b) edam	
c) cheddar	
d) stilton	

This section is about health problems or diseases

1) Are you aware of any major health problems or diseases that are related to a low intake of fruit and vegetables? (tick one)	
a) yes	
b) no	
c) not sure	
If yes, what diseases or health problems do you think are related to a low intake of fruit and vegetables?	

2) Are you aware of any major health problems or diseases that are related to a low intake of fibre? (tick one)	
a) yes	
b) no	
c) not sure	
If yes, what diseases or health problems do you think are related to low fibre?	

3) Are you aware of any major health related problems or diseases that are related to how much sugar people eat? (tick one)	
a) yes	
b) no	
c) not sure	
If yes, what diseases or health problems do you think are related to sugar?	

4) Are you aware of any major health problems or diseases that are related to how much salt or sodium people eat? (tick one)	
a) yes	
b) no	
c) not sure	
If yes, what diseases or health problems do you think are related to salt?	

5) Are you aware of any major health problems or diseases that are related to the amount of fat people eat? (tick one)	
a) yes	
b) no	
c) not sure	
If yes, what diseases or health problems do you think are related to fat?	

6) Do you think these help reduce the chances of getting certain kinds of cancer? (answer each one)	yes	no	not sure
eating more fibre			
eating less sugar			
eating less fruit			
eating less salt			
eating more fruit and vegetables			
eating less preservatives / additives			

7) Do you think these help prevent heart disease? (answer each one)	yes	no	not sure
eating more fibre			
eating less saturated fat			
eating less salt			
eating more fruit and vegetables			
eating less preservatives/ additives			

8) Which one of these is more likely to raise people's blood cholesterol level? (tick one)	
antioxidants	
polyunsaturated	
saturated fats	
cholesterol in the diet	
not sure	

9) Have you heard of the antioxidant vitamins?	
yes	
no	

10) If YES to question 9, do you think these are antioxidant vitamins? (answer	yes,	no,	not sure
vitamin A			
B complex vitamins			
vitamin C			
vitamin D			
vitamin E			
vitamin K			

Appendix B.10 Personal Details

We need to ask you some questions about your family, your medical history and your child's medical history. This is to help us build up a picture of the families in **'Be Smart'**. All your answers are strictly confidential. Please tick or circle the appropriate answer.

Questions about you and your family

1) Are you male or female?

   a) male
   b) female

2) How old are you?

   a) 18-24
   b) 25-34
   c) 35-44
   d) 35-44
   e) 45-54
   f) more than 55

3) What is your relationship to the child who is enrolled in **'Be Smart'**

   ____

4) Are you:

   a) single
   b) married
   c) living with partner
   d) divorced
   e) widowed

5) Where is the child's place of birth?

   ____

6) Where is the place of birth of each parent of the child

   ____

   ____

7) How many children under 18 years of age are living with you?

   a) 1
   b) 2
   c) 3)
   d) 4)
   e) other (please specify)

8) What is the highest level of education you have completed?

a) primary school
b) secondary school
c) O levels/ GCSEs
d) A levels
e) technical or trade certificate
f) diploma
g) degree
h) post graduate degree

9) Do you have any health or nutrition related qualifications?

a) yes (please specify)

b) no

10) What is your job, please include the running of a household. If you are not working now, what is your usual job?

11) If you have a partner, what is his/her job, please include the running of a household. If they are not working now, what is their usual job?

Medical history

Please answer the following questions by ticking the appropriate Yes or No box.
Have you ever in your life had any of the following?

Description of illness	No	Yes
Heart or circulatory illness		
Blood pressure problems		
Diabetes		
Allergies to any food or substances If yes please specify		
Are you currently receiving any medicines, pills or tablets from a doctor on prescription? If so please specify		
Do you smoke? If so please specify approximately how many a day?		

What is your height? ____________________

What is your weight? ____________________

Your child's medical history

Description of illness	No	Yes
Has your child ever had to consult a specialist doctor If yes please specify		
Does your child have any chronic, long term illness or condition. If yes please specify		
Is your child currently receiving any medicines, pills or tablets from a doctor on prescription? If so please specify		
Does your child suffer from allergies of any type? If yes please specify		
Is your child on a special diet? If yes please specify the type Who prescribed this diet?		
Does you child have a good appetite? If no how would you describe your child's appetite		

Thank you for your time.

Appendix C

C.1 Lunch time observation (date--)

Names →								
Food checklist	**Quantity served**	**Quantity leftover**	**Quantity served**	**Quantity leftover**	**Quantity served**	**Quantity leftover**	**Quantity served**	**Quantity leftover**
Egg sandwich								
Marmite sandwich								
Cheese sandwich								
Ham sandwich								
Chicken sandwich								
Tuna sandwich								
Hummus sandwich								
Peanut butter sandwich								
Salad garnish								
Crisps								
Cheese straws								
Cheese string								
Pizza								
Yoghurt								
Fromage frais								
Cake- fairy								
Cake-								
Biscuits-jammiedodge								
Biscuits- jaffa cakes								
Biscuits-								
Biscuit								
Fresh fruit-								
Water								
Fruit squash								

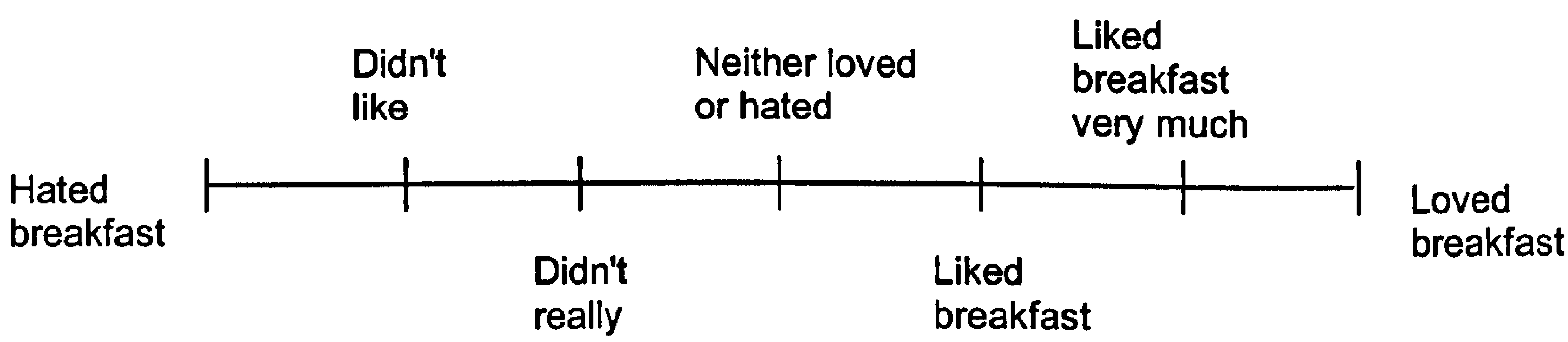
Appendix C.2 Palatability rating

Name ---

Class ---

Date ---

How much did you like your breakfast?



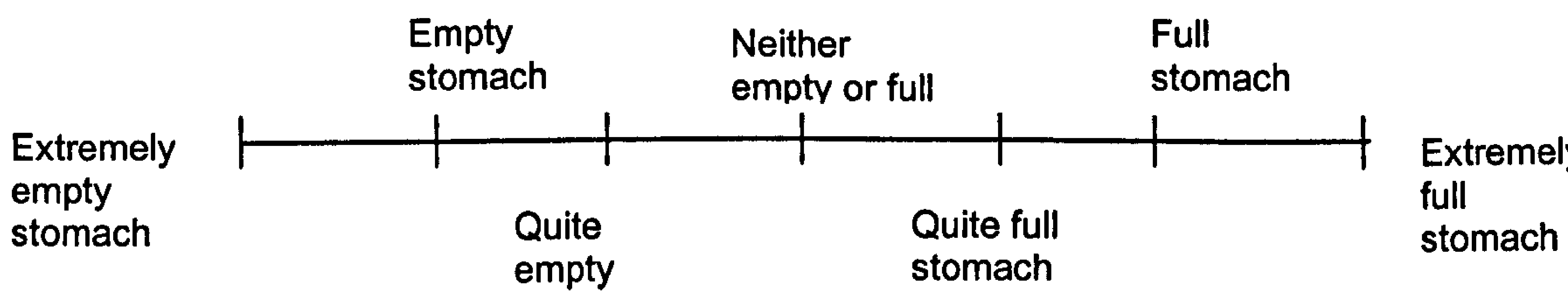
Appendix C.3 Satiation rating

Name --

Class --

Date --

How full do you feel after breakfast?



Appendix C.4 Satiety rating

Name --

Class --

Date --

Did you eat your fruit at breaktime?

Yes/no

Did you eat or drink anything else apart from fruit or water at breaktime?

Yes/no

How hungry are you?